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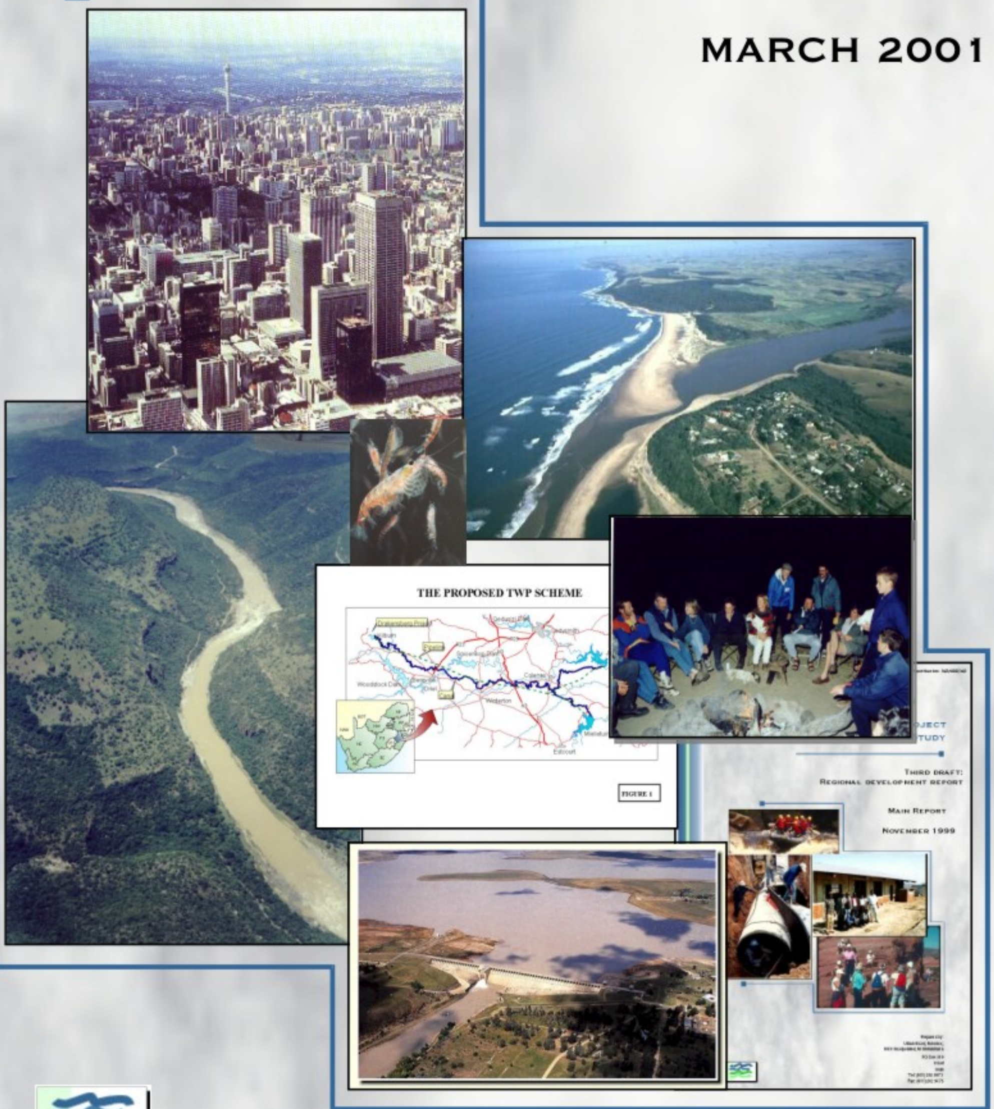
Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

PROJECT LEGAL AND ADMINISTRATIVE FRAMEWORK

MARCH 2001



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REPORT

ON THE

PROJECT LEGAL AND ADMINISTRATIVE FRAMEWORK

OF THE

THUKELA WATER PROJECT

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DUARD BARNARD AND ASSOCIATES MARCH 2001

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SUMMARY

This report is divided broadly into three parts, The first describes the characteristics of and the manner in which, policy and decision-making processes are run and the context in which these should be seen for the TWP. Secondly, it looks at the requirements, characteristics and implications for the TWP, of generally applicable environmental law principles, and specific legislation such as the Constitution, the National Water Act, NEMA and other related statutes. Thirdly it examines the legal context of certain key environmental issues formulated during the scoping phase of the environmental assessment process, and which were summarised in the Background Document and Environmental Issues Report.

The purpose of the Report on Legal and Administrative Framework for the TWP is to provide a structure in which the many decisions made to implement the project, are harmonized with the applicable legal requirements, in a way that avoids or neutralises conflict and prevents delays in the implementation, or even the cancellation of the project.

Policy and decision-making processes

The process of incremental decision-making is an integral and indivisible part of implementing and applying policy and legislative prescripts. It is also so that the legislative requirements dictate that an incremental process of implementation be followed in implementation. Such a process, as was the case with the TWP, would firstly consider broad issues and aspects relating to the achievement of some strategic intent or specific higher order goals, contained within a broad policy framework.

The second part of the process considers various stages of more detailed analysis, built around a focus on the detailed implementation, where a proponent such as DWAF, must be satisfied that the framework "promised" in the original assumptions and policy guidelines, will in effect be established and that the management programme devised will in fact be implemented properly. This is what happened with the TWP. The first round of decisions were made after an extensive exercise of reconnaissance and pre-feasibility studies had been carried out. This then led to the feasibility level investigations, whose purpose it is, to establish the broad framework from which decisions regarding the implementation of the for development can be made. After this decision has been made, the third part of the decision making process will come into play namely, dealing with detailed implementation of the project. It is essential that the outcomes at all stages of the decision making process for the TWP, namely the different records of decision, are reduced to writing in a clear and unambiguous manner.

As a result of the incremental decision making process followed in the TWP investigations, it would appear that rights have been vested to undertake a project such as the TWP. In the normal run of things, rights that have vested, become final and need not be revisited or reconsidered. The implications for a Department of State such as DWAF, are that actions of the State must focus on the best interests of all its citizens. Should a contemporary evaluation show that the detrimental effect to the entire community of implementing a right would be bigger than refraining from implementing it, the it would be proper to refrain from implementing that right. Because of the Constitutional requirements in South Africa today that "*everyone has the right to administrative action that is lawful, reasonable and*

procedurally fair", it has become imperative that any administrative actions taken should be seen to be not only lawful and procedurally correct, but also have be reasonable. An administrative decision must therefore reflect that a reasoned process had been followed in order to arrive at it. What is more, the official who took the decision can be required to explain and justify the trend of reasoning followed.

In terms of factors and considerations that affect the viability of the TWP, it is not important that at this stage to test whether the decisions taken in the past were reasonable or not. Decisions taken in the past must be measured against the requirements that existed at the time the decision was taken. What is important for the TWP is that the position *vis-à-vis* future decisions be clearly understood. Part of the future decision could include a re-evaluation of the validity of a previous decision. The key to dealing with the difficulties and risks of administrative actions in the future, is to ensure that the test of reasonableness is always applied. It must be built into all the decision-making processes so that all the important factors which should be considered, are considered *and* ***that there is a paper trail to show for it*****.** These would include things such as Records of Decision and other documents.

Environmental law and specific legislation

The main pieces of legislation that are dealt with in the report are:

Constitution of the Republic of South Africa Act, 108 of 1996;
Development Facilitation Act, 67 of 1995;
National Water act, No 36 of 1998;
Water Services Act, No 108 of 1997;
Environment Conservation Act, No 73 of 1989;
National Environmental Management Act, No 107 of 1998.

From the National Water Act, two issues of importance have been identified relating to the implementation of the TWP. They are the question of a national water resources strategy (NWRS) (sections 5, 6 and 7), and the question of the Reserve (sections 16, 17 and 18).

What the Act quite simply wants to achieve is that in both cases the focus must be on a properly staged or phased management system as part of a water resources strategy for the country. The water resources of the Thukela River must be part of this overarching strategy and it is therefore necessary that DWAF as a matter of urgency addresses the management of water in this river system. However, it is submitted that it is not necessary for DWAF to delay a decision concerning the implementation of the TWP, until such a national strategy regarding the Thukela has been established. It would not be unreasonable to expect of DWAF, given the particular circumstances in this case, to make a decision regarding the continuation of the TWP, in the absence of a NWR Strategy.

The case is similar although not entirely the same for the determination of the Reserve. What has to happen is that wide-ranging research will have to be done and a water resources strategy developed within a carefully structured process. This process and the information required are virtually identical for decisions regarding the implementation of the TWP and for the formulation of a NWR Strategy. Failure to act within the spirit of the law, would not amount to reasonable administrative action. Work on determining the Reserve and the formulation of a strategy for the management of the water resources of the Thukela River, as part of a national strategy, must therefore be put in hand without delay.

Conclusion

The report concludes by commenting on each of the issues raised at national policy, regional and site specific level, for the TWP, and as contained in the Background Document and Environmental Issues Report (section 7). In some cases there are certain legal requirements, which will have to be attended to during the decision-making phase, implementation and operational phases of the TWP. Failure to do so could in some cases have fairly serious effects on the viability and progress of the project.

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REPORT ON PROJECT LEGAL AND ADMINISTRATIVE FRAMEWORK

TABLE OF CONTENTS

GLOSSARY

AIDS	Acquired Immune Deficiency Syndrome
AJA	Acting Judge of Appeal
CJ	Chief Justice
DWAF	Department of Water Affairs and Forestry
ECA	Environmental Conservation Act No. 73 1989
HIV	Human immuno-deficiency virus
JA	Judge of Appeal
NEMA	National Environmental Management Act No. 107 1998
NWRS	National water resource strategy
RWQO	Receiving water quality objectives
SCA	Supreme Court of Appeal
TWP	Thukela Water Project

THUKELA WATER PROJECT FEASIBILITY STUDY
PROJECT LEGAL AND ADMINISTRATIVE FRAMEWORK

1. INTRODUCTION

The Thukela Water Project (TWP) is one of several projects that could be implemented to augment water in the Vaal Catchment. It is "a water transfer scheme, whereby existing transfers of water … from the Thukela River in KwaZulu-Natal to the Vaal River System" (this module's ToR) could be increased. The Department of Water Affairs and Forestry (DWAF) "is in the process of conducting a feasibility study for a proposed water resource development in the Thukela River Basin for inter-basin transfer to the Vaal River System" (p1, chapter 1: Department of Water Affairs and Forestry, South Africa. 1999. *Background Document and Environmental Issues Report* – the Background Document: PB V000-00-6499).

The main components of my instructions are to investigate two aspects. The first is to describe the "*characteristics of and the manner in which, policy and decision-making processes are run and the context in which these should be seen*" for the framework in which the TWP must be evaluated. Secondly, "*the requirements, characteristics and implications for the TWP, of generally applicable environmental law principles, and specific legislation such as the Constitution, the National Water Act, NEMA and other related statutes*" or the applicable environmental law.

2. THE PURPOSE OF THE REPORT

The purpose of the Report is to provide a structure in which the series of decisions that must be made to implement the project, meet with the applicable legal requirements in a way that avoids or neutralises conflict and prevents delays in the implementation of the project or even the cancellation of the project. In this regard the choice of the words "*feasibility study*" is a useful point of departure to elaborate on the purpose of the Report.

A feasibility study is *"a study of the practicability of a proposed project*" (Concise Oxford p492). The purpose of such studies is to identify aspects that may have an effect on the viability of projects. In conducting feasibility studies, aspects can be revealed that may be so serious that they could prevent implementation of the project. An example is where a study of a site identified provisionally as a waste disposal site reveals a fatal flaw. The study may also reveal aspects not necessarily fatal to the project but that could increase the cost, delay commissioning or extend the time needed to implement the project. Early identification of such aspects in a feasibility study makes it possible to address them in a way that ensures that any adverse effects are dealt with, mitigated or avoided. This helps to ensure that if the project is continued with, its final design is capable of efficient implementation within budgetary constraints.

To a large extent feasibility studies for many years focused on the technical feasibility of projects and the affordability of the project given the final technical design. For a variety of reasons that need not be discussed now, it has become equally important to establish the environmental legal feasibility of projects. This is among others what the Supreme Court of Appeal had in mind when it found in a recent case that “together with the change in the ideological climate must also come a change in our legal and administrative approach to environmental concerns”. (*Director: Mineral Development, Gauteng Region, and another v Save the Vaal Environment and others* 1999 (2) SA 709 (SCA), the so-called Save/Sasol case, at 719D)

Environmental legal feasibility has much in common with technical feasibility. In both cases an investigation of all relevant aspects might reveal that a proposed project should be abandoned. Investigations might also reveal that the project could be implemented but should be changed or adapted to meet with appropriate requirements. It could also indicate that although the project could be implemented, given the information revealed, an alternative option should rather be implemented. In both cases failure to investigate all appropriate issues is risky. A fatal or serious flaw might in such a case be established after the project had been decided upon, contracts concluded for its implementation and costly work done. In the case of a technical flaw the reality of the technical flaw could dictate that the project be abandoned or redesigned at great cost. In the case of an environmental legal flaw, an application to a court of law could also confront the client with the reality that the project must be abandoned or must be redesigned at great cost.

3. DEFINING THE FRAMEWORK IN WHICH THE TWP MUST BE EVALUATED

The project as it stands is specifically defined as a water transfer scheme, transferring water from the Thukela River to the Vaal River System. It is legally not acceptable to consider this project in isolation. Over the past number of years a wide-ranging general environmental legal structure had been established that definitively laid down the parameters in which the TWP must fit. These parameters were further refined through the development over the years of a process of incremental decision-making, which is a cascading of consequential decisions. These decisions start off with a decision as to whether, in principle, the project should be undertaken with further decisions addressing the broad framework for implementation, the detailed implementation and then the ongoing management of the project. It is correct that the client must base its further decisions (such as the placing of a dam in the Thukela River) on existing or vested rights established on the strength of decisions taken in the past. It might however find that it has to revisit some decisions taken previously.

The two concepts of incremental decision-making and of vested rights must therefore be analysed in more detail.

4. GENERAL ENVIRONMENTAL LEGAL STRUCTURE

The discipline of environmental protection is of relatively recent origin. It is only over the last few decades that it has become generally accepted that the earth’s environmental resources should be protected. At first the focus was on the conservation or the protection of the resources. It was sought to achieve this through the prohibition of actions that could impact adversely on the environment. Legislation for this purpose is generally known as command-and-control measures. It tended to be reactive. Thus it was made a criminal offence to pollute water or the air or to allow erosion of the soil. These measures simply did not work. A department such as DWAF for example tried to protect water quality through their Uniform Effluent Standards approach. This is a typical command-and-control approach. In the document “Water Quality Management Policies and Strategies in the RSA” published in April 1991 by DWAF, the failure of uniform standards to prevent the steady decline in water quality country wide forms the justification of the change in direction of water quality control.

In order to address environmental quality effectively a new approach was necessary. The approach that was adopted can be called the management approach. This approach first emerged in South Africa in discussions during the 1980’s that resulted in the publication by the Council for the Environment of the guidelines for Integrated Environmental Management in April 1989. The management approach that were then generally applied throughout all fields of environmental control is well illustrated by the Receiving Water Quality Objectives approach reflected in the document “Water Quality Management Policies and Strategies in the RSA” referred to above. The very last thing that I need to do is to explain this concept to DWAF. The implications that it has with regard to the environmental management approach should however be highlighted.

5. THE PROCESS OF INCREMENTAL DECISION-MAKING

5.1 Broad Overview

In all modern states, governmental functions have greatly expanded with the emergence of government as an active force in guiding social and economic development. In developing economies, government assumes a much wider range and diversity of responsibilities for many different types of economic behaviour, than would be the case in a developed country. All modern governments, to a greater or lesser extent, participate directly in the economy, purchasing goods, operating industries, providing services, and promoting various economic activities. Government is one of the most important consumers of goods, and governments do use their pricing, purchasing, and contracting powers to achieve various economic, social and even political aims.

South Africa is no exception and government in this country is the major or dominant organising power in planning and directing economic and social change and advancement. The manner in which this is done is through a cycle or process of policy formulation, legislative empowerment and application or implementation. Assemblies, congresses, and other parliamentary institutions provide for public hearings on major issues of policy and require formal deliberative procedures at different stages of the legislative process.

Application and implementation of policy directives and legislation is effected through a system of public administration, which has a number of specific features. The first is that the organisation has a hierarchical, or pyramidal, character, by which a single chief executive oversees a few subordinates, who in turn oversee their chief subordinates, who are in turn responsible for overseeing other subordinates, and so on until a great structure of personnel is integrated and focussed on the components of a particular program. Secondly, there is a division of labour or specialisation within the organisation, in which each individual in the hierarchy has specialised responsibilities and tasks. Thirdly, there is usually maintenance of detailed official records and the existence of precise procedures through which the personnel of the system communicate with each other and with the public.

In the context of the Thukela Water Project (TWP), and in dealing with the issue of incremental decision-making, it is important to understand that this process is an integral and indivisible part of implementing and applying policy and legislative prescripts. The manner in which policy and legislation are shaped and formed is therefore also important, since it will influence the manner in which a project such as the TWP will be structured, the way in which it is administered and the administrative processes which are used.

5.2 Policy and Legislative Processes

Policy is a purposive course of action based on currently acceptable societal values followed in dealing with a problem or matter of concern, predicting the state of affairs which would prevail when that purpose has been achieved (Centre for Developing Enterprise, Building Policy Skills in South Africa, 1995).

It may be said that all new policy is likely to evoke some form of dissent in a democratic society. Nevertheless policy making and implementation, need not necessarily be adversarial in nature. What must be realised is that different policies, and even different pieces of legislation, which are formulated with different objectives in mind, may contradict one another. This does not then make them invalid or flawed, but it does place a big responsibility on those in positions where administrative decisions have to be made, to do so in a manner which respects the rights of others, and minimises the chances of conflict.

There are many different ways in which policy can be formulated or made. The following are perhaps the most important and it is not the intention to discuss or analyse all of them in this document:

- Institutional model
- Process model
- Group model
- Elite model
- Rational model
- Incremental model
- Game theory model
- Public choice model
- Systems model

A particular policy may also not be the product of any one of the models listed, but rather a combination of two or more. What is important in the context of the TWP, is that in this country, policy making has moved from being very much in the mould of the elitist approach, to a situation where the process model, together with factors such as public choice and incremental decision-making are now the order of the day.

The reason for this was the change of priorities and the need for and demands of reconstruction and development that emerged and became established during the decade of the nineties. The challenge for development in this country remains to find an agreed way forward, among many differing groups and agendas, with different interests and responsibilities.

The TWP is a very large and complex development project, originating from policy level decisions within the national government. These policies relate not only to strategic water supply. Other major government policies such as job creation, land reform, economic empowerment of previously disadvantaged people and elimination of discrimination and establishment of equity in natural resource utilisation, will have to be considered in assessing the consequences of the TWP as well. It is a project that will have profound effects at many different levels and in many different ways over a long period of time. Government ministries such as the Department of Water Affairs and Forestry, are mandated to carry out and implement government policy. There is a very specific onus on them to see that 'environmental considerations be accorded appropriate recognition and respect in the administrative processes in our country.' They must see to it that there is 'a change in our legal and administrative approach to environmental concerns' as stated in *Director: Mineral Development, Gauteng region, and another v Save the Vaal Environment and others* 1999 (2) SA 709 (SCA) at 719D per Olivier JA, the Save/Sasol case.

What is discussed below therefore, is an explanation of some of the more important legal and institutional considerations and requirements for the implementation of a development project, namely the TWP. It is within this framework that the officials who are involved in the decision-making processes for the TWP, will have to act. Members of the public, or interested and affected parties, should also understand what their rights are within the context of the TWP, the place which they have in the decision-making process, and the way in which they are able, or not allowed, to influence it.

5.3 The Incremental or Sequential Decision-making Approach

Most environmental decisions are taken in a structured incremental or sequential decision-making approach. This is not because there is some law that stated that an incremental decision-making approach must be followed. It is rather because the exigencies of relying on the management framework to achieve acceptable environmental outcomes, dictate a process of taking decisions incrementally. It is of course unavoidable that legislation will increasingly reflect an acceptance that this incremental process is being followed. As is for example explained on p130 to p133 of the book *Environmental Law for All*, by Duard Barnard, sections 9 and 39 of the Mineral Act, 50 of 1991 introduces an incremental decision-making process. There are also several other examples.

Of importance furthermore is the attitude reflected in the Green Paper on Development and Planning published May 1999 by the National Development and Planning Commission and the Department of Land Affairs. It states in paragraph 4.6.3 on p53 that

"*in the case of large projects, local authorities should adopt a sequential system of approvals, which enables an ongoing 'conversation' between developers and local authorities, as opposed to a simple 'yes/no' decision* *at the end of a long process. Commonly, these would have at least three stages.* 1. *Approval in principle … 2. Approval of a developmental framework* … 3. *Approval of building plans …"*

In its effect, the RWQO (receiving water quality objectives) approach enforces an incremental decision-making process. This approach presupposes that different water bodies will have different water quality requirements. The proponent of a new project that may have a severe impact on water quality will consider this reality in planning his project. If he is a prudent businessman, he will approach DWAF right at the beginning of the planning process launched by him to develop his project. He will provide DWAF with the broad outlines of his process and the proposed location of his works. At that stage DWAF might inform him that the requirements of the receiving water body in that catchment will demand particularly high compliance with certain water quality guidelines. The proponent might then find that the cost of installing machinery capable of meeting such high standards could well outweigh the costs of removing to a different catchment where the requirements of the receiving water body is substantially less onerous. In effect therefore the first decision that the proponent takes after involving all important stakeholders right from the beginning deals with the principle as to whether he should establish his project and where it should be done.

This is in effect the first stage in the incremental decision-making process. During this stage a specific set of circumstances must be considered. In the Save/Sasol action, it is for example stated (at 718G) "*at the s9 (of the Minerals Act) stage the basic issue is whether a mining license should be granted or not; at the s39 stage what is under consideration is the environmental management programme".* Obviously a different set of considerations must be considered when a decision in principle must be decided to the set of considerations that should be considered when an implementational aspect should be decided.

In the example dealing with receiving water quality standards, the next incremental decision that should be made, after a decision had been reached with regard to the place where the project should be sited, is a decision as to the broad framework of implementation. For this purpose the proponent needs to satisfy DWAF that the process that he proposes to establish, the machinery that he intends using and the design of his plant, dealing with aspects such as storm water, wastages, emergencies, etc. is such that the laid down receiving water quality standards can be met.

The next incremental stage is the detailed implementation where DWAF must be satisfied that the framework "promised" by the proponent is in effect established and that the management programme devised by the proponent and provided to and agreed to by DWAF is in fact implemented properly.

From this discussion the following can be extracted. An incremental process of decision-making had been established as a general framework for decision-making as it may affect the environment. This process works hand in hand with the ordinary management process that the business community had established over the years. The process requires that all aspects, including environmental aspects, are considered right from the beginning of the process. As is implied in the IEM literature, all role-players should be brought on board at the beginning of the planning process. The first step that should be cleared out is whether a development should be allowed in principle. For this decision a certain set of considerations needs to be considered. Once the first decision had been made, the second stage is to establish the broad framework for development and again a different set of circumstances must be considered in order to arrive at an acceptable decision in this regard. Once this decision had been made the third decision, dealing with detailed implementation needs to be made.

5.4 The Incremental Decision-making Process Relevant to the TWP

Deciding on the utilization of the South African water resources is certainly not something that could be dealt with other than at the highest national level. The cascading of decision-making with regard to water management on different management levels are well illustrated in the National Water Act. Deciding whether water should be transferred to the Vaal Catchment and, if so, how, is a decision that should probably be taken at the very highest level of decision-making, namely the Cabinet. If not at that level, then at least by the Minister of DWAF.

What is more, is that it is not now and has for many years not been the approach of DWAF to take one-off yes/no decisions. The approach was to do it in an incremental manner. In this regard the TWP Feasibility Study - Background Document and Environmental Issues Report of September 1999 sets out the incremental process that had been followed by DWAF in considering the water needs of the Vaal Catchment. Consider for example the different options investigated and mentioned in paragraph 2.2 with regard to deciding on a source of water for augmentation purposes and in paragraph 2.3 an investigation into the need for augmentation if viewed against savings in water use resulting from appropriate demand management strategies. It is on the strength of this incremental approach that the point had been reached where the feasibility study is considering the transfer of water out of the Thukela from a few sites, down from some 70 sites originally investigated.

This feasibility study however dealt only or at least mainly with technical feasibility and the attendant expenses. At no stage did the feasibility study focus specifically and in depth on the environmental legal feasibility of the project.

6. THE ENVIRONMENTAL LEGAL INCREMENTAL PROCESS AS IT AFFECTS THE TWP

In order to meet with the requirements of incremental decision-making as it affects the environmental legal component of the TWP, the following steps must be investigated:

The first step is what should the approach in principle be with regard to the transfer of water to the Vaal Catchment. Should it be done and, if so, from where should the water be obtained. This aspect closely correlates with the aspects dealt with in paragraphs 7.1.1, 7.2.1, 7.3.1 and 7.4.1 of the Background Document dealing with national policy or multi-regional level and the level of policy level assessment set out in the Background Document.

The second step deals with the broad framework for the implementation of a decided option. Once the decision had been made that water should be transferred from the Thukela Catchment to the Vaal Catchment, a decision must be arrived at with regard to a number of considerations. These could include the following: Where should the dams be, should a number of small dams or a restricted number of large dams be chosen, what approach should be followed with regard to the establishment of roads, services and residential infrastructure near the proposed dam, etc. This stage corresponds closely to the considerations mentioned in paragraphs 7.1.2, 7.2.2, 7.3.2 and 7.4.2 dealing with regional development and set out in the Background Document.

At the third stage, the detailed planning for the implementation of the project must be undertaken. It is at this stage that precise building structures, placing of dam walls, building of access roads, staff quarters, etc. is considered. This stage again closely correlates with paragraphs 7.1.3, 7.2.3, 7.3.3 and 7.4.3 dealing with site specific options set out in the Background Document.

Please do not regard this process as being controlled by rigid rules. The broad thrust of the process is given. The steps do not however necessarily follow the given sequence or chronology strictly. Furthermore, although they are different steps, they not only influence one another, but can definitively set the parameters in which the next step should taken. It is therefore inevitable that an iterative process of assessment or investigation should be used. As further mentioned above, it is not as if there is any law that makes it incumbent on DWAF to follow this incremental process. It is practical realities that dictate that such a process should be followed. Somewhere along the line a decision in principle must be reached. There is no sense in doing an enormous amount of detailed implementational research before clarity as to the advisability of the decision in principle had been reached. (It should be mentioned that we do not regard present TWP Feasibility Study as the doing of detailed work. This, in our view, is in effect still part of the process of establishing the broad framework for implementation. It is one of the final steps before detailed investigation is carried out.)

The practical problem it would seem, is that failure to properly sign off the decision in principle effectively can result in an extensive loss of time and money and wasted effort. Let us assume for a moment that if the project is considered many years later, it appears with hindsight that in considering alternative sources of water, the decision should have been to utilise icebergs. It may therefore happen that an interested or affected party can take DWAF to court for an order that the administrative decision to use the Thukela as a source of water should be set aside and should be replaced with a decision to use icebergs instead. The time and effort spent on considering the Thukela as a source of water would then have been wasted. The other problems caused by such a decision can be well imagined. An important focus must therefore be to ensure that the chances of something like that happening is minimised.

One should of course not be too prescriptive about how precisely the incremental steps should be taken. As happens in management planning in general, different options in principle are evaluated on the strength of information then available. The alternative then identified as the least expensive and most advantageous is decided upon. After subjecting this option to a more detailed analysis, it might well become apparent that certain aspects that at the first evaluation appeared to fall within acceptable parameters are now are shown to present far more formidable obstacles. This would obviously necessitate a revisiting of the decision in principle.

Environmental decision-making could be compared to making the decision to get married. Too frequently the management decision to marry is taken without properly considering the principle of whether to marry or not. The merits and demerits of the alternative marriage partners are not considered and each possible spouse is not revisited as frequently as may be necessary to establish the feasibility of the detailed implementation of a workable marriage relationship. A failure to conduct detailed investigations and research to ensure a good marriage management decision can cause the detailed implementation of the marriage project (by getting married) to be unsuccessful resulting in unpleasantness and a waste of time and money.

The TWP has not yet reached a level where the final go-ahead with all its implications has been taken.

7. VESTED RIGHTS

It is necessary to discuss the precise position or stage in the decision-making process that the TWP process has reached.

In paragraph 2.2 of the Background Document and Environmental Issues Report, four alternatives, to address the shortfall of water resources in the Vaal Catchment are mentioned. They are the reduction in the growth of the demand for water through appropriate demand management of water, the importation of water from neighbouring catchments such as the LHWP or the middle Orange River, the desalination of sea water and the mining of icebergs.

Other possibilities also exist and have from time to time been considered in strategic planning exercises, such as using tankers to ship fresh water from the mouth of the Zambezi, piping water from the Zambezi and moving agricultural activity to northern neighbouring countries.
The conclusion that was reached was that the most acceptable option was probably the importation of water from neighbouring catchments, one of which would be the Thukela Catchment, but that this needed to be looked at to a greater level of detail. (See 2.5 of the Background Document and Environmental Issues Report.) Lesotho Phase II was also a strong contender
The question that in all fairness could now be posed is whether this preference needs to be revisited. After all, it had been considered in some depth and an informed decision was made. Why reinvent the wheel?

Some background with regard to this aspect is appropriate. As a general rule, it must be accepted that once a right to do something has been vested, that right may be executed regardless of whether it could be a destructive right. With hindsight Thesen Island in the Knysna lagoon should not have been used for industrial purposes as it is now being used. A sand quarry (Eggo-Sand) should not have been permitted at the position where it is now halfway into the Magaliesberg Protected Natural Environment. The fact however is that when those activities were initiated, they complied with whatever legal requirements were applicable at that stage.

The same principle applies where the activity has not necessarily been undertaken but where the developmental rights have been vested. A developer got the right in principle to establish a residential township near the Brenton Hotel above the Knysna lagoon. The implementation of this principle right would have destroyed the habitat of the Brenton blue butterfly. That developer was completely at liberty to continue with his development even if it did result in finally destroying the last available habitat for the Brenton blue butterfly. (The decision to stop that development in effect resulted in an expropriation of rights for the public benefit and, as is usual in all expropriation cases, the value of the resource lost to the developer had to be paid to him).

Whenever any developer, whether it is a private person or the government or whether it is a large or a small project that is undertaken, the first exercise should be to establish what rights have been vested. In the incremental decision-making process, if the principle right (also called a conceptual right) had vested, the next decision that needs to be made deals with the framework for implementation. If a framework of implementation had already been decided on finally, all that needs to be considered, is the detailed implementation of the project.

Theoretically speaking therefore, if, from a legal perspective, DWAF vested the right to transfer water from the Thukela to the Vaal Catchment, they need not revisit that aspect. The right in principle to utilise the Thukela as water source would have been established regardless of the fact that it might be the wrong decision in view of later legislation or later environmental thinking. This means that if an interested and affected party were to launch an application to the High Court to interdict or prohibit the DWAF from utilising the Thukela in general, such an application could be defeated on the strength that DWAF had vested that right.

Two aspects need now be considered. The one deals with the process of the vesting of rights and the other with the broader framework in which the State should consider vested rights.

7.1 The Vesting of Rights

Rights vest when the appropriate legal requirements and formalities had been complied with.

Ownership as a right in a property owned by a person for example vests in another person if three requirements are met: There must firstly be a basis for the transfer of rights such as a Deed of Sale. Secondly, the thing (a car, house or whatever) sold must have been delivered by handing it over or, in the case of immovable property, by registration in the Deeds Office. Thirdly the purchase price must have been paid or arrangements must have been made for the payment of the purchase price.

A manner in which a property, that is not subject to any controls such as a planning or structure scheme, may be used, vests with the acquisition of property rights. Where the property is subject to a planning scheme, the right to use the property for a specific purpose is dependent on the zoning of that property. Usually when the owner of property wants to use the property for a purpose other than the zoned purpose, he must apply for a rezoning or a consent use. He must then comply with a series of formalities and comply with the other requirements laid down in the relevant legislation. Once the appropriate authority, acting in terms of its enabling legislation, formally signs the consent use or the rezoning authority, it creates a new vested right.

Some reflection will reveal many more examples of how rights to use a thing vest. In certain cases the right to use water used to vest by virtue of the acquisition of riparian land. In many other cases it vested on the strength of a permit granted for that specific purpose.

Rights can vest at every stage of the incremental decision-making process. Thus the right in principle to mine vests if a Director: Mineral Development issues a mining authorisation in terms of section 9 of the Minerals Act. A property zoned agricultural or undetermined, if rezoned light Industrial, vests a right to use that property for light industrial purposes. Any conceptual authorisation that provides guidelines as to the spatial dimension of land can result in a right vesting to use property in a specific manner. The attitude of the developers of the Pecanwood Golf Estate on the banks of the Hartbeespoort dam is that, in its negotiations with DWAF, it acquired the right to establish peninsulas in the dam itself and to be of a length and width to allow residential erven to be established on them.

Building plans, detailed environmental management programmes and detailed plans and bills of quantities for structures such as dams and roads, are examples of detailed implementational plans that vest the moment that it is formally agreed to by the relevant authority.

Where private individuals apply to government authorities for permissions, it is usually fairly easy to establish whether a formal right had been given or not. It is usually reflected in some official permit, authority or letter. At times, such as in the Pecanwood development, it might not necessarily be specifically stated, but the correspondence over the years and the actions and interactions of all stakeholders including DWAF can be analysed to determine whether or not rights had vested.

The position whether organs of the State such as DWAF had vested rights to undertake projects is frequently less easy to establish. An organ of State such as DWAF may only do what its enabling legislation allows it to do. If the enabling legislation allows or authorises the building of structures related to water management, it is implied that a certain process should be followed to establish that right of use. In some cases legislation specifically sets out a process that must be followed before a right may vest. There could for example be a requirement that a proposal should be published for comment before it may be agreed to or must meet with the approval of some or other body. Where no formalities are laid down, the very least that would be required is that it should be shown that the official entitled to make that decision had considered all aspects relevant to this decision and had exercised his discretion in a proper manner. Although it is not an absolute precondition that the decision be reflected in writing, it would be particularly dangerous to rely on a decision that is not somewhere or other reduced to writing.

In short therefore, before an organ of State can rely on a right that had vested to undertake a certain activity, an investigation will have to be done to establish the enabling legislation relevant to the decision, the steps that should be taken in order to make such a decision and an evaluation of the steps actually taken to establish whether it had been done properly.

In this regard the position of the private individual is somewhat easier than the position of a government official in proving a vested right. Where a private individual had over time in negotiations with government officials, established a reasonable administrative expectation that the right will be given to him, he would be entitled to claim that right. For example, with regard to the Pecanwood development on the Hartbeestpoort Dam, the developer can base its claim on the fact that the DWAF, the developer and other role players had been acting throughout on an acceptance that permission to put up structures such as peninsulas would be granted. It could state that the only qualification of this right was that its establishment should not impact adversely on water quality and that an appropriate volume swop should be engineered to ensure that the carrying capacity of the dam is not decreased.

It may now appear from documentation that a permission in given circumstances had in fact been granted. (This would usually be so if a formal permission should be given such as is required for a river diversion.) If it appears however that such negotiations did take place but that an official written permission had not been granted, DWAF would not be entitled to change its mind and refuse the permission. The reason is that DWAF had created a reasonable expectation on the part of the developer that such permission would be granted. On the strength of this expectation and to the knowledge of DWAF the developer expended money, developed roads and executed activities. In such a case DWAF would be precluded from denying this right to the developer.

This position does not obtain with regard to an organ of State. An organ of State cannot create a reasonable administrative expectation to itself. If it had followed the required procedures, applied its mind to the question in hand, made a decision and reflected it in paper, the right vests. If not, the right did not vest.

7.2 The Implication of Rights that have been Vested

In any developmental process the procedure should be to establish what the rights are that have been vested. Rights that have been vested become final and need not be revisited or reconsidered. The developer then can continue to apply for the rights that should be granted in the next stage of the incremental decision-making process. In 1900 a decision was made with regard to land near Fernwood, bordering on the Kirstenbosch Botanical Gardens on the slopes of Table Mountain in Cape Town. Let us accept that the application was to use agricultural land for residential purposes, that the right to use the land in principle for residential purposes had been granted properly and that the framework for the implementation of this right in principle, namely the positioning of the erven, roads, services, etc. was also agreed to. All that would still have been needed during 1900 before the detailed implementation of the conceptual rights, namely the building of houses, could commence was to acquire the approval of building plans for houses and the precise road building and other construction activities.

Let us further accept that over the past 99 years, the owner of the land never built a single property or sold a single erf. At this stage if the owner decides to sell the erven, he would be secure in both the principle and the broad implementational rights that have vested and of which it is the holder. Even if interest groups in such a case are of the opinion that the implementation of the rights would detract from Table Mountain, they have no right to prevent the building of houses. If it is serious enough they may twist the arm of Government to expropriate that land in the public interest.

On the other hand however, the owners of erven would have to apply for the approval of building plans. These building plans would have to meet with the requirements of among others the National Environmental Management Act to the extent that it applies to building activities. In terms of section 7 of the National Building Regulations and Building Standards Act, 103 of 1977, a local authority if it is satisfied that a building will be erected in a manner that is unacceptable to the extent that the area will be disfigured, that it will be unsightly or objectionable, will derogate from the value of adjoining properties or will be dangerous to life or property, can refuse to allow such a building. This section may not deprive the owner of the property of his right to build a house. It may however force him to build a house in such a way that it avoids or minimises environmental degradation as far as is reasonably possible.

Theoretically therefore, it will be necessary for DWAF to establish precisely what rights had vested with regard to water augmentation to the Vaal Catchment. If the right to obtain the water from the Thukela Catchment had been vested, permission must still be obtained to extract the water from the position set out in the feasibility study. If the right to extract the water from that position had been obtained, it is only the detailed management and implementation of the project for which authority must be obtained. In view of the listing of activities in Schedule 1, Regulation 1182 [i.e. 1(i)(j)(k)(l) and 2(c) or (e)], the process that would have to be used will be Regulation 1183. The way in which the regulation would be applied of course will be adapted depending on the rights that have been vested.

7.3 The Implementation by the State of Vested Rights

While it is legally acceptable for a private individual to continue with a project because a right to do so had vested regardless of the environmental impact that it might have, the position of the State is not so simple.

A private entity is free to pursue whatever activity it sees fit as long as it complies with the relevant legal requirements. There is for example nothing that stop citizens from organising their financial activities through the establishment of trusts, closed corporations or companies to substantially reduce the income tax that they should pay, as long as it is done within the constraints of the law. Similarly, individuals may not simply be prevented from implementing their environmental rights even if their implementation may be environmentally degrading. That would amount to selective taxation and interference with property rights. Compensation should be paid so that the burden of providing a benefit to the entire community by preventing this specific destructive activity, is paid by the entire community out of taxpayer funds. This could for example be done where the seriousness of the degradation warrants it, by the State expropriating the potentially degrading or destructive right that an individual might have to the benefit of the common good.

The actions of the State however must focus on the best interests of all its citizens. The State could and should consider the rights that it had vested at any stage in the past, whether one or a hundred years ago. A contemporary evaluation could show that the detrimental effect to the entire community of implementing a right would be bigger than refraining from implementing it. The proper course of action would then be for the State to refrain from implementing that right. In effect the situation is similar to the example given above. In both cases the entire community sacrifices something in order to gain something of more value – in one case it pays out expropriation money and in the other it abandons an asset that could have brought in money. It is realised that the concept "best interests of all" is an inexact and widely worded concept. Difficult though it might be to apply, some attempt must be made to do so. If need be, an attempt could be made later to define the test more exactly. The real danger of course, is for the State not to consider the aspect at all if it should have been considered.

In considering whether or not a right should be abandoned, the State needs to weigh up the advantages and the disadvantages of a project based on the vested right. For this purpose whatever relevant aspect can influence this weighing up process should be pursued. Certainly the value of a riverine system that will be destroyed by a dam must be considered. So too must the assets that had been established in a partly implemented project be evaluated. The factors that should be evaluated in the process all depend on the specific circumstances. In general a vast spectrum of typical environmental considerations must nowadays be evaluated that a few years ago was unknown or not applicable. The SAVE/Sasol case for example has made it incumbent that the 'sense of place' of an area due for development should be considered.

7.4 Can the State be Forced to Re-evaluate a Vested Right?

Prior to 1993, the answer to this question would have been an unequivocal no. What was said in the previous paragraph reflects the almost abstract constitutional duty that a government has to always consider whether its actions meet with the needs of the best interests of the people. This is an age-old constitutional duty. Governments however could only be called to account for their administrative decisions in a normal course of the democratic process where a five-yearly general election could theoretically confirm or set aside an administrative decision that had been made. In effect therefore governments did pretty much what they thought appropriate. They did not have to consider something they did not feel like considering.

The penalty, that of being voted out of office, is at the best of times a highly theoretical remedy. The result was that administrative decisions by organs of State could in the past never be effectively questioned on the merits. If a Prime Minister stated that he had considered the implications of the implementation of the demolition of the western facade of Church Square in Pretoria and that it is a good thing, there was no court in the world that could interfere with that decision.

This position however changed drastically with the promulgation of the interim Constitution followed by the 1996 Constitution. In terms of section 33(1) of the new Constitution "everyone has the right to administrative action that is lawful, reasonable and procedurally fair". Administrative actions always had to be lawful and always had to comply with the procedures laid down. For example, the *audi alterem partem* rule requires that an official should hear all parties that may be affected by a decision before making a decision. Decisions of our courts

indicated that these duties have become wider, more general and more pervasive. Consider also how the entire process of decision-making had changed to accommodate this paradigm change.
It did not however effect a major change. It is the inclusion of the word "*reasonable*" that did bring about a dramatic change. The mere fact that an action must be reasonable requires that it can be tested against the tenets of reasonableness. As pointed out in the book *Environmental Law for All*, our courts will have to set out precisely what should be understood by reasonableness and what the actions are that should be taken to ensure that a decision is reasonable. This does not however detract from the fact that the Constitution requires that an administrative decision must reflect that a reasoned process had been followed in order to arrive at it. What is more, is that the official that took the decision can be required to explain and justify the trend of reasoning followed. This means that he or she will have to defend the decision on the merits thereof. Previously it happened only rarely that an official had to defend the merits of the decision. Such official was entitled to say that the court should not look over its shoulder in order to evaluate whether it was a good or bad decision. As long as the official met with all the legal technical requirements, his decision stood. The inclusion into our legislation of the requirement that administrative decisions must be reasonable has established a remarkably important requirement that organs of State must comply with.

Accept hypothetically that the right to obtain water from the Thukela Catchment rather than from the sea or icebergs vested when an appropriate decision was taken in 1996. In 2002 a further decision is taken to implement the TWP. Implicit in this decision is the decision that the previous decisions that had been taken namely to transfer water to the Vaal Catchment and to obtain such water out of the Thukela Catchment is reaffirmed. This does not of course mean the taking of a conscious administrative decision regarding these two aspects. The decisions had been taken earlier in 1996 and before. It is rather a failure to revisit the 1996 decisions. It is now conceivable that an interested and affected party might approach the court for an order setting aside or suspending the decision to implement the site specific TWP pending a re-evaluation of the decision in principle. If this applicant would be able to show that the failure to revisit that decision in effect amounted to an unreasonable administrative action, the court would be bound to grant his application.

I do not know to which extent the decisions taken in the past would meet with the requirements in present legislation. I do not think it is necessary to find out. Decisions taken in the past must be measured against the requirements that existed at the time the decision was taken. The position is different however if future decisions are taken. Part of the future decision could include a re-evaluation of the validity of a previous decision. This will be recognised as a typical management approach used by managers in all spheres. In the course of an ongoing project, especially if some time had lapsed between different phases of the project, the responsible thing to do would be to revisit the previous decision just to make sure that the process has not lost its validity. (After all, a businessman that is developing a new project will be irresponsible if he does not from time to time update himself on the marketability of his product.)

8. THE NEED TO ANTICIPATE COMPLICATIONS THAT COULD ARISE FROM LEGAL ACTION BASED ON ENVIRONMENTAL LEGAL REQUIREMENTS

It is realised that a rather sombre picture has emerged from what is said above. The impression is created of a lack of any certainty with regard to future planning and that citizen action might lead to the frustration of well-considered and carefully planned projects.

This is not the case. The key to dealing with this threat is the same as the key to dealing` with threats caused by technical problems. It is the simple key of reasonableness. If any stakeholder at any stage of any process should approach a court for an order that might impact on the project, it will be required of such a stakeholder to show a want of reasonableness. Reasonableness furthermore would not require compliance with a myriad of detail and particulars. It will require a comprehensive evaluation where the full spectrum of aspects that should have been considered was in fact considered. Furthermore it is accepted that it will not be feasible and therefore reasonable to expect of an organ of State to go into more detail than is necessary to make a reasonable well-informed management decision. The protection that an organ of State therefore can build into its decision-making processes is to consider everything that should be considered AND ARE INDEED ABLE TO SHOW A PAPER TRAIL FOR IT, such as in Records of Decision and other documents. It is not enough for an official, twenty years down the line, to assume that his predecessors did their work properly. He should be provided with the documentation that enables him to show conclusively what had been done.

8.1 The Role of the Public

A party that could be adversely affected by any decision of the State have always had the right in terms of the *audi alterem partem* rule to be heard before a decision is made. This general principle however was fairly restricted in practice. A party that wished to rely on the right to be heard would have had to have a legal interest. This excluded many people that felt themselves to be affected or threatened by a project. Over the past few years with the extensive widening of the *locus standi* in our Constitution and now also in NEMA, the ranks of the number of people that may have to be heard was extended substantially. A broad change in administrative law furthermore brought about a change in the extent to which this right to be heard was interpreted. This right had been supported substantially by legislation. The first legislative enactment that firmly established this as a wide-ranging right, was the general environmental policy determined in terms of the Environment Conservation Act on 21 January 1994. Any decisions made subsequent to January 1994 should preferably show adequate public involvement. The decision in the SAVE/SASOL matter specifically instructs officials not only to broaden their approach to the involvement of the public. It also requires of them to change the paradigm in which they are thinking. Future decisions will have to be made only after the public have been involved adequately.

DWAF is therefore faced with two problems. The first problem is whether decisions taken after January 1994 involved the public adequately. The second problem is whether everything was taken into consideration that should have been taken into consideration and whether the decisions made were reasonable under the circumstances.

8.2 How to Validate or Deal with Previous Decisions

Three approaches could be considered.

8.2.1 First approach

The first approach is to analyse decisions that have been taken and the circumstances under which they were taken carefully in order to see whether they meet with the appropriate requirements. I am aware thereof that DWAF had for decades now been very sensitive to many environmental issues that were then not regarded as important at all. It is probable that an evaluation of decisions taken will reveal that by and large, DWAF did what they had to do. With regard to public involvement, it has also been the policy of DWAF to workshop and discuss ideas and concepts widely. It is a process that might perhaps not be typical of contemporary public participation exercises but I would not let that upset me. In my opinion most of the contemporary public participation exercises amount to little more than circuses that, if judged on the noise and hot air they create, go well beyond what is required of them. If considered against the value it added to the project, the performance is less impressive.

8.2.2 The second approach

The second approach is to ignore the existing decisions and to initiate an entirely new process that effectively involves the public and that starts right at the beginning where a decision needs to be made as to whether augmentation should take place at all and if so where the water should be sourced from. While this is a valid approach and might well, after the investigation of relevant aspects have to be resorted to, the approach that should be considered favourably is the third one.

8.2.3 The third approach

The third approach accepts that decisions had been made but that if good reason is shown, such decisions will be revisited. I have found that the most successful way of dealing with such a situation is to prepare a Briefing Document. This Briefing Document sets out the background to any decisions taken, the *status quo* as to decisions and the way forward. Where the developer had decided not to revisit any previous issues, that fact is stated. What is provided to the reader however is an extensive array of information that would enable every member of the public to evaluate the decision. The invitation is then also extended to such members of the public to discuss decisions with the developer and to inform such a person that if he feels that a decision does not meet with the appropriate requirements, a court action can be launched to have it set aside.

The developer, which in this case would be DWAF, could also state in the Briefing Document that the decisions that have been reached, were reached on information then available. It can then mention its preparedness to reconsider a decision that had been reached if any further information should justify such a revisiting. This provides an opportunity to any member of the public to acquaint itself with the full decision-making process that has been followed. It does not automatically throw out all the good work that has been done. It however provides an opportunity for any interested and affected party to consider the entire decision-making process that has been followed and to focus the attention of DWAF on any aspect that has not been considered. This enables DWAF then to consider this aspect, bring it into the decision-making framework and, where appropriate, change their decisions.

The main advantage of following this procedure is that it is the closest to providing a guarantee that court action will not prevent the implementation of whatever option had been decided upon. Such an action of DWAF would be eminently reasonable. A member of the public, given the opportunity of closely checking, as it were, on the decision-making process followed by DWAF, can identify gaps in the process and can then at an early stage and in the spirit of proper planning take steps to ensure that the gaps are dealt with. Where such an opportunity had been given to such a party, he will effectively be precluded from raising such issues a few years down the line.

At the same time, to the extent that an argument could be raised that a decision taken in 1996 was taken without the proper involvement of the public, the decision is now protected inasmuch as any failure to involve the public at that stage, is addressed by inviting the involvement of the public at this stage to rectify such a decision if it should be necessary. Furthermore any aspect that should have been considered and was not considered can now be identified and dealt with adequately. To the extent that new developments and new technology or new research with regard to an aspect such as HIV-AIDS, could be brought to the attention of DWAF. This could make the decision-making process less problematic and easier for DWAF. Care should however be taken to structure this process in such a way that a document can be produced that will form a conclusive answer to any court action launched at a later stage.

8.3 Preparing the Basis for Further Investigations

The files of DWAF containing the deliberations that led to the decision, the documentation reflecting the decision and the research on which it was based must be investigated. For that purpose the assistance would be needed of the officials that were specifically involved in it as well as the legal officials that assisted in that regard.

The purpose of this investigation is to establish precisely what the decisions are that had been taken and the basis thereof.

9. THE SECOND COMPONENT OF THE TERMS OF REFERENCE – THE INSTRUCTION TO ANALYSE THE LAW AND ITS APPLICATION

In the first part of the Report an attempt was made to set out the legal framework for the policy and decision-making process in which the TWP decision should be seen. This is the first component of the instructions quoted in the Introduction, paragraph 1 above.

The second component of the instructions is that the "*requirements,* *characteristics and implications for the TWP, of generally applicable environmental law principles, and specific legislation such as the Constitution, the National Water Act, NEMA and other related statutes*" should be considered. In addition, the instructions are amplified and explained in 7 further points, dealing with specific aspects.

In addressing the second part of the instructions, the purpose of this part of the Report is two-fold. It will firstly list all the specific legal requirements and will discuss them in order to clarify the aspects that should be considered.

It will secondly analyse and answer the questions posed in sections 7.2.1, 7.2.2 and 7.2.3 of the Background Document. The answers will then be discussed and where necessary explained against the background of and with reference to the detailed legal analysis.

10. THE APPLICABLE SPECIFIC LEGAL REQUIREMENTS

In this section, the relevant sections will be quoted and explained in order to convey its essential meaning.

10.1 Constitution of the Republic of South Africa Act, 108 of 1996

In addition to the sections in the Constitution that are of particular importance to the environment and to the decision-making process that the TWP will entail, there are also several sections that are of passing importance to the TWP. Thus, in Chapter 10, sections 195 to 197 the duties of DWAF regarding public administration generally, are set out. In section 195(1)(g) it is for example stated that "*transparency must be fostered by providing the public with timely, accessible and accurate information*". For the purpose of this Report however, it is only necessary to focus on the Bill of Rights contained in Chapter 2. Important sections are the following:

10.1.1 Section 24 , dealing with the environment reads as follows:

"Everyone has the right –

(a) to an environment that is not harmful to their health or well-being; and
(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –
  (i) prevent pollution and ecological degradation;
  (ii) promote conservation; and
  (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development".

Comment:
The section has two focuses. It establishes a right for the public (in s24(a)) and places a duty on the State to take certain actions (in s24(b)).

S24(b) is not clear as the extent of the duty that a State organisation such as DWAF has. The question that arises is whether DWAF can be forced to take action, and if so under what circumstances and how extensive can this action be? What is clear, is that where a department such as DWAF has in fact undertaken actions, the actions would have to meet with the requirements in s24(b). It must therefore take reasonable measures to avoid the ecological degradation, to promote conservation and to secure the sustainable development of a sensitive area in which a dam is built. This does not mean that no dam may be built. It certainly means that failure to consider this aspect in some depth would not be reasonable. Reasonable action, on the principle or policy level, could include the revisiting of options such as desalinisation. Reasonable action on the regional level, where the broad framework for implementation is considered, could include confirming the extraction of water out of the Thukela River but revisiting the decision to build the main dam in it. On revisiting the decision it could *hypothetically and by way of an example* be shown that major ecological degradation could be avoided by building a large storage dam in a less sensitive nearby valley. Studies may show that it will cause substantially less degradation. The water can then be transferred out of a weir in the Thukela to the storage dam. The instructions in s24(b)(ii) and (iii) will have the same effect of forcing DWAF to consider these actions properly.

10.1.2 Section 25 deals with property. The relevant part reads:

(1) No one may be deprived of property except in terms of law of general application, and no law may permit arbitrary depravation of property. …

(4) For the purposes of this section - …
(b) property is not limited to land".

Comment:
The depravation of property can also take place by 'taking' or removing those components of the property that adds value to it. Thus the taking of water or even slightly more indirectly, the removal of a certain level of flow in a river such as the Thukela might result in the devaluation of properties that relied on that quantity of water or that based its activities (such as recreational activities) on a certain level of water. (Note that factors such as the level of water in a river does not necessarily vest rights – it will depend on the circumstances.) A law of general application, as is also specifically mentioned in s25(2), deals with expropriation. It is a factor that should be investigated and that could add to the cost of establishing a structure such as a dam that could impact on such values.

10.1.3 Section 33 deals with just administrative action. The relevant part reads as follows:

"(1) Everyone has the right to administrative action that is lawful, reasonable and procedurally fair."

Comment:
The key word here is "*reasonable*". Action always had to be lawful and procedurally fair. It is correct that our courts have given a wider meaning to this requirement. Thus, in the case of *Van Huysteen and others NNO v Minister of Environmental Affairs and Tourism and others*, 1996(1) SA 283 (C) at 284E it is stated that these words *"must be generously interpreted and the austerity of*

tabulated legalism must be avoided". The test for how wide the discretion of officials in administrative action is, is also mentioned in the SAVE/Sasol case. It is wider than it used to be.

The inclusion of the word "*reasonable*", as discussed above adds a completely new dimension. An official can now be called upon to explain to a court why, on the merits of the matter, the decision was taken or a certain course of action was undertaken. His action must therefore demonstrably meet with the requirements of reason. This is the main reason why attention is consistently focused on the need to act reasonably. The aspects in this regard, regarding for example the revisiting of certain decisions made, are discussed in some detail above.

10.1.4 Section 38 deals with the reinforcement of rights:

It is not necessary to quote out of this section. It in effect gives *locus standi* to so many people that even a meddling outsider can launch an application to interdict building activities.

10.1.5 Section 39 deals with the interpretation of the Bill of Rights. The relevant part of the section reads as follows:

When interpreting the Bill of Rights, a court, tribunal or forum –

(b) must consider international law; and
(c) may consider foreign law.

Comment:
In terms of this section it is accepted that in the interaction between South Africa and the rest of the world, a closer identification of interests between different countries is inevitable. The march of globalisation also makes it inevitable that our legal principles should be interpreted where possible to accord with international interpretations.

A study was prepared by Turton A.R. and Meissner R., *Thukela Water Project Feasibility Study: Strategic Impact Assessment of the Hydropolitical Aspects*. In paragraphs 3.5, 3.11 and 3.12, reference is made to *"the activity within the international water sector*" (3.11.1). Such references should not merely be seen as being of interest or as factors that for strategic purposes should be borne in mind. Section 39 requires of DWAF to consider it. It is correct that activities such as the formulation of a World Water Vision may not yet be part of international or foreign law. Knowing the thrust of the development of the process of law however, it is inevitable that some of these deliberations will in time (and probably sooner than later) find its way into the legal structures of other countries. It will be prudent therefore to act pro-actively in considering these developmental thrusts.

10.2 Development Facilitation Act, 67 of 1995

The act is quoted as its "*General principles for land development"* contained in section 3 is important. The other more detailed planning-related aspects will play a less important role in this Report but will of course be important where the detailed planning of the project is addressed.

It is important to study the entire section 3. It will convey the thinking and mindset of the legislator when dealing with development. In addition to some of the sections that I will quote, there are for example sections dealing with the promotion of the combination of compatible land uses (1)(c)(v), the active participation of IAP's (1)(d), the development of the skills and capacities of disadvantaged persons (1)(e), and several others. A reading of section 3 will illustrate how the "*change in the ideological climate*" (referred to in the Save/Sasol case) has taken place and what its shape is.

10.2.1 Section 3(1)(j) reads as follows:

"(j) Each proposed land development area should be judged on its own merits and no particular use of land, such as residential, commercial, conservational, industrial, community facility, mining, agricultural or public use, should in advance or in general be regarded as being less important or desirable than any other use of land".

Comment:
In essence this section requires of developers, such as DWAF, to consider the merits of the proposed project. The merits of providing water and providing it out of the Thukela is fairly obvious. It cannot be regarded in isolation however. It must be considered in contrast to the demerits of using this source and the merits of using another source or the merits of extracting the water in another manner. It is only then that the value of the resource, the Thukela River, can be adequately judged.

10.2.2 Section 3(1)(h) reads as follows:

"(h) Policy, administrative practice and laws should promote sustainable land development …"

Comment:
This subsection has five subsub-sections that refer for example to the promotion of the establishment of viable communities, the sustained protection of the environment, etc. It spells out the need for sustainability in development with all the implications that it has. It therefore supports and strengthens the sections in the National Water Act and NEMA that requires that development should be sustainable. Sustainable development will be discussed in more detail below.

10.3 National Water Act, 36 of 1998

10.3.1 Section 2 sets out the purpose of the act. The relevant parts read as follows:

"2. The purpose of this Act is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors –

(a) meeting the basic human needs of present and future generations; …
(d) promoting the efficient, sustainable and beneficial use of water in the public interest;
(e) facilitating social and economic development;

(f) providing for growing demand for water use;
(g) protecting aquatic and associated ecosystems and their biological diversity; …
(i) meeting international obligations;"

Comment:
The section does not only provide the broad enabling framework for water management. It also focuses on some specific aspects. Questions regarding the TWP that must be answered to meet the requirements of the section are the following:

Will water extraction out of the Thukela impact on water needs of future generations of people using water from the Thukela?

Can it be shown to a court at a later stage that DWAF had taken adequate steps to ensure responsible water saving practices in the Vaal Catchment, given the requirement in (d)?

Is it an acceptable way of providing for a future growing demand for water by shifting it from one part of the country to another or should other resources be looked at?

It must be realised that a requirement such as in (i) does not mean that reports of international water organisations referred to by Turton & Meissner in §3.11, should be slavishly followed. Neither should a requirement such as (g) mean that no dams may be built.

What is important is that each of these aspects must be considered carefully, a reasoned decision on the merits regarding the aspects be reached and a paper trail for the decisions shown.

10.3.2 Sections 5, 6 and 7 deal with the establishment of a National Water Resource Strategy (NWR Strategy). (Also see section 22.) Relevant parts of these sections read as follows:

"5. (1) … the Minister must, as soon as reasonably practicable, by notice in the Gazette, establish a national water resource strategy. …
(3) The water resources of the Republic must be protected, used, developed, conserved, managed and controlled in accordance with the national water resource strategy.

6. (1) The national water resource strategy must, …
(a) set out the strategies, objectives, plans, guidelines and procedures of the Minister and institutional arrangements relating to the protection, use, development, conservation, management and control of water resources within the framework of existing relevant government policy …
(b) provide for at least –
(i) the requirements of the Reserve and identify, where appropriate, water resources from which particular requirements must be met; …
(iii) actions to be taken to meet projected future water needs; and
(iv) water use of strategic importance; …"

22. (5) A responsible authority may, subject to section 17, authorise the use of water before –

(a) a national water resource strategy has been established;

(b) a catchment management strategy in respect of the water resource in question has been established;

(c) a classification system for water resources has been established;

(d) the class and resource quality objectives for the water resource in question have been determined; or

(e) the Reserve for the water resource in question has been finally determined.

The definition of water use in section 21 includes activities incidental to a TWP decision such as the taking of water from a water resource, the storing of water or the altering of the bed, banks, course or characteristics of a water course.

Comment:
The sections are particularly important. As also appears from what had been stated above, the general thrust of all environmental legislation increasingly focuses on the establishment of general environmental management systems. Piecemeal control over environmental resources is not acceptable any more.

The focus on a properly staged or phased management system is clearly apparent in the sections. They accept that our water resources will have to be managed in accordance with a properly planned strategy. Similar requirements in the Development Facilitation Act were referred to in passing above and will also be dealt with in an analysis of NEMA below. It forms part and parcel therefore of an overarching general structured approach.

It states, as does much other legislation, that any use of our water resources must take place within the constraints of a management strategy. The legislator regarded this as urgent. The timeframe for the establishment of this strategy is fairly tight. It must be established as soon as reasonably practicable. It is not required for government to do a national strategy immediately. In terms of section 5(4)(a), it “may be established in a phased and progressive manner and in separate components over time …”. Some idea of the timeframe that the legislator had in mind however is the requirement in section 5(4)(b) that it must be reviewed within five years. It can therefore be expected that at least the important parts of the programme must be in place in a period less than five years.

It is also required in section 5(5) that the public should be involved in the development of the strategy. Dealing with water resources in the Thukela is a major water management focus in this country. The strategy specifically requires in section 6(1)(g) that provision should be made “for inter-catchment water transfers between surplus water management areas and deficit water management areas …”. There are other pointers in section 6(1) that equally underline the particular importance that DWAF as a matter of urgency addresses the management of the water in the Thukela River.

The question that must now be answered is whether a decision should be made by DWAF to continue with the TWP before such a national strategy regarding the Thukela had been established.

Section 22(5) clearly authorises such a decision. The question therefore is not whether it is legally possible or not. The question is rather whether reliance should in this case be placed on this authorisation. In other words, given the particular circumstances in this case, would it be a reasonable administrative action to make a decision regarding the continuation of the TWP in the absence of a NWR Strategy?

Generally speaking, one cannot delay decisions simply because some or other scheme or policy had not been put in place. This is the most effective way of subjecting a process to innovative procrastination thereby making sure that no decision is ever made. Decisions must be made on the information available or such further information generated or gathered that is necessary for the making of the specific decision that serves before the decision-maker.

In general therefore, it must be accepted that implementational decisions must be made by DWAF regardless of whether a NWR Strategy had been put in place and regardless of whether a reserve had been established or not. I do not therefore regard it to be essential that a formal NWR Strategy is in place before a decision can be made with regard to the use of the water in the Thukela Catchment.

My problem lies with a different question altogether. It deals with the information that should be generated to support a decision on the use of the Thukela Catchment regardless of the requirement for the establishment of a strategic study.

In preparing an NWR Strategy, wide-ranging research will have to be done and a strategy developed in a carefully structured process. The questions posed in section 6 will have to be answered and the structure of the process will have to comply with the requirements in the Act. In contrast, in order to prepare the ground for the making of a focused decision regarding the TWP, a certain minimum “quantity” of information is required to ensure that the decision is acceptable, valid, informed and credible. Is the information required for the TWP and for an NWR Strategy not virtually identical?

In my opinion the answer is ‘yes’. The answer is ‘yes’ not because a NWR Strategy must be prepared. It is ‘yes’ for another reason, namely that it is required by the thrust of management directed decision-making and the general legal framework in which the TWP decision should be placed. The legal framework is reflected in the trend of the National Water Act in general and sections 5, 6, 7 in particular. This is however only the tip of the iceberg. It is also required in other sections of the National Water Act and in other legislation that has precisely the same thrust.

In summary therefore, it is in my view not necessary to get the NWR Strategy in place. A similar exercise of information collection and policy determination however must be undertaken. Such action is required by a broad legislative thrust that establishes a certain definitive approach to such important decisions. Failure to act within the spirit of the thrust, would not amount to reasonable administrative action.

It is of particular importance to realise that the investigation that should be undertaken under this heading must have a *national* focus. It correlates therefore with the focus in paragraph 7.1.1 and 7.2.1 in the Background Document.

10.3.3 Sections 8, 9, 10 and 11 deal with the establishment of catchment management strategies (CM strategies). Relevant parts of the sections read as follows:

"8. (1) A catchment management agency contemplated in Chapter 7 must, … establish a catchment management strategy for the protection, use, development, conservation, management and control of water resources within its water management area."

Comment:
Where the NWR Strategy sets out a national strategy, the CM strategy focuses on the establishment of a strategy on a regional/local level. It is not important now to consider how large such a catchment may be. A fairly wide discretion is granted in establishing a water management area (defined in section 1(1)(xxv)). It can be accepted that the Thukela Catchment may be one water management area or could fall into more than one such an area. The requirement is that a catchment management agency (CM agency) must establish the CM strategy. A CM agency must therefore be established in accordance with the requirements in sections 77 to 80 of the Act before a strategy could be established. (This is of course subject to the authorisation in section 72 that vests the powers and duties of CM agencies in the Minister if a CM agency had not yet been established. The pertinent question would again be whether it would be reasonable under the circumstances to rely on this authority.)

The comments made in 10.3.2 above are applicable here. If the attitude is taken that the formal requirements in the Act must be in place before a decision regarding the TWP may be taken, it means that it is not only that a NWR Strategy must be established. A final demarcation of the water management area affected by the decision must also be in place. A CM agency must be established after the time-consuming procedure set out in section 78 is followed. Only then can the equally time-consuming process laid down in section 8 be followed to establish a CM strategy. If one accepts that a NWR Strategy must be established before a decision regarding the TWP can be reached, one must also accept the need for the establishment of first an NW agency and subsequently an NW strategy. This time-consuming procedure underlines the unworkability of such an approach.

On the other hand, it reinforces the need to consider a TWP decision strategically. Again the legislator makes it clear that the correct point of departure for an administrative decision such as for the TWP is that a carefully structured process should be followed. On considering section 9, dealing with the contents of a CM strategy, the same carefully planned well-managed approach is apparent. The way in which the regional planning should slot into the national planning is specifically indicated in section 9(b) that states that it may not be in conflict with the NWR Strategy.

In summary therefore, it is in my view not necessary to get the CM agency or the CM strategy in place before deciding on the TWP. A very similar exercise however must be undertaken in continuance of the process referred to in 10.3.2 above. Note here that, as in 10.3.2 above, the focus will be on a carefully structured process that addresses a wide variety of technical issues and that in the process involves the public in an effective interactive manner.

The main difference between both this exercise and the generation of a CM strategy is the same as the difference between the suggested exercise in 10.3.2 on the one hand and the generation of a NWR Strategy. This is that the focus is different and the questions that will have to be answered will be different. Among others, it will be far more specific in order to answer a well-defined specific question. The procedure followed will be different and the research required will be different in that it will probably be narrower, restricted and more focused. The answers must be provided in a much shorter timeframe. (The work done in this regard would obviously be of value if and when an NWR Strategy or CM strategy is established).

It is of importance to realise that the investigation that should be undertaken under this heading must have a *regional* focus. It correlates therefore with the focus in paragraph 7.1.2 and 7.2.2 of the Background Document.

10.3.4 Sections 12, 13, 14 and 15 deal with the classification of the nation's water resources as a basis for its protection. The relevant part of section 12 reads as follows:

12. (1) As soon as is reasonably practicable, the Minister must prescribe a system for classifying water resources.

Comment:
The management focus in this section, to establish clear goals relating to the quality of the relevant water resources, is obvious. The comments made in 10.3.2 and 10.3.3. above regarding the time-consuming nature of establishing detailed implementational steps are certainly appropriate here as well. That the detailed implementational focus of this section should however form part of the research and planning for the TWP, is equally obvious. This is less of a novelty in the sense that the DWAF has been applying these sort of guidelines also with respect to environmental impacts for many years.

It is to be noted that this investigation will have a *site specific* focus and will therefore correlate with the focus in paragraph 7.1.3 and 7.2.3 in the Background Document where it will form one part of the total investigation that would have to be undertaken at this level.

10.3.5 Sections 16, 17 and 18 deal with the Reserve. The relevant part of these sections reads as follows:

"16. (1) As soon as reasonably practicable after the class of all or part of a water resource has been determined, the Minister must, … determine the Reserve for all or part of that water resource……

17.(1) Until a system for classifying water resources has been prescribed or a class of a water resources has been determined, the Minister –
(a) may, for all or part of a water resource; and
(b) must, before authorising the use of water under section 22(5), make a preliminary determination of the Reserve."

The definition of the word "Reserve" is in section 1(1)(xviii) and need not be quoted here.

Comment:
Logically speaking, the determination of the Reserve if it were to be done strictly in accordance with the Act, would require that a classification system for water resources in accordance with section 12 must first be in place. Again the argument holds good that a decision regarding the TWP may not be delayed until such structures are formally in place.

Again however a substantial amount of research will have to be done to provide answers to the questions that the determination of a Reserve will in any case require. There are again two focuses. The one is the focus where the Reserve must be established. The other focus is what the quantity of water is that the TWP may extract. To meet with the requirements of the first focus, the Reserve must definitively lay down the minimum quantity of water necessary to sustain basic human and ecosystem needs. To meet with the requirements of the second focus, it will not be necessary to determine the Reserve. All that will be required is an answer to the question whether the water extracted from the Thukela will dip into the Reserve or not. The investigation must be based on the quantity of water that will be extracted.

It can be accepted that a TWP decision may not prejudice the quantity of water in a Reserve. In other words, the TWP may not be agreed to until it is clear that after the water had been extracted, there will still be enough water to make up the Reserve.

The requirements in the Act regarding a Reserve are of crucial importance. They establish a basic and non-negotiable quantity of water that must be made available. As a logical possibility, it must be accepted that a TWP decision could remove some of the water necessary for the Reserve in the Thukela and transfer it to the Vaal Catchment. It is to avoid such an eventuality that an investigation will first have to be done to establish that a TWP decision will not prejudice the establishment and maintenance of a Reserve for the Thukela.

This does not of course require the establishment of the precise Reserve for the Thukela. It needs a broader and a less demanding exercise. Using broad parameters, the “worst case scenario” with regard to a Reserve could be established.

If the TWP will extract less water than the generous assessment of the maximum potential level for a Reserve, the process of planning the detailed implementation of the project could continue. If the study shows that the planned water extraction in accordance with the TWP decision will reduce the generous ‘provisional’ determination of what the Reserve could be, further detailed research would be necessary. Research would continue until it is clear that the extraction water will not reduce the Reserve, as it will be finally determined. If in the end the Reserve is still shown to be bigger than the quantity of water that could be extracted to make the TWP project viable, the TWP will have to be cancelled.

The authorisation given in section 17 to make a preliminary determination of the Reserve, is at once the authority to determine a figure that can ensure that the later establishment of a formal Reserve is not prejudiced and also an indication that the legislator would require under such circumstances that consideration be given to the needs of the Reserve, thereby ensuring that the full Reserve is not prejudiced. Thus a determination of a very crude approximation of the worst case scenario of the Reserve could be described as a preliminary determination of the Reserve of the Thukela River for the purposes of validating an extraction of water from the Thukela River for TWP purposes.

10.3.5 Sections dealing with the impact on the Thukela , a river of major importance

The restrictions or guidelines in the Act regarding impacts on an important river must be investigated. The Act does not contain any specific or dedicated chapter or section dealing with river management or protection in the way that pollution prevention is dealt with in, section 19 or the placing strategy for water use charges in Chapter 5. Measures relating to the protection and management of rivers are found throughout the Act. Some attention should be given to it. The relevant parts of the sections that should be considered in this regard are as follows:

Section 19 deals with pollution prevention.

Section 20 deals with the control of emergency incidents.

"26. (1) Subject to sub-section (4), the Minister may make regulations - …
(g) regulating or prohibiting any activity in order to protect a water resource or instream or riparian habitat; …

(4) When making regulations, the Minister must take into account all relevant considerations, including the need to – …
(b) conserve and protect water resources or, instream and riparian habitat;

27. (1) In issuing a general authorisation or licence, a responsible authority must take into account all relevant factors, including - …
(c) efficient and beneficial use of water in the public interest;

This random selection of the more typically environmental sections, is quoted to illustrate how the detailed use of water which to a large extent would apply to site specific aspects referred to in 7.1.3 and 7.2.3 in the Background Document, joins up with the national and regional perspectives dealt with above. In addition to any other focus that the Act may have, a healthy respect for the value and functions of water courses is shown. The importance to protect the integrity of any water resource such as the Thukela River, forms a recurring theme throughout. It does not mean that intervention into a water resource is of course prohibited. Where necessary dams must be built, water courses channelised or water courses used in whatever manner is indicated. It does mean that care must be taken to investigate the impacts of such actions closely before such actions are undertaken.

It would be necessary and in any case wise to establish some value of the water course that could be adversely affected by a TWP decision. As will be seen below, it must be done in any case in terms of other legislation. The focal point here however, is slightly different. Investigations were done into the need for water in the Vaal Catchment area. Several other issues had also become focal points. This scope of investigations would be incomplete if it does not include a focus on the value of the Thukela River and its related components such as ecosystems, sponges, geological structures and all those other aspects that finally determine the value of a river purely as a river. This investigation must be given the prominence that it deserves and must take its place as one of the several considerations that form the basis of the decisions that must be taken with regard to the TWP matter.

10.3.6 Chapter 11 , including sections 109 to 116 deals with government waterworks. The relevant sections read as follows:

"*109. The Minister may acquire, construct, alter, repair, operate or control government waterworks in order to protect, use, develop, conserve, manage and control the nation's water resources in the public interest."*

110. (1) Before constructing a waterwork, the Minister must –

(a) prepare an environmental impact assessment relating to the proposed waterwork which must, where the Minister considers it appropriate, comply with the requirements contained in regulations made under section 26 of the Environment Conservation Act, 1989 (Act No. 73 of 1989);"

Comment:

Subject to what is said at the end of this paragraph, the sections specifically import a procedure of another Act into the decision-making process of the National Water Act. It does not appear as if this section specifically places the duty on DWAF to investigate the principle of whether a waterworks should be established or not. It accepts that such a decision in principle had already been obtained. In contrast to for example section 2 dealing with the purpose of the Act and Chapter 2 dealing with water management strategies, this section does not focus on the national or policy level of decision-making. It does place certain duties on DWAF with regard to more typical regional-level issues.

If the last part of section 109, starting with the words "in order to protect" had been left out, the requirements of section 110 and others would have been restricted to ensuring that the actual construction of a dam, or the site specific detailed implementation of a dam building decision, must be preceded by an environmental impact assessment. By including the second part of section 109, a wider duty is implied. The need to protect or conserve the nation's water resources implies that a decision for the construction of waterworks can only be taken after several sites and several approaches had been considered.

This interpretation ties up with the specific instructions and also the general thrust contained in NEMA. It also rounds off the series of measures listed and discussed in 10.3.6 above. It would not be adequate therefore, if the Jana or Mielietuin Dams are decided upon unless and until the acceptability of the site itself had been tested against guidelines that include the protection and conservation of water resources.

The importation of the procedure of another Act, the Environment Conservation Act (ECA), into this Act gives rise to an unexpected complication. Before any construction activities in pursuance of a TWP decision is commenced, an R1183 process would have to be executed if regard is had to the Environment Conservation Act, 73 of 1989. (See an explanation of the law relating to the ECA and Regulation 1183 in 10.5.2 below.) Section 110 of the Act however, has a requirement that on a cursory reading looks similar but is in conflict. In accordance with section 110 of the Act, the use of the ECA and therefore of R1183 is only required "where the Minister considers it appropriate".

What is clear is that an environmental impact assessment must be prepared regardless of whether the procedure in R1183 is used or not. (In order to meet with the different environmental legal requirements, the procedure would in any case resemble the R1183 process closely.) The crucial importance of section 110 is something different. It determines who makes the final decision. If R1183 is used, the final decision-making authority in terms of R1183 is the Minister of Environmental Affairs and Tourism. If the Minister of Water Affairs and Forestry however considers it appropriate not to use R1183, the effect of his decision is also that he or she will take the final decision as to whether the environmental impact assessment was properly done and whether and how the project can continue.

In my view it would not be wise for the Minister of Water Affairs and Forestry to sit in judgement upon an application where he or she is also the applicant. It would be much wiser to leave this decision-making function to DEAT. The chances of subjectively influencing the decision are substantially diminished. More importantly, the perception of the public could be that the Minister of Water Affairs and Forestry wants to bulldoze the proposal through and for that reason is not prepared to subject the application to evaluation by the DEAT. Such perceptions can be very potent and where a potentially inflammable situation must be dealt with, care should be taken to avoid such a potential for problems.

10.4 Water Services Act, 108 of 1997

This Act only has a limited impact on this development. The purpose of the Act deals with basic water supply and sanitation. It therefore deals with what should happen to water that is available rather than how to make water available. Even so some reference should be made to some parts of the Act.

10.4.1 Section 2 lists the main objects of the Act. The relevant part of the section reads as follows:

"2. The main objects of this Act are to provide for –
(a) the right of access to basic water supply and the right to basic sanitation necessary to secure sufficient water and an environment not harmful to human health or well-being; … the promotion of effective water resource management and conservation."

10.4.2 Section 3 deals with the right to water. The relevant part of the section reads as follows:

"3 (1) Everyone has a right of access to basic water supply and basic sanitation."

Comment:
The sections are largely self-explanatory. Regardless of any other factor, the basis of water management is to provide everyone with basic water and sanitation regardless of whether they stay in the Thukela Catchment or in the

Vaal Catchment. This right is similarly coupled with the duty to ensure the type of environment that is protected in the new Constitution.

10.5 Environment Conservation Act, 73 of 1989 (ECA)

The ECA is overarching legislation. It addresses several typical environmental management issues such as environmental policy, nature conservation, pollution control, environmental management and others.

The legislative programme of the Department of Environmental Affairs and Tourism (DEAT) is to prepare sectoral legislation for each field and as it is promulgated, to repeal the sections in the ECA that deal with the subject. NEMA contains the principle and the environmental management component of environmental governance. The corresponding sections in ECA were repealed.

It is necessary to consider the ECA for three reasons. Firstly it contains the legislation dating back a few years which at that stage was binding on DWAF among others and against which actions of DWAF could be tested. Secondly, due to the effect of some transitional sections in NEMA, several repealed section in ECA must still be applied and will be applied for several years to come. Thirdly, some of the sectors in ECA for which sectoral legislation had not yet been passed are still binding.

10.5.1 Sections 2 and 3 deal with policy. The relevant part of the sections read as follows:

“2 Determination of policy

(1) … the Minister may … determine the general policy … to be applied with a view to –
(a) the protection of ecological processes, natural systems and the natural beauty as well as the preservation of biotic diversity in the natural environment;
(b) the promotion of sustainable utilization of species and ecosystems …;
(c) the protection of the environment against … deterioration …”

“3 Compliance with policy

(1) Each Minister, competent authority, local authority and government institution upon which any power has been conferred or to which any duty which may have an influence on the environment has been assigned by or under any law, shall exercise such power and perform such duty in accordance with the policy referred to in section 2.”

Notice 51 of 1994 of 21/01/1994 determined the general policy in terms of section 2 of the ECA.

Comment:
The main purpose of discussing the sections in some depth is to illustrate how long good environmental governance has been required in our law. This is to neutralise the tendency to regard 5.9.1997, the date on which R1182 and R1183 was promulgated, as the starting point for legally enforceable environmental

governance.

On reading section 2 the impression is gained that it would only become effective once a policy had been determined. This is not the position. As it stood, it defined the framework within which environmentally-related decisions had to be considered. In the case of *Corium (Pty) Ltd. and others v Myburgh Park Langebaan (Pty) Ltd. and others* 1995 (3) SA 51(C), the court had to consider the granting or refusal of a permit that would impact on a protected natural environment governed by section 16 of the ECA. In this regard the court found at 65I that the Administrator

"*had to take into account the policies, purposes and the true intent of the 1989 Act which established the status of the ground with which it was proposed to interfere. … the expressed purpose of the Act is the preservation of ecological processes and natural systems and natural beauty, indigenous wildlife and biotic diversity … I think it is necessary to add … that the 1989 Act goes further than s(16)(1)(a) (dealing with a PNE) in regard to what its intentions are. Part 1 of the Act, s2, provides for the drawing up of a general policy for environmental conservation … Such a policy has not been … published. But it seems to me highly relevant in attempting to ascertain the purposes of the legislation to observe that, in providing for such a policy to be drawn up, s2 says that the policy shall be drawn up and applied with a view to four considerations which are spelt out in s2(1)(a), (b), (c) and (d) of the Act."*

From 1989 therefore, the broad framework in which projects such as the TWP had to be considered, was contained in the policy section of the ECA.

On 21/01/1994 the general policy was formally determined in accordance with section 2 of the ECA. It became binding secondary legislation on publication. That was confirmed in the case of *Van Huyssteen and others NNO vs. Minister of Environmental Affairs and Tourism and others* 1996 (1) SA 283 (C). In that case the court had to consider whether the general policy had to be considered if a rezoning decision in terms of the Cape Land Use Planning Ordinance were applied for. At 303D the court said

"The direct link between a rezoning application under the Ordinance and Act 73 of 1989, is to be found in s3 of Act 73 of 1989, … which clearly obliges second and third respondents to exercise the powers conferred by the Ordinance … in accordance with the policy determined under s2 of the Act."

From January 1994 therefore, it was also the duty of DWAF to apply the contents of the general policy. The implication of course is that if any decision were taken by DWAF since 1994, they would have to be able to show that they complied with the policy. Failure to show compliance can entitle the court to set aside that decision.

The general policy is wide-ranging. The premises and principles in it include the duty to act as a trustee of the natural environment in the interest of succeeding generations. All activities that may have an influence on the environment must be considered and steps taken to protect, maintain and improve it. The protection of ecological processes, species, habitats and land forms is regarded as essential for the survival of life on earth. Sustainable development is accepted as a guiding principle for environmental management. In more detail regarding land-use, it is stated that

"Judicious use of land is an important foundation of environmental management. All government institutions … must therefore plan all physical activities … in such a way as to minimise the harmful impact on the environment … Before embarking on any large-scale or high-impact development project, a planned analysis must be undertaken in which all interested and affected parties must be involved. … particular efforts must be made … to protect water resources … Among the main attractions South Africa has to offer as a tourist destination, are its aesthetic qualities and the scenic beauty of the environment …"

With regard to nature conservation it is among others, stated that the

"maintenance of the ecological integrity and natural attractiveness of protected areas must be persued as a primary objective. All responsible government institutions must apply appropriate measures, based on sound scientific knowledge, to ensure the protection of designated ecologically sensitive and unique areas …"

Regarding the urban environment it is stated that a holistic environmental approach will form an integral part of all facets of urban planning and development. It is not clear what is meant by urban. The impression is gained that new developments that have an urban character, even if it is in rural areas, would qualify. In effect a holistic evaluation of a project will consider the ripple effect or the knock-on effect of an action. In the Corium case, referred to above, this principle was accepted as being part of our law. The case stated at 67A that

"it is clear … that the ripple effect of the ecological destruction of the piece of ground with which we are now concerned, will adversely affect the ecological of the adjoining areas …"

The principles and approaches that make a careful evaluation and assessment of a project such as the TWP essential, had therefore formed the fabric of our law for a considerable period. The transitional arrangement in NEMA repealed sections 2 and 3 but confirmed that any action executed in terms of these actions remain legal. The repeal of section 3 therefore, removed the legal binding nature of the general policy. The fact that it had been determined however, retains it. The general policy must therefore be regarded as a guideline document.

As will be seen below, the principles in the ECA and the general policy had been restated in even more depth in NEMA.

10.5.2 Sections 21, 22 and 26 deal with the management system in the ECA. The relevant parts of the sections read as follows:

"21 (1) The Minister may … identify those activities which in his opinion may have a substantial detrimental effect on the environment, whether in general or in respect of certain areas." ….

"22 (1) No person shall undertake an activity identified in terms of section 21(1) … except by virtue of a written authorization issued by the Minister …

(2) The authorization referred to in subsection (1) shall only be issued

after consideration of reports concerning the impact of the proposed activity and of alternative proposed activities on the environment, which shall be compiled and submitted by such persons and in such manner as may be prescribed."

"26 The Minister … may make regulations with regard to any activity identified in terms of section 21(1) … -
(a) the scope and content of environmental impact reports …"

Government Notice R1182 dated 05 September 1997 identifies a number of activities in Schedule 1 including

"1. The construction or upgrading of - …
(i) canals and channels, including diversions of the normal flow of water in a riverbed and water transfer schemes between water catchments and impoundments;
(j) dams, levees or weirs affecting the flow of a river;
(k) reservoirs for public water supply;
(l) schemes for the abstraction or utilization of ground or surface water for bulk supply purposes;"

Government Notice R1183 also dated 05 September 1997 established the scope and content of environmental impact reports and how the environmental impact assessment process should be executed as required in sections 26 and 28 of the ECA.

Comment:
If regard were had to the wording of the ECA and the regulations promulgated in terms of the ECA, it would be incumbent on DWAF to apply R1183. If paragraph 10.3.7 above is considered, it appears that the National Water Act amended the position to some extent. As set out above, when it comes to the *construction* of a waterwork, the Minister of Water Affairs and Forestry may decide against applying R1183. To the extent that a decision must be made with regard to one earlier step in the incremental decision-making process, namely deciding on the principle of whether water should be transferred out of the Thukela or not, it seems as if the Minister is bound to use the R1183 process.

The environmental management system contained in NEMA builds on the system in ECA. NEMA also makes provision for the identification of activities such as in section 21 of the ECA and also makes provision for the preparation of a procedure similar to R1183. Authority is given to the national government and each of the provinces to do so.

The transitional arrangement is that the ECA system remains in place until a new impact assessment procedure had been finalised for a province or the central government and activities identified. Only then does the ECA system cease to operate with regard to that province or the central government that established their own process. For the foreseeable future the ECA structure will therefore remain in force.

10.6 National Environmental Management Act, 107 of 1998

The Act came into operation on 29 January 1999. It contains numerous sections that definitively lay down basic principles that must be complied with whenever any developmental activity is undertaken. It is advisable that the appropriate principles are quoted fairly extensively:

10.6.1 Principles binding on many role players:

"2.(1) The principles set out in this section apply throughout the Republic to the actions of all organs of state that may significantly affect the environment and –

(a) shall apply alongside all other appropriate and relevant considerations …

(c) serve as guidelines by reference to which any organ of state must exercise any function when taking any decision in terms of this Act or any statutory provision concerning the protection of the environment; …

(e) guide the interpretation, administration and implementation of this Act, and any other law concerned with the protection or management of the environment."

Comment:
The principles in NEMA are therefore binding on DWAF as well.

10.6.2 Sustainable Development :

"*2.(3) Development must be socially, environmentally and economically sustainable.*

(4) (a) Sustainable development requires the consideration of all relevant factors including the following: … " (And then a long list of activities are given, some of which are quoted below.)

Comment:
The need to ensure sustainability in development is frequently not taken seriously in the implementation of a project. It frequently gives rise to an almost knee-jerk reaction where, for a solemn moment, everybody agrees that the development should be sustainable and then goes on doing what they had always been doing in this regard.

This is not acceptable. The essence of sustainability in development is that the resources created in the process of a development should be at least equal to or more than the resources destroyed in that developmental process. This requires an investigation and subsequent quantification of the value of existing resources that will be destroyed. The second step is an investigation and quantification of what comes in its place. If the value of the new development falls short of the target figure of the value of the existing resources, the project must be revisited until an adequate value is ensured failing which the project must be abandoned.

Ensuring sustainability could require either that the adverse impact is reduced or the beneficial impact is increased. Thus a dam positioned where it causes extensive environmental degradation might be moved to a position where it is more expensive to build and maintain it but where the environmental destruction that it causes is substantially less. Alternatively, the mitigatory actions can be increased to such an extent their value equals the substantial value lost in the developmental process.

It would be wise to undertake this exercise, to do the quantification and to validate it in a public participation exercise in order to avoid being attacked on non-compliance with one of the most crucial environmental principles.

10.6.3 "Strong" and "Weak" Sustainability :

"2.(4)(a)(i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;"

Comment:
In environmental literature the concepts of "strong" and "weak" sustainability are used. Where natural environmental resources with a certain value are destroyed and are replaced with man-made resources with a similar value, the total capital of the earth is maintained and the requirements of sustainability are therefore met. As natural resources are destroyed however, it is called weak sustainability.

Development could also be structured in a way that retains all or as much as possible of the natural resources. Thus the use of 10 000 hectares of pristine wilderness area can be done by choosing a small section that had been degraded or that does not have a substantial natural value as the lodge and the high-impact area. The ecologically important area can then be retained and protected by ensuring that it can be seen by hikers, used by researchers, exploited for its bio-diversity but is nowhere degraded through use. This would be strong sustainability.

The planning process should therefore investigate this aspect specifically. An example already used is not to put the dam in an ecological sensitive part of the Thukela but in an ecologically less sensitive part or even in a catchment bordering on the Thukela with a transfer of water out of a relatively low weir to the major dam in the neighbouring catchment.

10.6.4 Visual, recreational or 'sense of place' degradation :

"2.(4)(a)(iii) that the disturbance of landscapes and sites that constitute the nation's cultural heritage is avoided or where it cannot be altogether avoided, is minimised and remedied;"

Comment:
This section joins with other similar sections. It need not be explained.

10.6.5 The Precautionary Principle :

"2.(4)(a)(vii) that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions;"

Comment:
This section introduces the precautionary principle. Care should be taken not to apply this principle incorrectly.

It does not mean that all risk must be avoided. It is therefore not a negative requirement. It in effect requires that any impacts be properly assessed until clarity is obtained as to its possible impact and that decisions are taken on adequate information. The section in effect sends the developer back to the drawing board if it hasn't got enough information to answer questions properly. The level of information required is the information necessary to satisfy a decision-maker on a balance of probabilities.

10.6.6 Requiring proper advanced planning :

"*2.(4)(a)(viii) that negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied."*

Comment:
The requirement that a project be properly investigated before it is undertaken is stated and restated so many times and in so many places that it becomes very repetitive. Every time however, it reinforces the need that a developer must do his homework properly.

"2.(4)(b) Environmental management must be integrated, acknowledging that all elements of the environment are linked and interrelated, and it must take into account the effects of decisions on all aspects of the environment and all people in the environment by pursuing the selection of the best practicable environmental option.

1.(1)(iii) 'best practicable environmental option' means the option that provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term;"

Comment:
In these two sections the principle of holistic evaluation is firmly introduced. Note in particular that the total benefit of a project and the total damage caused by the project must be considered. This ties up with the concept of sustainability in development and in effect requires the same treatment. In particular a quantification must be done of the typical environmental impacts. An alternative cannot be accepted as the cheapest until the social or environmental costs of all the alternatives had not been factored in.

Note too that holistic evaluation does not mean evaluating the project as a whole but rather the "ripple effect" or "knock-on effect" of a development and the way it affects the whole.

10.6.7 The internalisation of externalities :

"2.(4)(a)(ii) that pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied;"

"2.(4)(i) The social, economic and environmental impacts of activities,

including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment."

"2.(4)(p) The costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment."

Comment:
These three sub-sections introduce the concept of the internalisation of externalities. For every development the potential and possible impacts must be established and planning be adapted until such time as the adverse impacts are avoided or minimised.

In essence the principle is similar to the principle of equal taxation. It is not fair to subject a community to substantial adverse economic and other impacts without compensating them for it in order to provide other communities with improved services or with benefits.

In general, the internalisation should be done rather by improving planning to avoid externalities than by paying compensation as the former better meets with the requirements of sustainability.

10.6.8 Impacts on sensitive areas:

"2.(4)(r) Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure."

Comment:
Although not specifically stated in this section, it is submitted that a river such as the Thukela is included in this category, and should therefore be given the level of specific attention required in the section.

10.6.9 Sections 23 and 24 deal with the process of integrated environmental management:

Virtually every subsection in these sections (they cover about 2½ pages) should strictly speaking be quoted in view of the importance that it has to this project. For better accessibility it will however be discussed generally.

Section 23 contains the general objectives of this chapter. One of these objectives, in 23(2)(b) is to "*identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage, the risks and consequences and alternatives and options for mitigation of activities, with a view to minimising negative impacts, maximising benefits and promoting compliance with the principles of environmental management set out in section 2."*

Section 24 contains the process of implementation. In this section the continuation of the management system in sections 21, 22 and 26 of the ECA is contained in s24(2)(a), (b), (c).

In section 24(7) "*procedures for the investigation, assessment and communication of the potential impact of activities must, as a minimum, ensure the following …"* Several aspects are then listed. The need to investigate all aspects already mentioned frequently, is stated yet again, cumulative effects of different impacts must be considered, and several aspects are mentioned that should be incorporated in the planning process.

In its effect, these two sections repeat many of the instructions and introduce a few new ones that have a direct bearing on the management process. In essence however, this section merely gives details of the actions that should be followed in order to comply with the general principles set out in section 2.

10.7 Other Legislation

The most important legislation that affects this project was listed and discussed above. It may conceivably be that in the course of the project, further legislation might become relevant. In this regard, the Mountain Catchment Areas Act, 63 of 1970, and the Conservation of Agricultural Resources Act, 43 of 1983, are examples of legislation that, depending on specific circumstances existing at that stage, might be applicable.

If this should happen, the influence of this legislation will probably be limited. There are also certain common law rules such as the law of nuisance that could become important. Here as well the importance of the rules at this stage is not such that it warrants detailed investigation.

11. AN INVESTIGATION AND EVALUATION OF KEY ISSUES THAT HAD BEEN IDENTIFIED

11.1 Key Issues at National Policy or Multi-Regional Level

Each of the issues identified will be dealt with separately.

11.1.1 The effects on the receiving economic, social and bio-physical environments of the Vaal River resulting from a supply of water:

Several questions must be answered in this regard. One question is whether the transfer of water is really necessary. The one focus in this question is whether the more effective conservation of water would not adequately meet the need that a water augmentation programme seeks to address. It is fairly standard in environmental management that the "no-go" option should be evaluated and that studies in this regard should be made available. To the extent that this work had been done, the studies must be made available and used in the public participation process to demonstrate that this aspect had indeed been attended to.

Another question that should be addressed deals with whether it is economically advisable or necessary to augment water supplies. Research would normally be necessary in this regard in order to compare the marginal value of the water transferred in the broader economic perspective in order to compare it with the marginal value of that water in the Thukela Catchment.

I understood that several economic studies had been done. Evaluations have been made that indicate that water augmentation is essential. These studies must be made available, they must then be studied and incorporated in the basis documents that should be collected in a document such as the "Briefing Document" that I suggest.

It is necessary to look critically at these studies however. In the introduction to the article "*Climate: Making Sense and Making Money*", by Amory B Lovins and L. Hunter Lovins from the Rocky Mountain Institute 1997 at p1 with regard to another environmental good, the following warning is sounded:

"Samuelson, like so many business people, believes climate protection is costly because the best-known economic computer models say it is. Few people realize, however, that those models find carbon abatement to be costly because that is what they assume*. This assumption masquerading as a fact, has been so widely repeated as the input and hence the output of supposedly authoritative models that it is often deemed infallible."*

Care should be taken that the above quotation is not applicable to water transfer. The phrase "climate protection is costly" could be replaced with the phrase "water augmentation is essential" and the remainder of the paragraph amended accordingly. In this regard the following aspects should be looked at:

What were the assumptions on which the studies were based?

What were the terms of reference for these studies?

Were studies where water is the critical growth factor, used? In this regard an economic model can be skewed if it assumes a need for water in the Vaal Catchment where the industry could easily settle anywhere else where water is available.

Were the bottleneck effect of other growth factors such as the availability of other resources been considered? It is misleading to project a water need for an industry in the Vaal Catchment if that industry cannot be established in the Vaal because other critical resources are not available.

What should also be brought into the equation is the adverse impacts, to the extent that there are any, of such transfer of water.

11.1.2 The legal and administrative framework within which decisions had been made:

What the framework should be like is set out in detail above. It is now necessary to do a critical appraisal of the framework that had been used up to now. To the extent that this framework does not meet with the relevant requirements, corrective action should be taken. For this purpose the third approach in 8.2.3 above could be considered.

11.1.3. The consequences of a political backlash resulting from the export of water out of KwaZulu Natal to the Vaal River supply area:

This aspect had been fully dealt with in the study of Turton A.R. & Meissner R. "*Thukela Water Project Feasibility Study: Strategic Impact Assessment of the Hydro-political Aspects".* The study highlights the political sensitivity of this issue. To the extent that political realities need to be considered, this Report accepts that it will probably be dealt with at Cabinet level. The interface between this Report and a political decision lies in the ability of the political decision-makers to convince their constituencies that they acted in a politically responsible way by making a decision with technical, legal and administrative components.

This will be determined by the technical, legal and administrative correctness with which the matter is addressed.

More within the terms of reference of this study, is the manifestation of a political backlash should it arise, and how the long term sustainability of the project can be affected. Any political backlash that deals with votes, as said above does not fall within the scope of this Report. A political backlash that is translated into action taken on legal grounds against the project must certainly be anticipated in this Report. What could happen if a political backlash should arise and parties for whatever good, bad or indifferent reason in KwaZulu-Natal should decide to oppose it, it will have to do so on legal grounds. That will have to be an application to court to interdict the implementation of the procedure. This can be done regardless of whether the opponents of the project represent the full will of the body politic in KwaZulu-Natal or whether it represents only a marginal number of extremists. The result could be that the timing of a court action could be carefully and strategically design to cause maximum havoc. This could be after all contracts had been signed but before any work has been done regarding the actual building and construction processes. This can seriously embarrass the Government, can cause delays, can add a substantial amount to the costs of the project and can jeopardise the entire project.

I do not think that it will have any impact on sustainability. Once it had been decided that the project goes on and full legal sanction is given for the project, problems are not expected with regard to its management. If it is decided to cancel the project or if the effect of a court decision is to close it down, there is no project to sustain. The avenue that is therefore suggested is, starting now, to take steps throughout the process that pre-empts any future court action. It might even result in a court action brought by affected parties at a stage when it will not embarrass Government to the extent that it otherwise might do. This is preferable to a later court action. If the Government succeeds, then it opens the door for effective implementation. If the court action is against the Government, clear instructions have been received to then consider alternative approaches.

11.1.4. The legal protection of rivers :

Rivers are not specifically protected in South African law. In a way it is similar to the protection of soil against pollution (in contrast to the protection of soil against erosion, overgrazing etc). There is very little legislation that protects the soil against pollution. There is however a substantial body of legislation that protects water quality and that inevitably has the effect of protecting the soil against pollution. The protection given to water quality, ecosystems, biological diversity, aquatic life, the fact that a Reserve must be established and other requirements all contribute to the protection of rivers. This is not a satisfactory state of affairs as it reduces the management efficiency with which river protection is addressed.

The main source of protection for rivers is to be found in generally applicable legislation. Thus the principles contained in section 2 of the National Environmental Management Act, 107 of 1998, though general in nature effectively protects rivers as well. It is important to realise about a river and its immediate surroundings, that it probably has a higher level of biological diversity than land further away. A river has so many faces to it that it inevitably tends to increase the bio-diversity. There is the bio-diversity in the water itself; in the in-between zone between the water and the land; in wetlands that are frequently associated with rivers. The different temperatures, different angles of the slopes going to the river and different fronts of these slopes tend to encourage a bigger range of bio-diversity. The fact of a slope facing either north, east, west or south are only one factor that affects bio-diversity. Usually the soils near rivers are deeper and more fertile where the natural erosion resulted in such deposition of soil at convenient positions.

The requirement that a development should comply with the requirement of sustainable development (section 2(4)(a)(i) of NEMA that deals with bio-diversity) lists a large number of factors where rivers are concerned that requires investigation. Added to this are the possible archeological, cultural, recreational, residential, agricultural and other benefits that rivers frequently have. For obvious reasons people over the ages preferred to settle near or next to rivers, to build their houses, to bury their dead and others. It is not surprising that there frequently are very emotional and highly voluble outcries whenever a valley area needs to be evacuated in order to establish a dam. It is usually because much that has value to people and that in the broader perspective might have value, could be lost in the process.

The establishment of a dam invariably has environmental impacts downstream. In some cases these impacts could be managed. In other cases it cannot. There is for example an increasingly large body of research that shows that the Aswan Dam has so affected the land downstream from the dam, that much more was lost than had been gained through the dam.

It is required in NEMA in for example section 23(2)(c) and section 24(1) that activities such as the establishment of a water transfer scheme which requires authorisation by law "and which may significantly affect the environment must be considered, investigated and assessed prior to their implementation …" In deciding about whether these impacts would have a major adverse effect or not, NEMA further requires in section 2(4)(a)(vii) that "a risk-averse and cautious approach" should be applied. This section introduces the precautionary principle, which is discussed in paragraph 10.6.1 above. The implication is that if a court case is brought 10 years down the line and DWAF cannot show that it had at the appropriate stage of the project considered these aspects, general environmental protection of rivers could be used against it.

There are also several sections in the National Water Act, 36 of 1998 that has the effect of protecting rivers. The determination of the Reserve of course is a major protection for rivers. A Reserve has the intention of ensuring that the quantity and quality of water must be established to ensure that it satisfies basic human needs but more importantly in this case, to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. (Section (1)(xviii)). In principle a dam will destroy many aquatic ecosystems. The question can well be asked whether a dam that cannot secure the ecological sustainability of the Thukela River may be built. At the very least it is essential to consider the ecological sustainability of the entire area that could be affected by a dam in preparation for establishing the Reserve. If a reserve had not been determined, the exercise will have to be done in order ensure that the later determination of an adequate reserve is not prejudiced. In the process "the social, economic and environmental impacts of activities, including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment". (NEMA section 2(4)(i)).

Obviously the apparent contradiction between the duty contained in the National Water Act to make water available by for example promoting the equitable access to water on the one hand and protecting the aquatic ecosystems on the other hand, must be resolved. The exercise necessary for this purpose must compare the values of maintaining the aquatic ecosystem and providing water. This will among others be determined by how critical either of these two needs are. Conceivably if water can be obtained from the sea after desalination, a strong argument could be made out that the initially more expensive exercise of using desalinated sea water, in effect is the better option if the total value of the ecosystems are considered and if the need for strong sustainability (sustainability that does not rely on the replacement of natural with man-made resources but on maintaining natural resources) are met with.

In principle no river merits special protection.

It is the total of the components that decide the extent of the protection that should be afforded to a given river. In this regard the Thukela River probably merits more protection than most because it probably has more ecological or other value that could be destroyed. Thus a process of using the water from the Thukela River by pumping it out of a low weir into a less sensitive and less valuable adjoining valley where a huge dam can be erected, could theoretically be an approach that addresses this issue.

11.1.5. Building large dams in the present international climate:

The international climate with regard to the building of large dams is discussed in the Hydropolitical study of Turton & Meissner. The international attitude is such that it should be regarded with respect. The problem facing DWAF in this regard, is that it is always dangerous to take decisions and undertake projects that does not meet with the attitudes and guidelines that the general international community then uses. It has many impacts. This includes the wealth of information that could be obtained internationally and that could be used in a court case to show that South African is out of line. Again it becomes necessary to investigate this specific issue specifically and conduct further planning within its parameters.

The main danger is not so much the failure to meet with what is acceptable internationally. Where appropriate, where carefully considered and where local conditions justify a departure from international norms, such a departure would be acceptable. The danger is not investigating the issue.

11.1.6. The determination of the Reserve in the Vaal and Thukela Catchments:

As discussed in paragraph 10.3.5 above, the determination of the Reserve has the purpose of protecting the quantity and quality of water necessary for humans and for ecosystems. It is a minimum requirement. It is conceivable that aquatic ecosystems in the Vaal Catchment can be adversely affected if large quantities of water continuously flow along a certain river. It is not seen that it will have other major impacts. As the Reserve has the purpose of establishing a minimum quantity of water that must be allowed to remain in the river and water transfer into the Vaal will not reduce that minimum but will make more water available to maintain it, it should not be a problem. Some investigation should therefore be done to establish to which extent the aquatic ecosystems could be adversely affected by such a transfer of water.

The position with regard to the Thukela River is substantially different, as was said above. Two aspects should be considered in this regard. The one is the destruction of aquatic ecosystems through a dam, through the water impounded behind the dam and through a change in the downstream impact of water. (In this regard it should also be pointed out that the holistic impact of a dam should be considered as well. It should show that the knock-on effect and the impact that the dam would have on the interactions between all the different environmental components downstream, produces an acceptable result).

The other problem is one of water quantity. If a Reserve has not yet been established, it is not possible to know what quantity is necessary to also ensure protection of aquatic ecosystems. Deciding on a volume of water that could be extracted without investigating this issue in depth might prejudice a later decision regarding what a reserve should be. It is therefore necessary to conduct a study to be able to show, not necessarily what the Reserve is, but to prove that the water that will be extracted will not prejudice the Reserve or will not extract more water than would be required by the Reserve at a later stage. There is a difference between reaching a conclusion that on a worst case scenario, a certain quantity of water would be required, thereby enabling the making of a decision for the extraction of a quantity of water that will be more than the relatively large worst case scenario, and determining the final Reserve which is a more precise figure and which would be less than the worst case scenario.

11.1.7. The impact of HIV/AIDS over the next few decades:

This is of course a vital aspect. It is generally accepted that AIDS will have some effect on the population. The effect could be major. Again the question is not so much what the effect will be as the necessity to investigate the issue adequately. If confronted in a court case by the allegation that the DWAF had not proved that the structures it intends building will be necessary at all, the Court can take the attitude that DWAF had not done its homework properly and sends it back to do so. A body of research into AIDS, its spread, its mortality figures, addressing it and many others are widely available and had been done extensively. It does not appear therefore that it would be a major task to establish this. Some figures however must be made available. In this regard it is pointed out that the staged approach with regard to the establishment of water transfer structures would be advisable. The projection of mortality because of AIDS for example over the next 5 years could be substantially more reliable than the projection of between 5 to 10 years from now. To do planning therefore to meet with the next 5 years in such a way that the 5 to 10 year programme can be toned down conveniently if AIDS figures were to show a sharp reduction in the need for water, then the chances of a court interfering with the programme would be substantially reduced.

11.1.8. The status of decisions of DWAF already made:

This aspect is dealt with in some detail above. As is pointed out, some revisiting of decisions made and perhaps even some "retrofitting" of decisions could be indicated. The approach that could be considered for this purpose is set out in paragraph 8.2.3 above.

11.1.9. The implications of non-augmentation for the economy of the country:

This is an aspect that was dealt with in some detail in 11.1.1 above. Particular care should in this regard be taken to consider the mobility of business. Policies in the past dealing with the decentralisation of industry simply did not work. That was mainly because it was approached on the wrong basis and for the wrong reasons. Natural growth in industry is a different matter. It might therefore be that industries that considered establishing themselves in the catchment of the Vaal River, might decide against it if the cost involved is prohibitive. The cost could well for certain industries revolve around water. The cost can also be influenced by the cost of purifying water. The pattern of development in the Vaal Catchment is strongly in the direction of Zero Effluent Discharge Facilities. This is because the probabilities are that the receiving water body, the Vaal River is critical with regard to the contaminants in it already and on the other hand in view of the cost of transporting water, the cost of the water itself will increase sharply. Where an industry relies heavily on water it might just decide that it is cheaper to establish itself near Newcastle or Estcourt or Ladysmith because it makes financial sense.

In such a case the economic feasibility study should be careful to distinguish between development that because of water shortage will not be established at all and development that because of water shortage in the Vaal River will be established in the Thukela Catchment. Another aspect of importance in this study is to establish whether the free availability of water in the Vaal Catchment does not have the potential of skewing development. The availability of water among others sends out an economic signal. This signal is that development should be undertaken in the Vaal Catchment as there is adequate water available. The question now is whether other infrastructural aspects are adequate and in place to meet such an increase in development. Are there appropriate places for residential purposes, for recreational purposes for the people working there, are there enough roads, can waste be disposed of adequately, is the feeder area for this development area able to cope etc.

11.1.10. General financial/economic issues :

This is not noted as a key issue but in my opinion it should form part thereof. In essence development must be shown to be justified. It must therefore show that, seen over the long term, it will bring more benefits than detrimental effects. For this reason an extensive quantification exercise would be essential. It is preferable that it be shown that a particularly large variety of aspects had been considered and had been properly quantified in order to make an informed and a justified decision.

In this regard, it is of course possible for DWAF to produce the research itself and to rely on it. This however could be a risky approach to the matter. It might for example happen that side-line critics, 10 years down the line, can poke holes in this evaluation. This is especially easy if reliance is placed on that most exact of all signs, namely hindsight. A substantial measure of protection can be built in if crucial aspects are brought into a debating forum thereby giving everybody an opportunity of dealing with it specifically. I would however not recommend the general shotgun approach with regard to public involvement.

For example, I am aware thereof that desalination is widely touted as a solution. I would not recommend that this aspect be dealt with by way of an in-house study done by DWAF. I would certainly also not recommend that it be thrown open to the general public as a wide debate. I would rather recommend that carefully planned workshops be organised. For this purpose all possible role players that could make an informed and scientific contribution to this process should be involved. For this purpose the relevant international figures in this field should be invited. It should not be a public affair to begin with. It should also structured with the recognition that people that could play a major role in such a process would not be prepared to make public any information that could lose them their competitive edge. The approach therefore would rather be to have a slightly more general workshop that collects the appropriate information to the extent that it is possible to do so and that establishes directions of development.

Where the possibility is shown that the cost of desalination can be brought down and a broad indication is given as to the timeframe in which it can happen, the matter can be taken forward in two ways. The first would be to prepare a type of ‘strawdog’ or discussion document that could be made available for information purposes and that can be generally distributed in order to enable all other role players who might have a suggestion in this regard to join in the debate. Another approach is to structure the workshop in a way that will make it possible for people that have a technical solution but did not want to expound it at the workshop, to meet privately with DWAF officials subsequently in order to provide detail in more depth. The information document can then be updated from time to time and can be used as proof at a given stage, if that is the position, that desalination is not acceptable. If technology changes favourably, it could be used as a justification to introduce it when appropriate.

The approach with regard to the example used, desalinisation, could equally be used for other focal points and at different levels. Having the information available however, is not enough. If such information is inaccessible, it results in informational illiteracy. The public will react to it as if it doesn’t exist. Care should therefore be taken to ensure that with regard to such crucial issues, a constantly updated summarised report is available.

Regarding the smooth implementation of any system, it is in my view important to have such a document available to negative any accusation that DWAF did not consider this aspect properly.

11.2 The Impact of Issues at a Regional Level:

In evaluating the issues on the regional level, care must be taken to distinguish between the approach that should be followed in addressing issues at the national level and addressing issues at the regional level. The decision to be made at the national level is in effect the first step in the incremental decision-making process discussed in 5.3 and 5.4 above. The aspects that should be considered and the principles against which the actions should be considered, deal with deciding whether or not water should be transferred out of the Thukela Catchment.

Once this decision in principle had been decided, the next step is to decide on the broad framework for the implementation of this decision. Different principles govern this second step in the process and the information that should be generated would then obviously also be different. Research at the first stage would mainly consider the advisability or not of such a project at all. The decision to approve the project in principle would usually be subjected to certain broadly framed conditions to indicate how implementation should broadly be done. Once this decision had been made, the position changes. It, during the second phase, requires an evaluation of the issues on regional level to establish how the project could be implemented within the constraints of the condition and in a manner that avoids or limits and makes good the adverse impacts of the project. To the extent that research is available in this regard, it can obviously be used subject thereto that it be made available to the public in the public participation exercise. It appears however that further research should be done to address aspects that had not yet been addressed.

11.2.1. The impact on the construction, commissioning, operation and decommissioning of the project on a variety of factors.

In this regard several general studies would have been done for the first phase of the decision-making process. It is accepted that there are probably a substantial number of reports available that deal with a variety of processes in the catchment and with the natural functioning of the Thukela. A variety of aspects could conceivably have been considered in this regard. The aspects so discussed should be mentioned, the studies undertaken discussed, the potential impacts identified and analysed.

Human activity equally forms one of several fields of detailed study that would have been done.

The question of bio-diversity considerations would also have been dealt with for the purposes of making a decision with regard to the first stage of the decision-making process in order to establish whether any development would meet with the requirements of sustainability. To a large extent this would require a level of information that will enable informed decisions to be made with regard to different broad alternatives of the positioning of such a project.

At the second stage of the decision-making process the broad framework for the implementation of the decision in principle to allow the transfer of water out of the broad Thukela Catchment must be established. The studies leading to the first decision would broadly have shown that the threat to bio-diversity could be overcome and that the natural functioning of a river such as the Thukela could be addressed adequately. The management decision that needs to be made now, is how the adverse impacts that would inevitably accompany such a process could be minimised most effectively by positioning the project correctly. The essence of the studies done for this purpose therefore would have to meet with the requirements of comparing and deciding between different options, using an appropriately wide matrix.

From the above it would appear that what is of particular importance at this stage is the positioning and the deployment of the project.

I accept that for the purpose of deciding on the positioning, any practical management tool could be used. I stand to be corrected but I seem to remember that a certain Mr Leopold (not Aldo Leopold) devised such a comparative system for the USA. This relied on giving appropriate values to a wide range of aspects, thereby allowing the comparisons of apples with apples rather of apples with pears. Other management tools, such as establishing the financially quantified totals of the environmental impacts of the different options and choosing the least expensive could also be used.

11.2.2 The impacts of a dam in the Thukela downstream :

Again this issue would have been dealt with in some detail in the first stage of the process. The threats and dangers inherit in such a dam for downstream users would have been spelled out in the first stage already and the decision would have been made that the impacts could be dealt with. At the second stage it now becomes necessary to set out in more detail the mitigation of any adverse impacts and the different ways in which mitigation can be ensured. In the discussion of the applicable legislation, the need to deal with this aspect thoroughly and comprehensively is set out.

11.2.3 The impact on the freshwater requirements of the estuary and wildlife:

This fits in with the question in 11.2.2. Inasmuch as an acceptance of the fact that the mere building of a dam would require regulation of water flow and others, it appears that what would have to be undertaken is the evaluation of different regulatory structures and procedures and its appropriate modelling beforehand in order to ensure that the best regulatory process is implemented.

11.2.4 The impact of the support infrastructure of the project :

This is essentially an aspect that needs to be addressed in socio-economic studies. The basis for the study would also have been established in stage 1 where the broad impact both beneficial and adverse, of this aspect of the project would have been evaluated and factorised into the final decision. Again the investigation for the second stage should focus on exploiting the most advantageous use of the infrastructure. Where the dam is a destination only, expensive roads built to it could have an add-on value that is restricted to only the recreational use and maintenance function of the dam with perhaps a few farmers benefiting from better tar roads. On the other hand if the dam for typical construction purposes provides a major, previously disadvantaged or isolated community with an upgraded road system of which 80% is tarred, a substantially larger add-on value can be established.

11.2.5 The effect of the export of water on the economic development of KwaZulu-Natal:

This aspect is largely addressed in paragraph 11.1, at the national policy decision-making level. It should specifically address issues such as the possibility that an increase in water to the Vaal Catchment will entice potential development to the Vaal Catchment rather than encourage them to settle in KwaZulu-Natal.

11.2.6 The economic effect of the construction of dams and roads :

This also forms part of the broad economic study. As such it forms a basis for the development of a further aspect. This is to add economic capacity and other benefits to the area. For this purpose the development could be structured in a way that uses the skills that are available and that introduces skills training and other similar factors in order to maximise any economic benefits that the building of such an undertaking will cause.

11.2.7 The impact on crime levels :

This requires a different study to be done.

11.2.8 Forward and backward linkages :

This aspect only comes into play once the decision has been made in principle that a certain development should be taken. Again the position is that effective backward and forward linkages do not happen automatically. They must be built in. Backward linkages require a certain basis before it can be effectively deployed. Whether this basis can be established or whether it is there, is part of the research that should be done. The same applies to forward linkages. This is an aspect that in the broad implementation of a project can a play a major role and can also play a definitive role in deciding on the precise placing of the scheme itself.

11.2.9 The impact on the movement of people :

This too is a factor that only comes into play after a decision in principle had been made. Research in the second stage is essential in order to establish the proper placing of the development. There is little point in establishing a project in such a way that it can only be effectively utilised by communities that must undertake a large scale migration to the project before the benefits of the project can accrue. Such a project, whether it is one large project or whether it is a series of smaller projects, could be established at a place or at places where there are already people available that could benefit from such a development. In the process care could be taken to maintain the integrity of communities and to develop it rather than to detract from it. In this regard, for example, a major problem in many developments is the effect that a labour force coming from major cities could have on a number of local interactions. In this regard the studies for Saldanha could be evaluated. They deal with the training and empowerment of local people to benefit from a project and the structures put in place to avoid the migration of unwanted elements to Saldanha. (Apparently bus loads of work seekers arriving at Saldanha were simply turned back, as the employment structure gave preference to local people in a carefully structured manner.) Usually the number of employment opportunities that such a project can create are restricted and appropriate practices can be used to ensure that it goes to the locals.

In the process attention could and should also be focused on the requirements of national security by which is meant the security and stability created through improved local governance, improved responsibility in land-use, and a better ability to make the best use of available opportunities. While this research can only be done in detail once the decision in principle had been reached that water can be transferred out of the Thukela Catchment, it forms part of the placing of the project and part of the framework for its implementation. In the process of deciding on the siting of the project, the community or communities that will be targeted must first be identified. In the third stage, the precise manner in which the communities will be involved will be developed in an interactive process with the local communities.

11.2.10 The impact on the Land Reform Programme :

The comments with regard to (9) above is equally applicable here.

11.2.11 Practices in the upper catchment that will negatively impact on the long term sustainability of the scheme:

There is not information available to answer this question. It might be necessary to do some research in this regard. The one aspect of course, as also discussed in the Turton & Meissner study, is the effect that a hostile population might have on the project. Inasmuch as this issue would mainly be resolved at the national and policy level, it is not expected that this can cause a major problem on this level. More important perhaps, is to look at the positive side by structuring the project in such a way that the long term sustainability is important for the people. In this regard the correct planning from the beginning, getting people to take ownership of the project and planning it in a way that meets with their approval such as by doing the siting with sensitivity can contribute to the process.

11.2.12 The loss of habitat and bio-diversity caused by the project:

This too is an aspect that should make a major contribution to deciding whether water transfer out of the Thukela Catchment should be allowed at all.

If that had been decided in the positive, it forms one of the important items on the checklist to establish the most advantageous position for the proposed dams.

11.2.13 Public disease and HIV/AIDS aspects associated with the scheme:

This will probably have a fairly minor impact during the second stage. It will form part of the broad process of planning the implementation of such a scheme. Avoiding aspects that could cause disease and planning for the establishment of clinics to deal with disease when it takes place would form part thereof.

11.2.14 The impact on carrying capacity :

This too, to a certain extent, influences the decision in principle but having done so, the precise positioning of the project will also rely on this aspect.

11.2.15 The use and availability of environmental indicators :

In this regard a substantial body of work had been done with regard to how environmental indicators can be used. Locally available research in this regard for example includes the publication Walmsley RD and Pretorius JR (1996) State of the Environment Series Report No 1: Environmental Indicators DEAT Pretoria. This aspect would rather be introduced at the third stage of the process (the site specific detailed implementation programme) for use during the fourth stage (the ongoing management of the project) to ensure that the targets set for the project are adequately met.

In keeping with the management focus in environmental legislation generally, it is legally necessary that the project implementation and detailed management into the future, be insured. The EMP that will be drawn up must contain adequate measures for this purpose.

11.2.16 The impact of the TWP on natural resource utilisation :

This too is an aspect shortly addressed at the first principle stage that requires a substantial amount of processing during the second stage. It can also play a definitive role in the siting of the project. Appropriate research should be structured for this purpose.

11.2.17 Implications for eco-tourism in the upper Thukela Catchment:

This aspect which is in many ways similar to the aspect dealt with in 11.2.16 above, is also of major importance and the establishing of the precise position where implementation should take place must take specific cognisance of this aspect.

11.2.18 Legal and administrative factors at regional level :

Again the broad principles applicable to environmental law will have to be applied in a fairly supple manner to ensure compliance. It will be realised that at this stage the broad framework for implementation is being finalised. This too requires of the developer to consider a number of aspects. To some extent the holistic impact should be considered. The cumulative impact, the need to consider alternatives, the need to internalise externalities, must all be applied at this stage. For this purpose a full list of aspects that should be specifically dealt with should be prepared.

The legal guidelines that will govern decisions in this regard and the concomitant administrative duties are dealt with above.

11.2.19 The loss of land or habitat and scenic landscape attributes :

This aspect will play a fairly important role in the first stage of decision-making, namely at the stage where decisions in principle must be made. Once that had been done it again reflects on the need to establish the implementational framework properly and for that reason to choose the appropriate situations adequately.

11.2.20 General :

What becomes fairly obvious after an evaluation of all these different aspects mentioned above, is that the technical questions that must be answered in deciding on the placing or positioning of the final site is by no means the most important part of the research that will have to be done. It is at best one of several major considerations in establishing the precise placing. The focus must be to achieve the most advantageous development. It is conceivable that a position or a series of positions can be identified for the establishing of the necessary dams and weirs and aqueducts, that in total can even double the construction costs. At the same time however it could have a major effect on economic development in an area that is in sore need thereof. It can for example establish a wide variety of developmental possibilities, create opportunities for agricultural, tourism or economic development and do so for two or three or four different communities where the benefit of the development far overshadows the enlarged costs to establish a more expensive dam structure.

For example, building two dams a few dozen kilometres downstream rather than one dam upstream could make sense if in the process substantial reserves of aquatic eco-systems and bio-diversity can be protected, the pristine character of an area retained, the tourism potential in that area developed but that the communities near the actual dams are involved in a manner that improves their ability to establish sustainable work opportunities. This can be by exploiting the employment opportunities that the protection of the natural and pristine areas and the improved access to it offers. It can also be through the establishment of industries near the communities.

It is realised that some of the suggestions or comments in this paragraph and also in other paragraphs in this Report might indicate a procedure that could increase the cost of dam building. The important aspect to realise is that whatever water transfer method is used and however it is implemented, the alternative option finally decided on must be the option that is the cheapest option to the entire community. This concept could be illustrated by an example. Let us assume that the construction costs of option A is a factor of 7 as opposed to a factor of 9 for option B. This does not make A the cheapest option. If the additional or social costs for A is 6 and for B is 1, the total for A at 13 and B at 10, makes B the cheapest option. It must be remembered that the community bears the full brunt of the entire project regardless of whether a large cost burden is caused by the environmental externality or whether it is caused by construction activities.

A useful way in which this exercise can be done is to quantify it appropriately to financial figures to explain and justify a substantially large investment in a dam where the larger investment can have substantial other benefits.

11.3 Site Specific Investigations

At this, the third stage of the project, the right granted in principle to undertake the project is simply not even considered anymore and the framework for the detailed implementation is clearly spelled out and finalised. What now becomes necessary is to develop a detailed management plan aimed at setting out with some precision how the project should be executed.

11.3.1 The direct effects of the construction, commissioning and operation of the dams:

In this regard, extensive research would have been done for the first and second phases. Especially the second phase would have shown the parameters in which implementation should take place to ensure optimal benefit. Within the parameters then established, the detailed planning must now take place to ensure that these aspects are addressed appropriately.

11.3.2 The impact of roads and associated infrastructure such as pump and power stations have:

The comment made in 11.3.1 above also applies here.

11.3.3 The impact on eco-systems and organisms in the dam basin and downstream:

The comment made in 11.3.1 above also applies here.

11.3.4 Recommendations that should be made to the DWAF for compensation for loss, resettlement or processes that should be used in the process:

Once a specific area had been identified during the second stage I order to establish the broad framework of implementation, it becomes particularly important to realise that omelettes cannot be made without breaking eggs. This process of breaking eggs must be carefully handled. It should already have been introduced in the broad implementational framework stage. There will be benefits for the establishment of a project near a community. This community must at an early stage know that they will have to make certain sacrifices as well. Obviously the sacrifices must be restricted to the minimum. Putting the dam where important archaeological, religious or cultural resources are that would in time covered with water, is always looking for trouble. If at all possible it must be avoided. If it must be done, it must be handled with great care. That is why at the stage when the broad framework for implementation is established, these aspects should be looked at. Once it is accepted that a certain amount of degradation is inevitable, a specific structure for dealing with the problem must be established. The structure itself must be established in co-operation with the people that would be affected by the decisions. It should obviously make provision for appropriate representivity but also for the introduction of guidelines for deciding on issues developed in co-operation with communities and to their satisfaction. Then the process should be carefully followed in dealing with all of the subjects such as those mentioned.

11.3.5 The environmental management systems needed for the management of impacts during construction:

Within the framework set out in phase 2, it now becomes necessary to develop detailed programmes to ensure that the process be dealt with adequately. This is discussed below.

11.3.6 The risk assessment resulting from significant energy levels released over dam spillways:

This is an aspect that to a lesser extent should be considered in the first stage and to a far larger extent during the second stage. It should form part of the many factors that is considered when the broad framework of implementation is considered.

It is realised that it is usually a good place to put a dam wall where the valley's sides are steep and a high wall can conveniently be situated. Such a placing has many advantages of construction, of cost, of reducing water loss through evaporation etc.

It has many detrimental impacts as well because those places can also destroy a substantial amount of bio-diversity, recreational opportunities and others. The good dam building sites are frequently placed in an area where the surroundings can be fairly pristine. The dam building activities can destroy that. As such therefore, that question to a large extent should be addressed during the second phase of decision-making. Once that framework had been established however, this aspect should be dealt with in detail at the third level as well to ensure that the detailed planning effectively protects what then should be protected.

11.3.7 General :

The main tool of the trade that has emerged over the past few years to deal with the type of impacts reflected in this the third stage of decision-making, is an environmental management programme. This programme must be a **management** programme not a wish list or a list of vague promises. It must therefore set out in detail what may be done, what should be done, what may not be done, what should not be done, what the aims are, what processes should be used, what the targets are that should be aimed for and others. Furthermore the EMP must be placed within the parameters that had been set during the second stage of decision-making.

In preparing the EMP, it is obvious that the detailed planning for the document must primarily be done by the consultant that will undertake the project jointly with the DWAF. On the other hand, to the extent that its implementation might impact on other people, those other people should be closely involved in the drafting and finalisation of the EMP itself. The EMP should be a major document with several chapters, each of which addresses a different aspect. Thus the risk assessment done for floods will generate a number of framework measures necessary to address high-risk situations. In the EMP therefore, each of these measures will be developed and planned into detailed particulars. To the extent that it will require an early warning scheme to downstream water users, either to remove their water pumps or themselves from near the river's edge, whether it deals with the protection of banks from the erosion effect of floods or whatever, it must be dealt with fairly meticulously in the EMP.

In the same way the establishment of roads, pump stations or power stations must be described in much detail. Where the detailed implementation of the project could have an effect on the opportunities to people to join in the economic development or to protect them from adverse impacts, the planning must be done in advance. Thus the migration of noise pollution must be considered for the precise placing of the roads or its noise attenuation screens and filling stations can be positioned at conveniently placed positions for the use of a community.

11.4 Ongoing Management

This aspect is not dealt with in particular in the Background Document. However some provision would have to be made to ensure that the ongoing management over time is structured according to certain guidelines. For this purpose steering committees, monitoring methods, development plans and others, must be established and executed to the best advantage of all. It might for example be necessary to incorporate the need for adequate regional planning principles in the EMP and the establishment of a planning forum to ensure the effective implementation of the planning principles to ensure an effective interface with an integration between the immediate project and its wider planning implications.

12 PREVENTING INFORMATIONAL ILLITERACY

It would have become clear that the implications of the step-by-step process of incremental decision-making and the hordes of principles that must be considered at each step has the very real danger of creating substantial confusion. In a project such as the TWP, it is particularly necessary that one start off on the right foot. If the point of departure is not clearly described and does not reflect a common understanding of the project by all role players, confusion and confrontation becomes inevitable.

In my experience, the preparation of a Briefing Document is a valuable tool to ensure clarity as to the starting point. In this Briefing Document, a comprehensive summary of the *status quo* of the project is given. The legal bases on which the programme is based and the rights on which DWAF relies, are stated. An indication is provided as to how that position had been reached. Conclusions arrived at or assumptions which will form the basis of further work are clearly stated. In fact, role players must be specifically invited to consider it carefully and to take the matter up if they do not agree with what in contains.

In this way an opportunity is created to force issues and to clear the air. If it means litigation, at least the litigation is launched at a time when it can be dealt with and not at a critical moment when it is likely to delay the project.

Once such a Briefing Document had been prepared, it serves as a basis for the further handling of information. The aim would be to use the Briefing Document as the starting point for a dynamic management tool that is constantly updated to include all the newest developments, the concerns raised, the research done and the decisions made. Used thus it becomes a comprehensive summarised document that could at any moment provide any role player with an exact description of the then ruling status of the project or any of its components. Such a dynamic document makes an important contribution to the improvement of the efficiency of the management of the information. It is also an accessible, easily understood paper trail, something which is essential if later litigation is to be handled without major problems.

DUARD BARNARD
PRETORIA
March 2000

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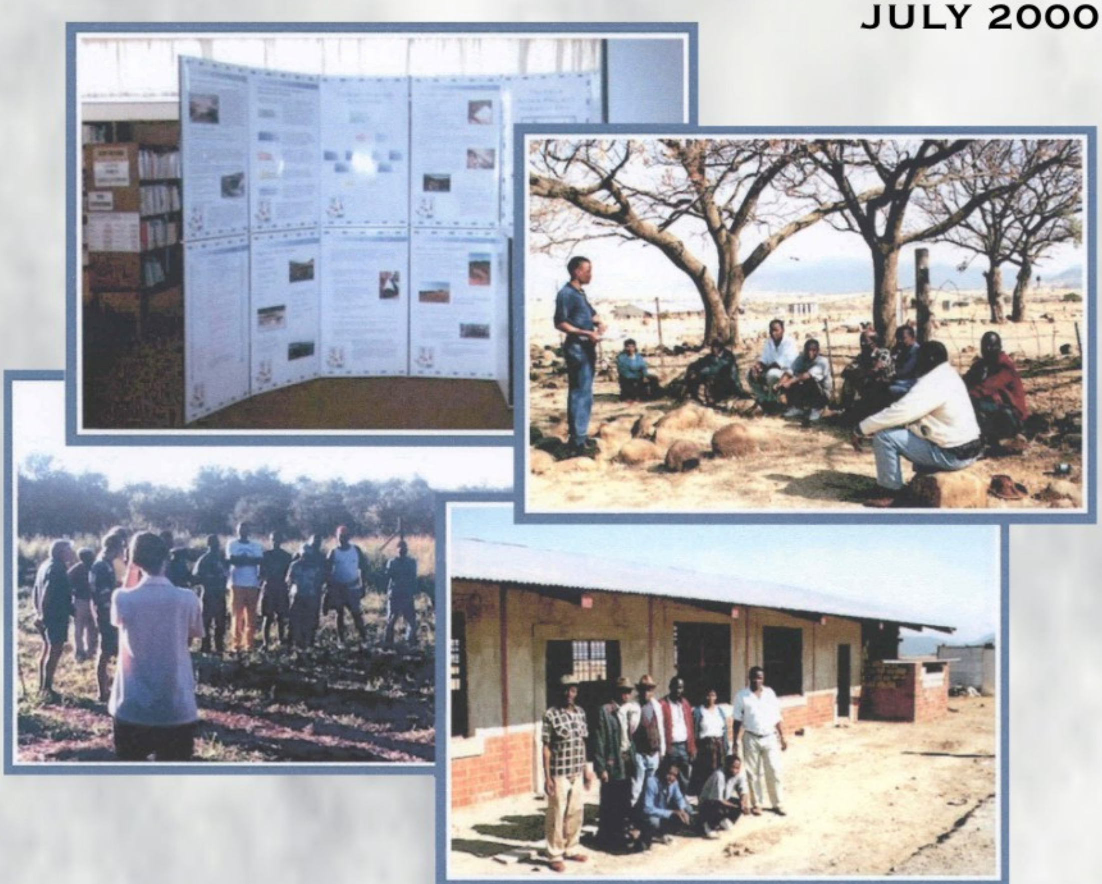
Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

PUBLIC INVOLVEMENT PROGRAMME

MAIN REPORT

JULY 2000



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THUKELA WATER PROJECT FEASIBILITY STUDY
PUBLIC INVOLVEMENT PROGRAMME

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THUKELA WATER PROJECT FEASIBILITY STUDY

ACER (Africa) Environmental Management Consultants July 2000

Approved for ACER (Africa) Environmental Management Consultants

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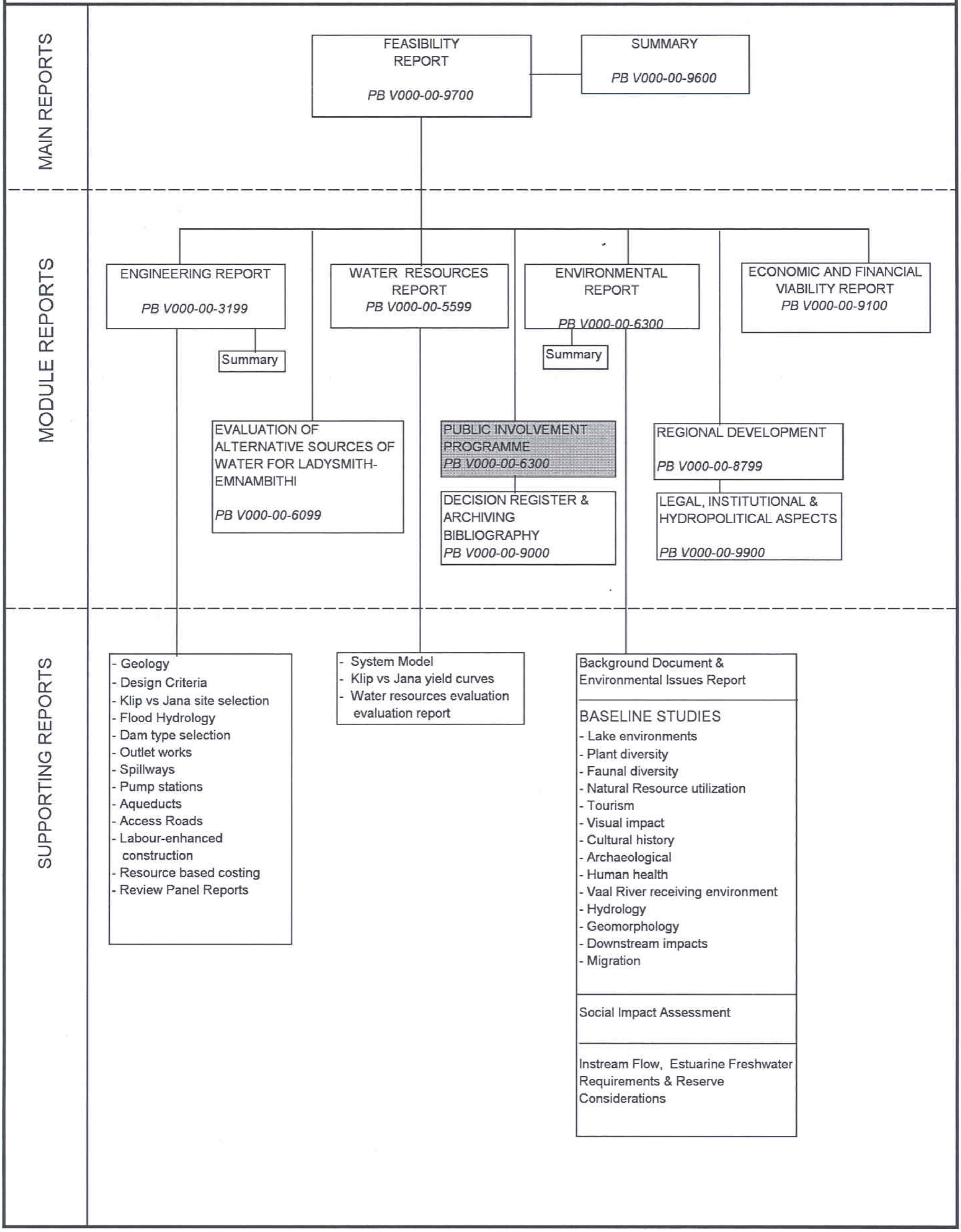
THUKELA WATER PROJECT FEASIBILITY STUDY

STRUCTURE OF REPORTS



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THUKELA WATER PROJECT FEASIBILITY STUDY PUBLIC INVOLVEMENT PROGRAMME

STRUCTURE OF REPORTS

Public Involvement Programme

Main Report

Summary

Appendix A

Progress Reports

Volumes

1 - 35

Appendix B

Minutes

- B.1 Catchment Liaison Meetings
- B.2 Working Group Meetings
- B.3 Transfer Scheme Steering Committee Meetings

Appendix C

Services

- C.1 List of Affected Stakeholders as Recorded During Trail Blazing
- C.2 Training Reports
- C.3 Slide Record of Transfer Scheme Steering Committee, Working Group and Integration Meetings
- C.4 Record of all Public Involvement Programme, Social Impact Assessment and Integrated Environmental Management Module Slides
- C.5 Database Information

Appendix D

Products

- D.1 Web Site
- D.2 Pamphlet
- D.3 Newsletters
- D.4 Internal News Sheets
- D.5 Technical Bulletins
- D.6 Mobile Displays
- D.7 IEM Advertisements
- D.8 TWP Feasibility Study Press Releases
- D.9 Catchment Liaison Meeting Advertisement

Appendix E

General

- E.1 Social Impact Assessment Terms of Reference
- E.2 Thukela Estates Irrigation Scheme Proposal
- E.3 Capacity Building Document
- E.4 Mziyonke/ Mankandane Water Supply Proposal
- E.5 Weather Stations Capacity Building Motivation
- E.6 Press and Information Kits
- E.7 Position Statement on Water Abstractions from Aqueducts
- E.8 DWAF Code of Conduct
- E.9 Thukela River Park Conceptual Considerations
- E.10 Migration Perspective
- E.11 Decision Register and Record of Decisions
- E.12 Newspaper and Other Articles Brought to the Attention of the Project Management Team During the Course of the TWP Feasibility Study

THUKELA WATER PROJECT – FEASIBILITY STUDY
PUBLIC INVOLVEMENT PROGRAMME

SUMMARY

INTRODUCTION

During 1994, the Department of Water Affairs and Forestry initiated an investigation to determine the most suitable option of augmenting water supply to the Vaal River System following the completion of Phases 1A and 1B of the Lesotho Highlands Water Project. The Thukela River option showed merit and, thus, an Interim Study was commissioned to better define development options in the Thukela River for investigation during a comprehensive Feasibility Study.

The Thukela Water Project Feasibility Study was commissioned in 1997 with most study teams commencing work in early 1998. The proposed scheme consisted of a dam in the Thukela River (either at the Jana or Klip site), a dam in the Bushman's River (Mielietuin site) and an aqueduct (either a canal, pipeline or a combination canal and pipeline) linking the dams to the existing Tugela-Vaal Transfer Scheme at Kilburn.

Public involvement is an integral component of Integrated Environmental Management, the principles of which have been embraced by the Department of Water Affairs and Forestry in all of its activities. Thus, ACER (Africa) Environmental Management Consultants was appointed as Public Involvement Consultant to undertake public involvement for the duration of the Thukela Water Project Feasibility Study.

SCOPE OF WORK AND RESULTS

The Department of Environmental Affairs and Tourism principles for public participation were adopted for the purposes of the Thukela Water Project Feasibility Study Public Involvement Programme. In brief, these can be described as follows:

- The meaningful and timeous participation of Interested and Affected Parties.
- A focus on important (key) issues.
- The due consideration of alternatives.
- Accountability for information used for decision-making.
- Inclusivity.
- Encouragement of co-regulation, shared responsibility and a sense of ownership.
- Dispute resolution.

Within the above principles, the duties and responsibilities of the Public Involvement Consultant ranged over a number of activities. Apart from introductions to stakeholders and assistance to study team members during field work, ACER was required to identify interested and affected parties and to facilitate their participation in the Feasibility Study process. To facilitate participation, information was disseminated to stakeholders via a number of methods, including pamphlets, newsletters and an Internet Web Site. Where there were capacity constraints to involvement, ACER was required to identify and recommend necessary training required to overcome constraints. In addition, ACER was involved in elements of public relations.

The operational strategy of the Public Involvement Programme is categorised best under “meetings, services, products and general activities”.

- Meetings.
  Three types of meetings were held during the course of the Feasibility Study:
  - A Catchment Liaison Meeting was held in continuation of such meetings from previous study phases. However, attendance was poor and, on analysis, it was interpreted that Catchment Liaison Meetings were no longer an optimal method of engaging stakeholders. Alternatives, for example, a mobile poster display, were sought and successfully implemented.
  - Working Group Meetings were held throughout the Feasibility Study with directly affected landowners and other interested parties. Working Groups were established for Bergville, Winterton, Colenso/Jana/Klip, Estcourt/Mielietuin/Weenen, the Thukela Biosphere Reserve and Mziyonke/Mankandane. Furthermore, in the first half of 1998, two additional Working Groups were convened, viz. Ladysmith/Emnambithi and Capacity Building Working Groups.
  - The Transfer Scheme Steering Committee was established as an important advisory body to the Department of Water Affairs & Forestry. It consisted of a wide range of organisations, from government (national, provincial and local) and the private sector. Members received regular interim progress reports and provided guidance and recommendations to the Project Management Team. Apart from one site visit in February 2000, Transfer Scheme Steering Committee Meetings were held biannually.

  Apart from formal meetings organised under the auspices of the Thukela Water Project, the Public Involvement Consultant and the Project Co-ordinating Engineer held numerous meetings with the uThukela Regional Council, the Service Providers’ Forum, local Tribal Authorities (for example, Mthembu Tribal Authority), the Emnambithi Regional Authority, Thukela Catchment Transitional Local Councils (for example, Weenen, Estcourt, Bergville, Winterton, Colenso and Ladysmith), Development Forums (for example, Bethany), Environmental Forums (for example, Mandeni) and service organisations (for example, Ladysmith Rotary Club, Nambithi Rotary Club and the Ladysmith Chamber of Commerce and Industry).

- Services.
  - ACER provided a range of services to study teams during the course of the Feasibility Study. Initially, and during the investigation of aqueduct alternatives, trial blazing and the identification of landowners and affected parties was of primary importance. Following on from this task was the role of facilitating introductions and guiding study team members during site visits. Although this benefited the entire study team, this aspect of work was particularly important in assisting Integrated Environmental Management team members, Environmental Specialists and Drilling Teams.
  - The Mziyonke/Mankandane Development Committee was initially established by ACER, and identified as a stakeholder group requiring training to enable members to more effectively participate in the Feasibility Study. Two training workshops were conducted through an independent training consultant. Training included:
    - The functions of a committee.
    - Organising committee meetings.
    - Reporting information on the project back to community members.

    In addition, a site visit to the existing transfer scheme and two local dams was undertaken. Following training, the committee put together successful proposals to the uThukela Regional Council for community halls.
  - Stakeholder correspondence and interaction has been ongoing throughout the Feasibility Study. All stakeholder interactions and details were recorded on a database that has over 1 000 individual stakeholders registered.
  - A number of public relations activities such as the sponsoring and operating of a watering table at the 1999 Bergville/Ladysmith Marathon were also undertaken.

- Products.

  ACER produced a range of media and visual products to disseminate project information.
  - A Thukela Water Project Web Site was established and updated during the course of the study. This is regarded as relatively unique for a project of this nature and, judging by the number of “strikes” proved valuable to stakeholders as a means of obtaining information.
  - Six newsletters were produced in English and Zulu documenting project background, milestones and technical details, and were distributed to all stakeholders on the database as well as being placed in office receptions in the catchment and further

afield. Newsletters proved very valuable as a means of communicating regularly with the full complement of registered stakeholders.

- Two sets of mobile display posters were produced. The first set provided general project background and individual project components. This display was set up in libraries throughout the catchment, was displayed in Durban, Pietermaritzburg and Pretoria, and was displayed in Ladysmith during a Ladysmith Chamber of Commerce and Industry function at which the French Ambassador to South Africa was a guest. The second mobile display showed a generic interaction of engineering, environmental investigations and public involvement modules over the course of a project's life cycle.
- An internal Intranet was established to facilitate communication between study teams and study team members. The Intranet hosted a range of information, for example, minutes of Intermodule Meetings and Internal News Sheets.
- Media releases from the project team were prepared and sent to local, provincial and national newspapers at appropriate times during the Feasibility Study. In addition, the Public Involvement Consultant provided inputs for a number of solicited and unsolicited media articles, for example, Engineering News and the Natal Witness, respectively.
- Apart from a significant contribution to regional planning via inputs to the Service Providers' Forum, as part of its involvement in the Regional Development Module, ACER, in conjunction with the Project Co-ordinating Engineer, attended to the following:
  - Preparation and facilitation of a Regional Development Workshop.
  - Drafted a proposal for the rehabilitation of Thukela Estates Irrigation Scheme.
  - Assisted with the drafting of a proposal for improved community water supply in the Mziyonke and Mankandane areas.
  - Drafted a Capacity Building Document following the Capacity Building Workshops.
  - Drafted a proposal to utilise the operation of weather stations (required for the Thukela Water Project) as a capacity building opportunity.
  - Sponsored the course fees for a representative of the uThukela Regional Council to attend a course on Integrated Environmental Management.

- General.
  - ACER prepared the first draft of the Social Impact Assessment Terms of Reference and assisted in the adjudication of proposals.
  - ACER prepared a position statement on the abstraction of water from aqueducts and also produced a code of conduct for study teams working on private property.

- ACER drafted a document to further define the concept of a Thukela River Park and, in contribution to the Integrated Environmental Management Module, prepared a specialist perspective on the effect of the Thukela Water Project on the migration of people.
- ACER also assisted the Project Management Team in the preparation of a draft format for the Decision Register and Records of Decisions.
- Finally, the print media was scanned on an on-going basis, with articles of interest and relevance being forwarded to the Project Management Team for information and action (if necessary).

DISCUSSION

It is the considered opinion of the Public Involvement Consultant that the Public Involvement Programme for the Thukela Water Project Feasibility Study has achieved its aims and objectives, and, importantly, has successfully applied the principles of public participation as elucidated by the Department of Environmental Affairs and Tourism. This is evidenced by key aspects such as:

- A continuation of public involvement from the Pre-feasibility Study, through the Interim Study, to the Feasibility Study, with an ever increasing number of stakeholders participating as development proposals were formulated and elucidated.
- The provision of sufficient project information in an easily assimilable and understandable manner to enable the participation of stakeholders in the formulation of project alternatives, for example, the alignment of aqueducts.
- A clear and unambiguous focus on matters that were important at any given time during the study, for example, the Jana/Klip debate, aqueduct alignments and regional development, as described and discussed in information dissemination media at the time, for example, newsletters.
- The expenditure of significant resources during the consideration of alternatives, particularly as relates to aqueduct types and alignments.
- Particular attention to the detail of information used during decision-making in support of co-regulation, shared responsibility and sense of ownership, for example, the production of Technical Bulletins. Also, assistance was rendered to stakeholders in the preparation of material in support of stakeholder perspectives, for example, a perspective paper on Thukela River Park Conceptual Considerations.
- As and when disputes and conflicts arose, these were dealt with by the Public Involvement Consultant and the Project Co-ordinating Engineer.

WAY FORWARD

After a lengthy and inclusive Public Involvement Programme, ACER believes that stakeholders in the Thukela River Catchment have been afforded sufficient opportunity to participate meaningfully during the Thukela Water Project Feasibility Study. In addition, stakeholders from further afield have also participated, but to a lessor degree of intensity. Various positive and negative issues and recommendations have been raised by stakeholders. These are not statements of fact but, rather, opinions and perspectives. Importantly, they have been addressed or accommodated within the feasibility study where applicable, appropriate and possible.

It is the understanding of the Public Involvement Consultant that the Thukela Water Project will probably proceed into further study phases. If this is the case, attention will need to be given to the broader base of interested parties who may wish to participate in future planning activities, for example, stakeholders in the receiving environment, viz. the Vaal River Supply Area. Provision for this has been encapsulated in a draft scope of work for future public involvement for the Thukela Water Project. However, if a decision is made not to proceed with the Thukela Water Project, public involvement activities will be wound down with all registered stakeholders being informed of the decision to cease investigations into the transfer of additional water from the Thukela River catchment to the Vaal River Supply Area.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

ACRONYMS

ACER	ACER (Africa) Environmental Management Consultants
DWAF	Department of Water Affairs & Forestry
GRP	Glass Reinforced Plastic
I&APs	Interested & Affected Parties
IEM	Integrated Environmental Management
PIC	Public Involvement Consultant
PIP	Public Involvement Programme
PMT	Project Management Team
TWP	Thukela Water Project

THUKELA WATER PROJECT – FEASIBILITY STUDY
PUBLIC INVOLVEMENT PROGRAMME

1 INTRODUCTION

Since the commencement of investigations into options to further augment water supplies to the Vaal River Supply Area, the Department of Water Affairs and Forestry (DWAF) has been committed to open and transparent communication with interested and affected parties. Furthermore, public involvement is an important component of Integrated Environmental Management (IEM), the principles of which are practised by the DWAF in all of its activities.

Accordingly, ACER (Africa) Environmental Management Consultants (ACER) was appointed as the Public Involvement Consultant (PIC) to undertake public participation during the Thukela Water Project (TWP) Feasibility Study. ACER was appointed prior to the commencement of Feasibility Study investigations so as to provide continuity between the Pre-feasibility and the Feasibility Studies. This report details the work of the PIC from December 1996 to February 2000[1].

2 TERMS OF REFERENCE

The terms of reference for the Public Involvement Programme (PIP) were set as follows:

- With the assistance of team members from other modules, the on-going identification of stakeholders and their incorporation into the PIP and Feasibility Study processes.
- Maintain existing and establish new liaison channels with stakeholders and stakeholder groups (including pre- and post- Feasibility Study period). Assist stakeholder groups to nominate or elect a contact person through whom the PIC can operate and who should represent individual stakeholder groups at public gatherings, for example, Catchment Liaison Meetings.

[1] Public involvement will continue through to the completion of the TWP Feasibility Study in July 2000. Activities undertaken between March and July 2000 are described in Annexure 1.

- Identify capacity constraints and, where necessary, address these through training and the provision of administrative, technical and logistical support to stakeholder groups to facilitate empowerment and participation in the PIP.
- Act as facilitator, negotiator and mediator on behalf of the DWAF to identify and define the interests of all stakeholders. Where necessary, elicit technical support from the DWAF Project Manager, the Project Management Team (PMT) and individual study team members.
- The arrangement, co-ordination, facilitation and documentation of all PIP activities, processes and results, including:
  - Catchment Liaison Meetings.
  - Working Group Meetings.
  - Individual contacts.
- Facilitate field activities of professional and technical personnel involved in technical investigations as part of the Feasibility Study. In this regard, the PIC will act as a conduit for study teams working in the area.
- Maintain public awareness of the proposed water project and Feasibility Study through a range of information dissemination activities, including:
  - Newsletters.
  - Internet Home Page and Web Site.
  - Technical Reports.
  - Public addresses to stakeholder interest groups.
  - Public relations.
  - Media relations (print, radio and television). In this aspect of the work, the PIC will be required to work in close co-operation with the Sub-Directorate Liaison Services of the DWAF.
- Identification of opportunities for regional development within the Thukela Basin and contributions to the formation of strategies to stimulate the planning, design and implementation of projects/programmes.
- Regular written reporting to the PMT (Appendix A).

3 BACKGROUND

During 1994, DWAF initiated an investigation to determine the most suitable option of augmenting water supply to the Vaal River Supply Area following the completion of Phases 1A and 1B of the Lesotho Highlands Water Project. The Vaal Augmentation Planning Study involved the investigation of three primary (Upper Orange, Middle Orange and Thukela) and one secondary (Mzimvubu) sources. Comparable Reconnaissance and Pre-feasibility

Studies were conducted for each of the three primary catchments. The DWAF decided to continue with investigations of the Thukela and Middle Orange options. Considering the Thukela option only, an Interim Study was commissioned to better define development options in the Thukela River for investigation during a comprehensive Feasibility Study.

At the outset of the Reconnaissance Study, 73 potential dam sites in the Thukela Basin were investigated. Seventeen of these were selected for further evaluation during the Pre-feasibility Study. The balance of options was then narrowed down to that being investigated during the TWP Feasibility Study, namely, Klip or Jana (Thukela) and Mielietuin (Bushman's) Dams and associated linking aqueducts, as shown in Figure 1. Three aqueduct options, namely a canal, pipeline or combination canal/pipeline, were considered during the Feasibility Study. In addition, further investigation of the raising of Qedusizi Flood Attenuation Dam as well as the TWP's impact on future potential development of the northern tributaries of the Thukela River formed part of the Feasibility Study.

Importantly, public involvement activities commenced at the outset of the Reconnaissance Study, initially, with directly affected stakeholders and, later, with a wide range of Interested & Affected Parties (I&APs). This demonstrates clearly the timeous involvement of I&APs as well as DWAF's commitment to inclusivity.

4 APPROACH AND DESCRIPTION OF THE THUKELA WATER PROJECT FEASIBILITY STUDY PUBLIC INVOLVEMENT PROGRAMME

4.1 Principles

As public participation is an integral part of Integrated Environmental Management, IEM principles relevant to public participation were adopted for the TWP Feasibility Study Public Involvement Programme. The Department of Environmental Affairs and Tourism (1998) has identified these as follows:

- Meaningful and timeous participation of I&APs.
- Focus on important (key) issues.
- Due consideration of alternatives.
- Accountability for information used for decision-making.
- Inclusivity (the needs, interests and values of I&APs must be considered in the decision-making process).
- Encouragement of co-regulation, shared responsibility and a sense of ownership.
- Dispute resolution.

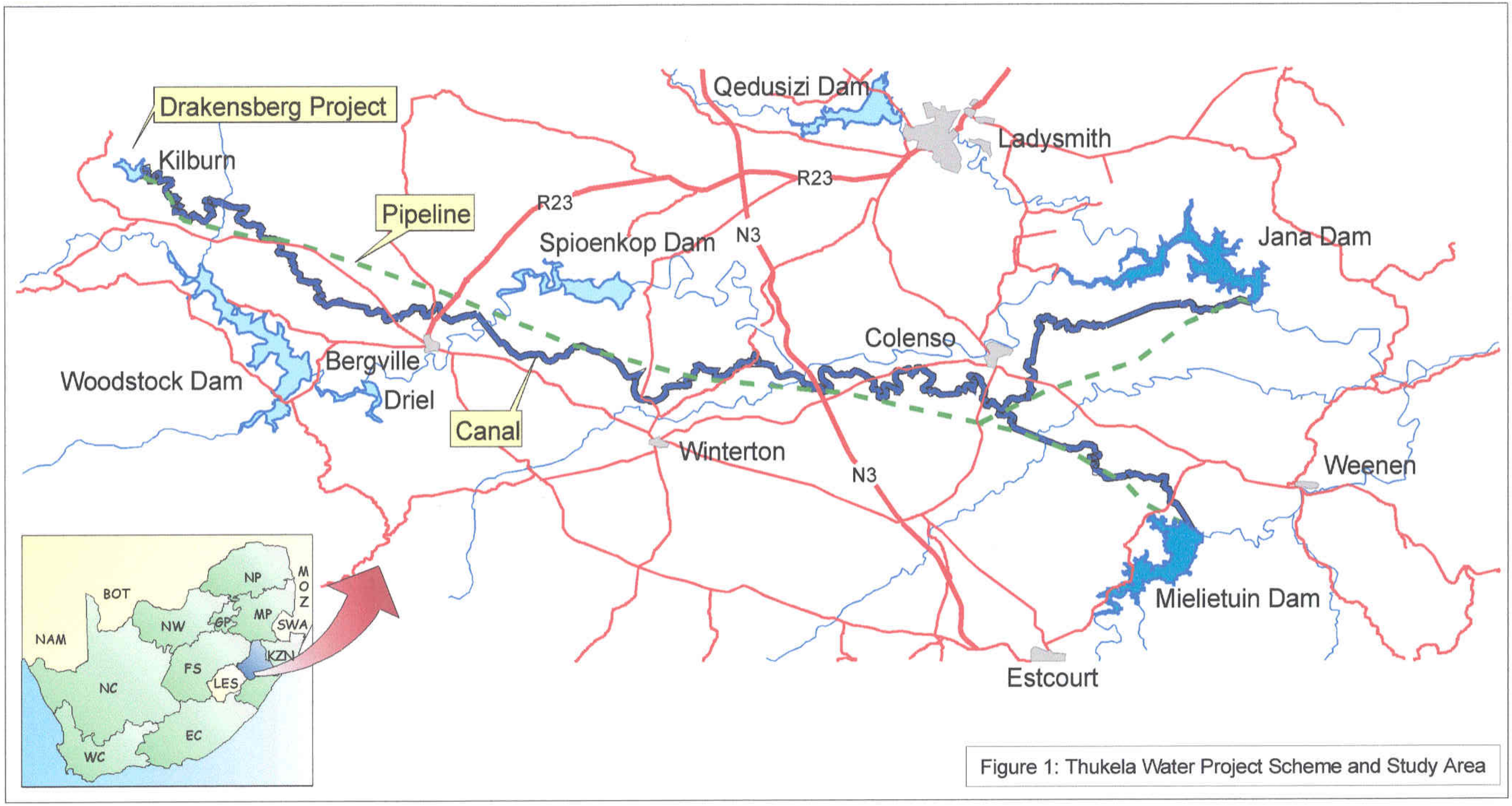

Figure 1: Thukela Water Project Scheme and Study Area

4.2 Description of Public Involvement Programme

The internal and external communication functions provided during the Feasibility Study by the PIC, both proactive and reactive, and can be best described in terms of three categories:

- Meetings.
- Services.
- Products.

4.2.1 Meetings

Three main kinds of stakeholder meetings were utilised during the Feasibility Study PIP, viz. Catchment Liaison Meetings, Working Group Meetings, and Transfer Scheme Steering Committee Meetings.

4.2.1.1 Catchment Liaison Meetings

These meetings originated during the Reconnaissance Study when different river catchments were under investigation. During the Reconnaissance, Pre-feasibility and Interim Studies preceding the TWP Feasibility Study, four successful Catchment Liaison Meetings were held. However, despite advertising and personal invitations, attendance of the fifth Catchment Liaison Meeting in Ladysmith on 5 October 1999 was poor. It was scheduled to discuss general information with interested and affected parties regarding the outcome of Feasibility Study milestones. Examination of the poor attendance revealed that many of the original Catchment Liaison Meeting members had been incorporated into the Transfer Scheme Steering Committee or local Working Groups and, thus, were already sufficiently well informed of progress. Indeed, the Catchment Liaison Meeting had been preceded by a series of Working Group Meetings. Therefore, after deliberation between the PIC and the PMT, it was decided that there was no further need for Catchment Liaison Meetings during the TWP Feasibility Study.

However, there remained a need to reach a wider representation of the general public. This was achieved via the attendance by the PIC and the Project Co-ordinating Engineer of meetings of catchment institutions, organisations and forums (Section 4.2.1.4), the placing of advertisements in the national, regional and local media (as part of the IEM Module), placed and unsolicited media articles and the mobile display (Section 4.2.3.6).

Details and minutes of the Fifth Catchment Liaison Meeting are provided in Table 1 and Appendix B.1, respectively.

Table 1: Details of the Fifth Catchment Liaison Meeting.

Meeting	No of attendees*	Date	Purpose of Meeting
Catchment Liaison Meeting	3	October 1998	To inform the general public of progress with the TWP Feasibility Study and to provide an opportunity to I&APs to discuss the Jana/Klip milestone

*Excluding members of the Study Team or Client

Plate 1 Members of the Mziyonke/Mankandane Development Committee outside the community hall (under construction) funded by the uThukela Regional Council after submission of a business plan compiled by the Development Committee following training provided as part of the Thukela Water Project Feasibility Study.

4.2.1.2 Working Group Meetings

Working Group Meetings have been held with directly affected stakeholder groups in the Thukela Basin since November 1996[2]. Following on from the basis established during the Interim Study, for the duration of the TWP Feasibility Study, issues arising and project milestones have been discussed with the following Working Groups:

- Bergville.
- Winterton.
- Colenso/Jana/Klip.
- Mziyonke/Mankandane (Mthembu Tribal communities).
- Estcourt/Mielietuin[3].
- Thukela Biosphere Reserve[3].
- Ladysmith/Emnambithi.
- Capacity Building.

Stakeholders from Ladysmith and, in particular, those from local government and business, were invited to participate in the Ladysmith/Emnambithi and Capacity Building Working Groups that were initiated at the start of 1998. Stakeholders affected by the proposed Klip Dam were consulted during various community and committee meetings. After the decision to proceed only with investigation of the Jana Dam in the Thukela River, Klip stakeholders were informed of the decision and kept informed of project progress through newsletters, i.e. no further meetings were held with these stakeholders.

The aim of Working Group Meetings was to provide a forum at which I&APs and study team members could engage directly on issues of local interest and concern. This form of interaction with directly affected stakeholders proved very successful and contributed significantly to a sense of co-ownership of the different development alternatives proposed. For example, based on the consideration of numerous alternatives, the final alignments of aqueducts are the products of intensive stakeholder inputs married with technical, environmental (social and biophysical) and economic feasibility, and bear testimony to the

[2] The exception is the Mziyonke/Mankandane Development Committee which was formed only in early 1998 following intensive efforts, over eight months, by the PIC, firstly, to gain access for project team members to tribal land and, secondly, to create a vehicle through which the people of Mziyonke and Mankandane could participate in the TWP Feasibility Study. It is important to note that the formation of the Mziyonke/Mankandane Development Committee separate to the Jana/Klip Working Group was purely for logistical reasons, the driving time from one side of the Thukela River to the other being of the order of three hours. In addition, at the request of Nkosi Mthembu, the Mziyonke/Mankandane Development Committee, although established under the aegis of the TWP Feasibility Study, has a wider operational focus and responsibility, particularly as relates to the development of the two communities.

[3] Including Weenen.

pivotal role played by stakeholders during the course of the TWP Feasibility Study. Information on Working Group Meetings held during the course of the Feasibility Study is provided in Table 2. Minutes of meetings are provided in Appendix B.2.

4.2.1.3 Transfer Scheme Steering Committee Meetings

The Transfer Scheme Steering Committee was established as an important advisory body to the Department of Water Affairs & Forestry. A wide range of organisations, including national, provincial and local government, and the private sector, were represented on the Transfer Scheme Steering Committee. The inaugural meeting was held in May 1997 and the committee continued into the Feasibility Study where it received regular interim progress reports and provided guidance to the study team. The committee met biannually (Table 3) and all members were given an opportunity to participate in a site visit. The PIC was responsible for the organisation of meetings, assistance with the setting of agendas and the preparation of meeting material, and the production and distribution of minutes. A complete set of minutes is provided in Appendix B.3.

4.2.1.4 Other

Apart from formal meetings organised under the auspices of the Thukela Water Project, the Public Involvement Consultant and the Project Co-ordinating Engineer held enumerable meetings with various institutions, organisations and forums in the Thukela Catchment. Examples include:

- The uThukela Regional Council.
- The uThukela Regional Council's Service Providers' Forum[4].
- Local Tribal Authorities, primarily the Mthembu Tribal Authority.
- The Emnambithi Regional Authority.
- Transitional Local Councils, most notably, Weenen, Estcourt, Bergville, Winterton, Colenso and Ladysmith.
- Development Forums, for example, Bethany.
- Environmental Forums, for example, Mandeni.
- Service organisations, for example, Ladysmith Rotary Club, Nambithi Rotary Club and the Ladysmith Chamber of Commerce and Industry.

4 Indeed, the Project Co-ordinating Engineer played a lead role in the successful establishment and operation of the Service Provider's Forum.

These meetings proved valuable for the dissemination of pertinent project information to enable meaningful participation by I&APs in an effort to strive for co-ownership of the proposed project as different project elements unfolded during the Feasibility Study process.

Table 2: Details of Working Group Meetings held during the course of the TWP Feasibility Study.

Working Group Meeting	No. of attendees*	Date	Purpose of Meeting
Ladysmith/ Emnambithi	6	January 1998	Introduction to the study and a description and discussion of aims and objectives
Ladysmith/ Emnambithi	6	February 1998	Presentation of the Inception Report and a discussion of preliminary options
Capacity Building	4	February 1998	Background and discussion on different capacity building strategies
Ladysmith/ Emnambithi	6	April 1998	A detailed presentation of options
Bergville	17	May 1998	General introduction of Feasibility Study and Study Team members. Discussion of concerns and anticipated Feasibility Study programme
Winterton	16		
Colenso/Jana/Klip	9		
Estcourt/Mielietuin	9		
Thukela Biosphere Reserve	23		
Mziyonke/ Mankandane	13		
Ladysmith/ Emnambithi	2	June 1998	Broad overview of the study, a discussion on a proposed presentation to the L/E TLC, and a description of the way forward
Capacity Building	4	June 1998	Capacity building opportunities and a discussion on the way forward
Colenso/Jana/Klip	5	October 1998	Presentation of first Feasibility Study milestone - Jana/Klip Decision
Bergville	13	December 1998	Alternative aqueduct route alignments. Meetings were held to discuss the alternative aqueduct routes investigated
Winterton	12		
Colenso/Jana	12		
Thukela Biosphere Reserve	5		

*Excluding members of the Study Team or Client

Table 2: (continued.)

Working Group Meeting	No. of attendees*	Date	Purpose of Meeting
Estcourt/Mielietuin	9	May 1999	Confirmation of environmental issues particularly in regard to Mielietuin Dam
Bergville/Winterton	69	October 1999	General project update and information regarding the IEM Module re-alignment and way forward
Colenso/Jana	6		
Thukela Biosphere Reserve/ Estcourt/Mielietuin	11		
Mziyonke/ Mankandane	22		

*Excluding members of the Study Team or Client

Plate 2 Resource users from Mziyonke and Mankandane.

Table 3: Details of Transfer Scheme Steering Committee Meetings held during the course of the TWP Feasibility Study.

Meeting	No of attendees*	Date	Purpose of Meeting
Transfer Scheme Steering Committee	11	February 1998	General introduction of Feasibility Study and Study Team members. Discussion of concerns and anticipated Feasibility Study programme
	27	October 1998	Presentation of first Feasibility Study milestone - Jana/Klip information and recommendations
	23	February 1999	Presentation of aqueduct route selection process and proposed IEM Module realignment
	12	August 1999	General project progress
	22	February 2000	Presentation of preliminary findings and way forward for the remainder of the Feasibility Study

*Excluding members of the Study Team or Client

Plate 3: Bergville/Ladysmith Marathon (1999) watering table.

4.2.2 Services

The PIC provided a range of services during the course of the Feasibility Study. These are described below.

4.2.2.1 *Trail Blazing*

Since 1996, work in identifying affected landowners has been ongoing. Apart from extensive trail blazing over a vast geographic area for the duration of the feasibility study, this work was particularly important in obtaining access to Mthembu tribal land, during the investigation of alternative aqueducts and aqueduct alignments, and during the identification of I&APs downstream of the proposed Jana and Mielietuin Dams. Stakeholder lists were compiled and distributed to study team members working in the area.

A breakdown of work which required trail blazing is as follows:

- North bank of the Jana and Klip Dams.
- Aqueduct alternatives.
  - Glass Reinforced Plastic (GRP) pipeline route.
  - Steel pipeline route, including three alternative routes through the Bergville/Bethany district.
  - Alternative canal alignment through the Winterton district.
  - Alternative canal alignment through the Thukela Biosphere Reserve.
  - Other minor alternatives at Jana Dam, Colenso and Kilburn.
- Pump stations and access roads.
- Road re-alignment at Mielietuin Dam.
- Stakeholders downstream of Jana Dam.
  - Regional Councils.
  - Tribal Authorities.
  - Town Councils.
  - Commercial business and agricultural water users.
  - Recreational and conservation water users.

A key feature of trail blazing was the early identification of affected stakeholders, firstly, to advise them of the proposed project and its affect on them, and, secondly, to facilitate their early involvement in the public involvement process. A complete list of stakeholders identified during trail blazing is provided in Appendix C.1.

4.2.2.2 Introduction and Guide

The PIC has fulfilled the function of introducing study team members to catchment and local stakeholders. This function has proved to be valuable in that stakeholders are made aware of specialists requiring access to their land and consultants save valuable time whilst undertaking field work.

The PIC provided assistance to all team members, in particular:

- IEM Module and Environmental Specialist Teams:
  - KwaZulu-Natal Nature Conservation Services.
  - Resource Economics Team.
  - Tourism Study Team.
  - Resource Utilisation Team.

    - Historical and Archaeological Study Teams.
    - Palaeontology Study Team.
    - Flora and Fauna Study Teams.
    - Social Impact Assessment Team.
- PMT members, including representatives of the client.
- Drilling Teams during investigations of:
    - Foundation conditions at Jana, Klip and Mielietuin Dam sites.
    - Quarry materials in Mziyonke.
    - Quarry materials in the Mielietuin Dam basin.
    - Geological foundation conditions of both canal and pipeline aqueducts.

4.2.2.3 Training

The PIC met with stakeholder groups on the north bank of Jana Dam on numerous occasions to explain the purpose of the various study modules and to update them on progress. Furthermore, after assessing the need for additional training, the Mziyonke/Mankandane Development Committee participated in two training sessions conducted by an independent training consultant, viz. Babah Kamanga & Associates. Training focussed on the following:

- Functions of a committee.
- Roles, functions and responsibilities of committee members.
- Organising community meetings.
- Reporting committee meeting discussions back to community members and stimulating debate.
- How to prepare a motivation to the correct authorities for funding of a development project.

Training reports are provided in Appendix C.2.

Training proved to be valuable in assisting committee members to understand the project and their role within it as well as to stimulate development in their area. As a direct result of training received, the committee prepared successful proposals to the uThukela Regional Council to build community halls for the Mziyonke and Mankandane areas. In addition, the committee has submitted a business plan to the uThukela Regional Council for assistance with planning a secure domestic water supply system for both communities.

Lastly, committee members were also taken on a site visit to the existing Tugela-Vaal Transfer Scheme, Spioenkop Dam and the Qedusizi Flood Attenuation Dam.

4.2.2.4 *Negotiation and Conflict Resolution*

Although much of the PIC's work with stakeholders should be regarded as facilitation rather than negotiation, negotiation and conflict resolution services were required on some occasions, in particular, when attempting to gain access to the north side of Jana Dam. This area is AmaThembu tribal land and has been wracked with internal faction fighting for a number of years. The PIC was involved in lengthy negotiations with Nkosi Mthembu and senior tribal authority members to gain access to this area for study team members.

Furthermore, for the duration of the Feasibility Study, negotiation was required for occasional problems arising from drilling work, access and resulting disturbance to game hunting and river rafting clients.

Apart from complying with IEM public participation principles, negotiation and conflict resolution proved valuable to individual study team members, study teams, and the study as a whole, firstly, by resolving disputes before they reached unmanageable proportions and thereby enabling work to continue, secondly, by assisting conflicting parties to understand and respect other points of view, and, thirdly, by capacitating stakeholders and study team members alike.

4.2.2.5 Visual Aid Material

The PIC assisted study teams to standardise all presentation material. This entailed producing a slide template which was distributed to all teams, as well as assisting the Project Co-ordinating Engineer to produce an electronic presentation of the entire TWP Feasibility Study.

Furthermore, in support of accountability for information used during the course of the TWP Feasibility Study, a record of presentation slides used at meetings by various study modules was compiled and maintained. The record contains slides from Transfer Scheme Steering Committee, Working Group and Integration meetings (Appendix C.3) as well as copies of all Public Involvement Programme, Social Impact Assessment and Integrated Environmental Management Module slides (Appendix C.4).

4.2.2.6 Database Management

A database, on which all stakeholders have been registered, was established. There are over 1 000 individual stakeholders registered and, importantly, all stakeholder contact has been recorded (Section 4.2.2.8).

Stakeholders have been classified in the following manner:

- Affected stakeholders.......... 361
- Natural environment/conservation.......... 98
- Historical/archeological/social/cultural.......... 19
- Local government.......... 179
- National and provincial government.......... 96
- Organised business.......... 77
- Organised agriculture.......... 13
- General interest.......... 169
- Political parties.......... 7
- Media.......... 9
- Contractors/service providers.......... 30
- Key study team members.......... 35[5]
- No longer affected.......... 14

A detailed breakdown of the database is provided in Appendix C.5 (including an electronic version in Microsoft Access 97).

4.2.2.7 Public Relations

Public relations undertaken by ACER during the course of the Feasibility Study were as follows:

- Arrangements for study teams to sponsor and operate a watering table for the 1999 Bergville/Ladysmith Marathon.
- Arrangements for study team members to raft the Thukela River with a commercial rafting operation directly affected by the proposed Jana Dam.
- Regular presentation of the TWP Feasibility Study during meetings of various

[5] For onward distribution to an additional 240 study team members.

institutions, organisations and forums in the Thukela Catchment, viz. the uThukela Regional Council, the uThukela Regional Council's Service Providers' Forum, local Tribal Authorities, the Emnambithi Regional Authority, Thukela Catchment Transitional Local Councils, Development Forums, Environmental Forums and service organisations (Section 4.2.1.4).

4.2.2.8 Stakeholder Correspondence

Stakeholder correspondence has been ongoing since the commencement of the TWP Feasibility Study PIP, primarily via information dissemination, in response to concerns, or for purposes of communicating with Working Group members in between scheduled meetings. All correspondence undertaken during the Feasibility Study is recorded on the TWP Database (Appendix C.5).

4.2.3 Products

As part of the PIP, the PIC produced a range of products for information dissemination to a wide audience of interest groups. Each was prepared according to set schedules primarily to maintain a steady flow of information to I&APs, as well as to provide details and stimulate debate over major milestones in the study. These products are described below.

4.2.3.1 Web Site and Intranet

ACER produced the TWP Home Page and Web Site (www-dwaf.pwv.gov.za/thukela) as part of the DWAF Internet Site (Appendix D.1). This site provided background to the project and also hosted two finalised reports, viz. Evaluation of Alternative Sources of Water for the Ladysmith/Emnambithi Area, and the IEM Background Document and Environmental Issues Report. By the end of February 2000 there had been 274 visitors to the site.

Given its value, into the future, the intention is to update the web site, primarily to provide the results of the TWP Feasibility Study. This is expected to occur in May/June 2000.

In addition to the external web site, ACER, with assistance from the Project Co-ordinating Engineer, also produced a TWP Intranet site. Material hosted on this site included Internal News Sheets, minutes of intermodule meetings, PMT perspectives, for example, Abstractions from aqueducts, and draft reports as they became available. The Intranet can be regarded as a relatively unique service for a project of this nature. However, its value was great, particularly as related to assistance with the integration of material as it became available from the various study modules.

4.2.3.2 *Pamphlet*

A general background and introductory pamphlet (Appendix D.2) was produced and distributed to office reception areas around the study area, study team consulting offices in KwaZulu-Natal and Gauteng, and the Department of Water Affairs and Forestry, Pretoria. In total, 2 000 pamphlets were distributed, 1 000 in English and 1 000 in Zulu. Importantly, the pamphlet served a useful purpose in providing timeous and accurate project information with which I&APs could commence their participation in the TWP Public Involvement Programme.

4.2.3.3 *Newsletters*

Regular newsletters, in English and Zulu, were produced from the commencement of Feasibility Study investigations. These were distributed by post to all registered individuals on the database and forwarded to update those new to the study. Six newsletters were produced during the course of the TWP Feasibility Study (Appendix D.3), usually 1 000 in English and 500 in Zulu. However, numbers printed in each language did vary occasionally.

The theme of each newsletter was selected to inform I&APs of recent project progress and milestones, as well as to provide general information, such as the details of the new Water Act. Judging by I&AP responses to newsletters (and their eagerness to receive them), a fair assessment is that newsletters served well the purposes of broad information dissemination and project progress updates, and, indeed, were well worth the production effort and cost. Details of the newsletters are provided in Table 4.

Table 4: Newsletters published during the TWP Feasibility Study.

Newsletter	Date of Publication	Major Theme
Newsletter 4 (English & Zulu)	October 1997	Background and TWP Feasibility Study Modules
Newsletter 5 (English & Zulu)	April 1998	Reporting Structures and In-basin Development
Newsletter 6 (English & Zulu)	August 1998	Working Group Meetings and Aqueduct Routes
Newsletter 7 (English)	December 1998	Integrated Environmental Management and National Water Act
Newsletter 8 (English)	April 1999	Regional Development and Scheme Layout
Newsletter 9 (English & Zulu)	September 1999	Capacity Building and River Protection
Newsletter 10 (English & Zulu)	December 1999	Environmental Issues and Technical Data on Pump stations and Aqueducts

Plate 4: Mobile Display in the Ladysmith Library.

4.2.3.4 Internal News Sheets

To improve team interaction an internal news sheet was produced and sent via email to all study team members (Appendix D.4) (also, latterly hosted on the TWP Intranet site). These News Sheets dealt with background information relating to project decisions and aspects of a social nature. Dates of release were as follows:

- News Sheet 1 August 1998.
- News Sheet 2 November 1998.
- News Sheet 3 December 1998.
- News Sheet 4 March 1999.
- News Sheet 5 May 1999.

4.2.3.5 Technical Bulletins

Technical Bulletins (Appendix D.5.) were initially produced separately for distribution but were later provided as an insert in newsletters. This information was targeted at those stakeholders who desire information on the technical specifications of certain project components, such as dam heights, servitude widths and component costs. As with newsletters, a fair assessment is that Technical Bulletins served well the purposes of providing specific technical information to I&APs, and, indeed, were well worth the production effort and cost. Furthermore, the Technical Bulletins fulfilled a number of the requirements of IEM public participation principles.

4.2.3.6 Mobile Display

Two Mobile Display presentations were produced during the TWP Feasibility Study.

- The first display, comprising 17 posters, was arranged in two parts:
  - An explanation of the background to the study and study modules.
  - Technical specifications and environmental impacts of proposed infrastructure.

  This presentation was displayed for approximately two weeks in the libraries of Ladysmith, Bergville, Estcourt, Durban, Pietermaritzburg. It was also set up at the DWAF Residensie Building, Pretoria, as well as in Ladysmith during a Ladysmith Chamber of Commerce and Industry function at which the French Ambassador to South Africa was a guest.

- A second poster series showing a generic planning and integration process was produced for the DWAF and presented at the Steering Committee meeting in February 2000. This display illustrated the relationship and integration of the engineering, environmental and public involvement components of a project from inception to commissioning.

An A4 version of both Mobile Displays is included in Appendix D.6.

4.2.3.7 Media Releases

Media releases from the project team were prepared and sent to local, provincial and national newspapers at appropriate times during the Feasibility Study. Also, the PIC assisted the IEM Module with the national media advertisements of the project (Appendix D.7). These advertisements were placed in accordance with Regulation R 1183 of the Environment Conservation Act, Act 73 of 1989, and served the purpose of nationally advertising the TWP Feasibility Study.

At a local level, in March 1998 ACER placed an article in local papers circulated in the Thukela Catchment, namely, the Estcourt and Midlands News, and Ladysmith Gazette, on progress with drilling investigations. In November 1998 a general information article on the TWP Feasibility Study was placed in the same newspapers. A general information article with a map was prepared for the provincial paper, the Daily News, and was published in June 1999 (Appendix D.8).

All articles provided contact details so that interested and affected parties could contact ACER, the PIC. Furthermore, an advertisement inviting the general public to the Catchment Liaison Meeting (Section 4.2.1.1) was placed in the Estcourt and Midlands News, and Ladysmith Gazette (Appendix D.9).

Lastly, apart from placed media releases, there were a number of unsolicited media articles to which the PIC contributed. Examples include articles in the Engineering News, The Natal Witness and the Ladysmith Gazette.

4.2.4 General

During the course of the Feasibility Study, ACER prepared a range of documents to assist the PMT and other study teams. A list of general activities undertaken is described below.

4.2.4.1 Social Impact Assessment Terms of Reference

Dr R-D Heinsohn, Team Leader for the PIP and member of the PMT, prepared the first draft of the Terms of Reference for the Social Impact Assessment (Appendix E.1) and assisted in the adjudication of proposals. This responsibility lapsed when the Social Impact Assessment component was taken over by the IEM Module Team Leader.

4.2.4.2 Regional Development Initiatives

The following activities were undertaken by the PIC, mostly in close conjunction with the Project Co-ordinating Engineer, as part of its assistance to the Regional Development Module of the Feasibility Study:

- Thukela Estates Irrigation Scheme Proposal.
  ACER conducted a detailed *status quo* assessment and prepared a proposal for the rehabilitation of the Thukela Estates Irrigation Scheme for the purpose of stimulating regional development initiatives. This proposal was submitted to the KZN Department of Agriculture (Appendix E.2).
- Capacity Building Document.
  Following the Capacity Building Working Group meetings, ACER prepared a document to report on the proceedings and to stimulate further input and action (Appendix E.3). This report was submitted to the PMT and the Regional Development Task Team.
- Mziyonke/Mankandane Water Supply Proposal.
  On request of the Project Co-ordinating Engineer, ACER completed a comprehensive survey of the Mziyonke and Mankandane communities detailing individual houses, number of occupants and domestic water sources, to record the current primary water supply status (Appendix E.4). This information was used by the Project Co-ordinating Engineer and ACER to compile a proposal for the upgrading of the communities' water supply service. The proposal has been submitted to the uThukela Regional Council for its consideration.
- Regional Development Workshop.
  ACER arranged and facilitated a workshop on behalf of the Regional Development Module to discuss and workshop potential developmental spin-offs with regional stakeholders. The meeting was attended by 38 key stakeholders from the region.
- Weather Stations Capacity Building Motivation.
  The Project Co-ordinating Engineer identified Weather Stations as a potential capacity building opportunity, and requested ACER to assist with the compilation

of a motivation for consideration by the DWAF (Appendix E.5). This opportunity arose as the DWAF requires local climatological data for dam construction purposes and this data collection requirement could be used as a capacity building opportunity for one or more local community members.

- Practical contribution to capacity building.
  As part of its contribution to capacity building in the uThukela Regional Council, ACER sponsored the course fees for a representative of the Council to attend a course on Integrated Environmental Management. The three-day course was held under the aegis of the CSIR Environmentek, and positive feedback was received from the beneficiary.

In evaluation of the above efforts, it can be fairly stated that the efforts of the Project Co-ordinating Engineer and the PIC have contributed substantially to regional planning initiatives.

*4.2.4.3 Press and Information Kit*s

ACER compiled Press and Information Kits for the purpose of providing, in one document, a comprehensive, yet brief, background of the TWP Feasibility Study. The kits comprised the past newsletters and the pamphlet (Appendix E.6).

4.2.4.4 Position Statement on Abstractions from Aqueducts

During the Pre-feasibility Study, the possibility that communities along aqueduct routes would be able to receive RDP water supply requirements out of canals was documented as one of the positive development spin-offs possible from the scheme. However, during the Feasibility Study it became necessary for the DWAF to clarify its position on abstractions from aqueducts. The essence is that, despite constraints, abstractions from aqueducts for domestic water supply remains an opportunity to be investigated on a case by case basis. In this regard, the DWAF is committed to finding the best solution for each scheme. This requires that the merits and demerits of all options be investigated to determine practicality, feasibility and viability. It is possible that aqueducts will not prove to be feasible and, therefore, it is the position of the DWAF that the TWP, through its Regional Development Task, should dovetail its intentions with those of Local and Provincial Government in support of Local and Regional Water Supply Schemes where ever these are established within the TWP's sphere of influence within the Thukela Catchment. Indeed, in order to maximise assurance of availability, existing and new storage units should be considered as priority sources of bulk water for primary water supply schemes. However, given that water treatment is expensive, preference should be given to using such sources of raw water for regional or, at least, sub-regional water supply schemes. On a cautionary note in the light of uncertain timing of the TWP, the DWAF advises that such water supply schemes should not be premised on the TWP. Nevertheless, in the interest of responsible and sustainable development within the Thukela Catchment of KwaZulu-Natal and elsewhere, wherever possible, DWAF will optimise its bulk water infrastructure in support of domestic water supply schemes.

This position statement was prepared by ACER on behalf of the PMT and DWAF (Appendix E.7).

4.2.4.5 DWAF Code of Conduct

As study team members, and in particular DWAF drillers, were to be working on private land, ACER drafted a TWP Code of Conduct to which team members were obliged to abide (Appendix E.8). This was distributed to all affected stakeholders.

In the case of landowners at the dam wall sites where lengthy drilling investigations were required, a landscape architect was contracted to ensure compliance to the Code of Conduct and the rehabilitation of the site on completion of the drilling assignments.

4.2.4.6 Thukela River Park Conceptual Considerations

During discussions at Working Groups meetings, and in particular, with the stakeholders opposed to Jana Dam, mention was often made of establishing a River Park to conserve this “wild and scenic” stretch of the Thukela River. To test the concept of a River Park and facilitate further discussion on this subject, ACER drafted a document to more clearly represent the idea behind a River Park, its purpose, and the effect of the Thukela Water Project on the establishment of a Thukela River Park (Appendix E.9).

4.2.4.7 Migration Perspective

During discussions to integrate specialist environmental information arising from the baseline studies, it became apparent that the migration of people, although referred to in other baseline studies, had not been considered in its own regard. ACER drafted a brief specialist perspective on the potential impacts of the proposed Thukela Water Project on migration (Appendix E.10).

4.2.4.8 Decision Register and Record of Decisions

Given ACER's involvement from the commencement of investigations into the proposed Thukela Water Project, ACER was well placed to compile the draft format for the Decision Register and four Records of Decision for finalisation by the PMT and relevant study team leaders. These documents will form part of the TWP Record of Decision Report.

The Decision Register (Appendix E.11) is a proposed list of all significant decisions made during the Feasibility Study requiring a Record of Decision. The draft Records of Decision (Appendix E.11) that have been produced thus far are:

- The TWP Scheme Layout which documented alternatives investigated during the Reconnaissance and Pre-feasibility Studies, and decisions made in finalising a scheme layout leading up to Feasibility Study investigations.
- The Jana/Klip Decision which documented the selection process between the Jana and Klip Dam sites in the Thukela River.
- Aqueduct routes which documented the selection process between canal and pipeline alternative alignments.
- The realignment of the IEM Module which documented the change in focus undertaken by the IEM Module during the Feasibility Study.

Other Records of Decision, for example, dam type selection and aqueduct alignments, are presently in preparation.

4.2.4.9 Media Scanning

On a continuous basis throughout the TWP Feasibility Study, various forms of media were scanned for articles of interest and relevance to the TWP Feasibility Study and DWAF. Copies of articles of interest brought to the attention of the PMT are provided in Appendix E.12.

5 DISCUSSION

It is the considered opinion of the PIC that the Public Involvement Programme for the Thukela Water Project Feasibility Study has achieved its aims and objectives. Equally important, it is the opinion of the PlC that the principles of public participation as elucidated by the Department of Environmental Affairs and Tourism have been successfully applied.

This is evidenced by key aspects such as:

- A continuation of public involvement from the Pre-feasibility Study, through the Interim Study, to the Feasibility Study, with an ever increasing number of stakeholders participating as development proposals were formulated and elucidated. Wherever possible, I&APs were identified at an early stage, and were provided with timeous and accurate information to facilitate their meaningful participation in the Feasibility Study. Also of importance, stakeholders were informed when they were no longer directly affected by the development proposals.
- Throughout the Feasibility Study, I&APs were provided with sufficient project information in an easily assimilable and understandable manner to enable their participation, particularly as related to the formulation of project alternatives, for example, the alignment of aqueducts.
- Although feasibility studies are iterative in nature, for the duration of the TWP Feasibility Study there was an attempt at a clear and unambiguous focus on matters that were important at any given time during the study, for example, the Jana/Klip debate, aqueduct alignments and regional development, as described and discussed in information dissemination media at the time, for example, newsletters.
- At a site specific level significant resources were expended during the consideration of alternatives, particularly as relates to aqueduct types and alignments.
- Particular attention was paid to the detail of information used during decision-making in support of co-regulation, shared responsibility and sense of ownership, for example, the production of Technical Bulletins. Also, assistance was rendered to stakeholders in the preparation of material in support of stakeholder perspectives, for example, a perspective paper on Thukela River Park Conceptual Considerations.
- As and when disputes and conflicts arose, these were dealt with by the Public Involvement Consultant and the Project Co-ordinating Engineer.

6 WAY FORWARD

For a variety of reasons, for example, a changing legislative environment during the course of the different studies and study phases, it became apparent that the TWP Feasibility Study would not deliver definitive results, in particular from an environmental perspective, necessitating additional investigations prior to the commissioning of Detailed Designs and Project Implementation. This has led to the definition of a Decision Support Phase comprising a number of activities to be undertaken prior to a final Ministerial decision (in about 30 months time) whether or not to implement the TWP:

- Environmental Reserve Determination.
- Strategic Environmental Assessment.
- Scoping and an Environmental Impact Assessment.
- Technical and Economic Optimisation.
- Institutional and Financing Arrangements.
- Legal Framework.
- Authorisation and permitting.

A significant proportion of the activities to be undertaken during the Decision Support Phase are environmentally focussed. As public involvement is an integral part of Integrated Environmental Management, the principles and practice of which have been adopted and embraced by the DWAF (Section 4.1), will need to be applied during the Decision Support Phase.

The two main aims of the Public Involvement Programme for the Thukela Water Project Decision Support Phase can be described as follows:

- To provide a structured framework and process to enable I&APs to participate in all aspects of the TWP Decision Support Phase and to make contributions to study activities and resultant reports.
- To provide for the integration of public input into Decision Support Phase tasks and study management decisions.

The appointment of a PIC for the Decision Support Phase, to follow immediately the closure of the TWP Feasibility Study, is recommended in order that a seamless interface between study phases can be attained.

However, should the DWAF take a decision at the end of the TWP Feasibility Study not to proceed with a Decision Support Phase (*circa* July 2000), it will be necessary to decommission the current Public Involvement Programme in a structured manner, involving the decommissioning of I&APs, some of whom have been involved in the proposed Thukela Water Project since its inception.

7 CONCLUDING REMARKS

After a lengthy and inclusive PIP, ACER believes that I&APs have been afforded the opportunity to participate meaningfully in the TWP Feasibility Study. In addition, stakeholders from further afield have also participated, but to a lessor degree of intensity. Furthermore, measures are in place for I&APs to continue to have input into any additional phases of the investigation in terms of future environmental investigations, design, construction, the management of impacts, and monitoring the effectiveness of management programmes.

Immediate steps into the future relate directly to a DWAF decision whether or not to continue with investigations into the proposed Thukela Water Project. If the decision is positive, public involvement will continue for the duration of the Decision Support Phase. However, if the decision is negative, public involvement activities will be decommissioned, with stakeholders being thanked sincerely for their valuable contributions over the past few years.

8 REFERENCES

DEPARTMENT OF ENVIRONMENTAL AFFAIRS & TOURISM. 1998. *Environmental Impact Management*. Newsletter No. 3, April 1998. Pretoria, South Africa.

ANNEXURE 1

Schedule of key public involvement activities undertaken between March and July 2000

- Meetings.
  - Project Management Team meeting, 16 May 2000, Pretoria.
  - A RDM/EIA Workshop, 19 May 2000, Pretoria.

- Services.
  - A site inspection on 20 June 2000 of the Jana Dam drilling site to document rehabilitation measures still outstanding. These were recorded and forwarded to the Project Co-ordinating Engineer for attention.
  - On-going media monitoring.
  - On-going stakeholder correspondence and data base maintenance.

- Products.
  - Updating of the TWP Web Site, primarily to include module reports as they became available.
  - Production of a poster for the Thukela Biosphere's display at the Weenen Nature Reserve.

- General.
  - Review of various reports at the request of the Project Co-ordinating Engineer.
  - Additional work on Decision Registers and the Record of Decisions.

PBV000-00-8799

Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

REGIONAL DEVELOPMENT OPPORTUNITIES

MAIN REPORT

MARCH 2001

Prepared by:
Thukela Basin
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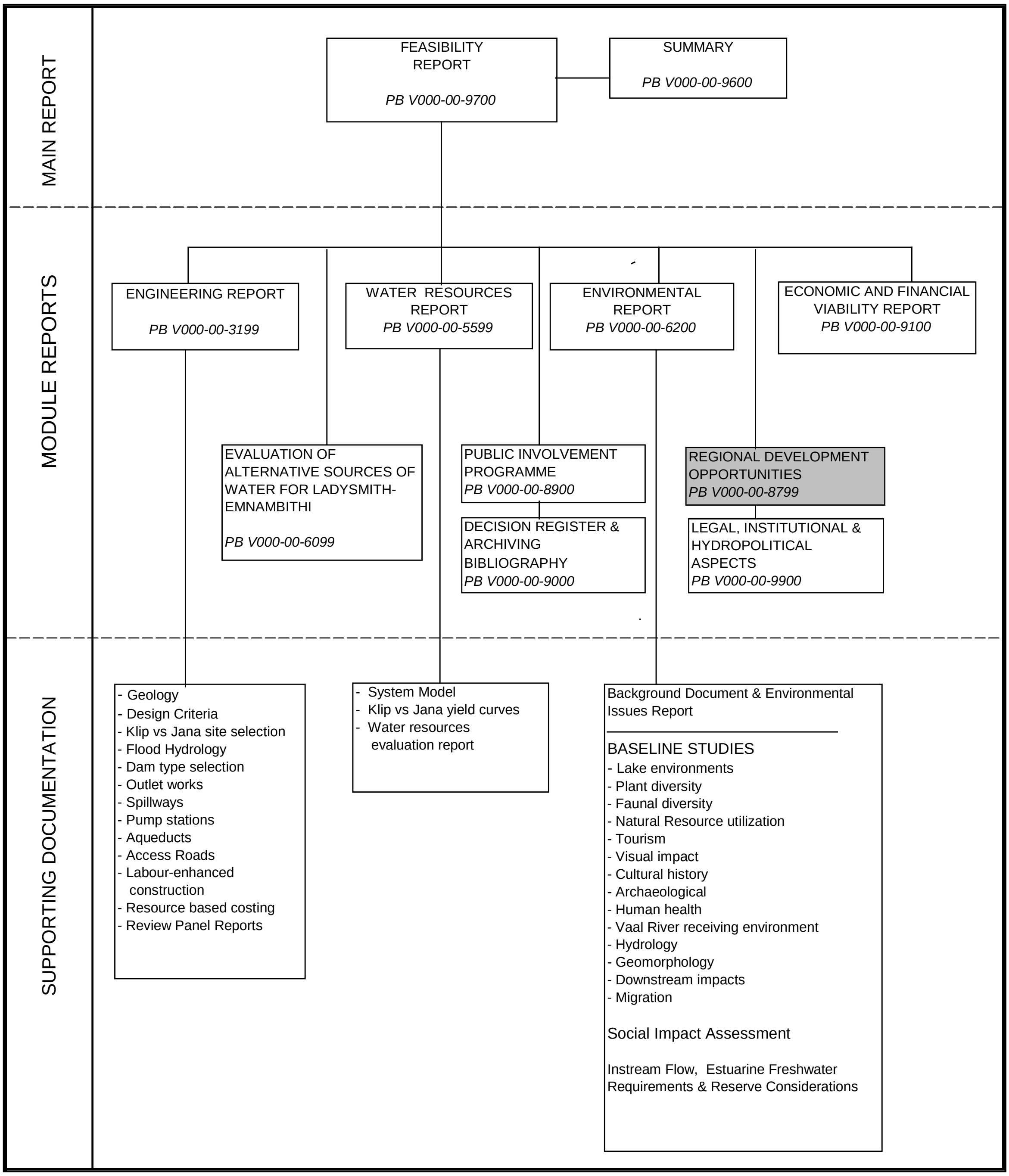
Thukela Basin Consultants

This report is to be referred in bibliographies as:

Department of Water Affairs and Forestry, South Africa. 2001. Thukela Water Project Feasibility Study. Regional Development Opportunities Main Report. Prepared by Urban-Econ with the assistance of Rolodex, BKS Inc and M Sikhhakhana, as part of the Thukela Water Project Feasibility Study. **DWAF Report No. PBV000-00-8799**.

STRUCTURE OF REPORTS



THUKELA WATER PROJECT FEASIBILITY STUDY
REGIONAL DEVELOPMENT OPPORTUNITIES MAIN REPORT

URBAN-ECON _____________ MARCH 2001

Approved for Urban-Econ by:

…………………………………
Eugene de Beer
Team Leader & Director

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

DAEA	KwaZulu-Natal Department of Agriculture and Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DPSS	Drakensberg Pumped Storage Scheme
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
EMC	Environmental Management Class
FSL	Full Supply Level
GDP	Gross Domestic Product
GGP	Gross Geographic Product
I&APs	Interested and Affected Parties
IEM	Integrated Environmental Management
IFR	Instream Flow Requirements
KZN	KwaZulu-Natal
LHWP	Lesotho Highlands Water Project
M AMSL	Metres Above Mean Sea Level
MAR	Mean Annual Runoff
NWA	National Water Act
NWRS	National Water Resource Strategy
PIP	Public Involvement Programme
PMF	Probable Maximum Flood
RCC	Roller Compacted Concrete
RDP	Reconstruction and Development Programme
RMF	Regional Maximum Flood
SADC	Southern African Development Community
SEA	Strategic Environmental Assessment
TVTS	Thukela-Vaal Transfer Scheme
TWP	Thukela Water Project
VAPS	Vaal Augmentation Planning Study
VRS	Vaal River System
VRSA	Vaal River Supply Area
VRSS	Vaal River Supply System
WCD	WORLD COMMISSION ON DAM

PREFACE

This Module Report on possible regional development initiatives associated with the Thukela Water Project proposals emanating from the Feasibility Studies was prepared by Urban-Econ. The authors were appointed to undertake one of 15 modules in the Feasibility Study and obtained information from and liased, inter alia, investigating teams assigned to the other modules. The report was prepared under the direction of the Project Management Team.

The report has been accepted as representing the outcome of the terms of reference assigned to Urban-Econ and has been used as an important source document for the preparation of a Main Feasibility Report on the Thukela Water Project. All the views, findings, interpretations and recommendations of the authors may not necessarily have been included in full in the Main Feasibility Report. Deviations from this report are noted in the Main Feasibility Report.

SUMMARY

This regional development investigation initiated by the Department of Water Affairs and Forestry is one of the first of its sort to be undertaken in South Africa. The initiative is intended to benefit the region in which most of the impact that will be caused by the construction of the proposed R5 billion Thukela Water Project (TWP) will be felt. The region referred to in this investigation, is the geographical areas that will be directly impacted on by the construction and operation of the dams and water transfer systems. The impact of the dams and aqueduct systems vary considerably, depending on the specific development aspect being considered. It is clear that the regional influence of the TWP on agriculture will, for example, be different from that on tourism. The study area which is the object of this investigation is therefore a generic region which could roughly be equated to the boundaries of the uThukela region of KwaZulu-Natal but could deviate from political boundaries depending on the nature of the impact being considered.

The purpose of the study is to identify the regional development opportunities that will arise as a result of the construction and operation of the dams and aqueducts constituting the TWP. The TWP is a major proposed undertaking by which water is to be transferred from the Thukela and Bushmans Rivers in KwaZulu-Natal to the Vaal River System. This water supplies portions of six of South Africa's nine provinces. The study seeks to maximise the development impact that the TWP could potentially have on the donor region by identifying and promoting such opportunities. The initiative to undertake an investigation of this nature originates from the recognition by the Department of Water Affairs and Forestry that large construction projects such as the TWP, can seldom have long-term sustainable development impacts on the local area in which they are implemented, unless a determined effort is made to maximise the benefits to local stakeholders. Large construction projects are mostly so large that the local economy is unable to fully exploit the opportunities created. The majority of the raw materials, equipment, and skills needed to undertake such an exceptionally large project, more often than not, have to be imported into the region where the project is to be constructed. Other than providing some of the labour for the low skilled and menial tasks, the local region often derives little long-term benefits from the project.

It must be recognised from the outset that the Department, whilst initiating this study, does not intend to encroach into the areas of responsibility of other Government Departments, authorities or development agencies. Thus, although the Department of Water Affairs of Forestry is conducting this study, it does not accept responsibility for implementing those development opportunities that fall outside of its direct jurisdiction. The initiative and responsibility for implementing the development opportunities identified in this study therefore rests with the respective functional government organisations, private sector organisations and also civil society. Every effort has been made during the Feasibility Study to sensitise local stakeholders to this communal responsibility and to ensure that the TWP has been incorporated in long-term development planning conducted by other agencies.

In exploring and investigating the development opportunities that the TWP may create in the region, a comprehensive approach has been adopted. This approach is based on the integrated development approach that has its basic premise that all facets of development must be related and integrated with each other. This means that the social, physical, spatial, environmental, economic and institutional dimensions of the development environment are considered as part of this project. The identification of the development opportunities from this broad base approach gave rise to the identification of 13 groupings of development opportunities. These groupings of opportunities relate to:

- Community development and welfare issues;
- Tourism;
- Commercial development;
- Industrial development;
- Agriculture;
- Training and capacity building;
- Materials procurement;
- Logistics;
- Physical infrastructure development at the Jana and Mielietuin dams sites respectively;
- Utilisation of access roads;
- Electricity supply; and
- Off-set funding.

A considerable number of opportunities have been identified within the above groupings. However, due to the relatively long lead time to construction, and uncertainty surrounding some of the basic parameters of the project, it is not possible at this stage to exactly define and quantify each development opportunity. The opportunities indicated should therefore be clearly understood to be mentioned for identification only. Little effort is made in this study to determine the feasibility of the individual projects identified. This is important since prospective private and public sector investors remain at all times responsible for their own feasibility investigations. Neither the Department of Water Affairs and Forestry, nor any of its agents, will be responsible for any investment decisions based on the findings of this report.

The table below provides an indication of some of the most important development opportunities identified. This is not a comprehensive list. The reader will have to study the report in more detail to obtain a full listing of the development opportunities identified.

DEVELOPMENT OPPORTUNITY	PHASE OF THE PROJECT	SECTOR TO INITIATE THE IMPLEMENTATION OF THE PROJECT
Local communities in the vicinity of the dams could benefit from infrastructure and social services provided at the dams, such as domestic electricity, raw water from the dams, access roads, health programmes and services and recreation (sports) fields.	Planning, construction and operational and maintenance phases	TWP Implementing Agent could prompt the opportunities during the design phase of the project. Working in conjunction with local, district and provincial authorities
Tourism – marketing of the region as an area of big dams in South Africa and the big five (animal malaria – free country)	Construction	Implementing Agent; District Municipality and KZN Tourism Authority
Tourism-museums about the dams, their background, construction, environment and surrounding communities and history. Communities can be effectively involved in these projects. The museum could provide a link between the culture and history of the region, the land reform initiatives, and the battlefields.	Construction operation and maintenance	Implementing Agent to initiate the design and location of a museum and accompanying facilities such as restaurant, parking etc.
Tourism – activity tourism in and around	Construction operation	District Municipality in liaison

the dams such as slalom canoe training facility, absailing, mountain climbing**, etc**	and maintenance	with private sector & tourism authorities
Tourism- accommodation and support services	Construction operation and maintenance	Private sector
Commercial –opportunities the SMME wrt retail, wholesaling, services and poverty alleviation.	Construction operation and maintenance	Private Sector
Industrial Opportunities – expansion of the existing industrial base by (I) directly related to the construction of the dams and aqueducts (ii) local small scale industrial opportunities created through increased domestic economic activity; and (iii) limited water intensive opportunities (marketing opportunity)	Construction operation and maintenance	District Municipality; local authorities; economic development forums i.e. chambers of commerce and industry, Department of Trade and Industry.
Agriculture – small scale share equity farmers down steam from the dams	Operation and maintenance	Dept of Agriculture; Dept of Education; private sector and civil society, Department of Manpower
Procurement – the procurement policy is probably the most important mechanism through which local supply firms could benefit	Construction and operational maintenance	Implementing Agent; private sector
Logistics – the spatial development of the region can potentially be influenced dramatically by the project.	Planning and design	Implementing Agent and District Municipality, other provincial and national Government Departments
Establishment of a Commercial Opportunities Bureau: Based in Ladysmith and Estcourt, the COB would address enquiries from tenderisers/contractors related to goods and services on the project, and direct them to relevant businesses or service centre in the region	Design and construction phases, to understand in detail the types of goods and services needed on the contract, and timeously establish databases and contact details et. Certain aspects of goods and services may also be stipulated in the contract documentation.	Estcourt & L'smith Municipalities; Chambers of Commerce, Provincial Government.
In the case of both Jana and Mielietuin Dams, re-use of the site facilities for community and/or tourism needs would have significant long-term benefits.	Design – to appropriately plan the layouts of the camps.	Implementing Agent, design team, District Municipality, town planners, community reps
A new and upgraded access road on the north bank at Jana, would have significant benefits for the greater community,	Preliminary/Detailed design stage, for review of transportation economics	Implementing Agent, design team, ISD team, District Municipality, KZN Roads Dept

improving access to Ladysmith/Ezakheni. It may well be that access roads to both banks may be the most viable, with the south bank road designed to a higher specification to accommodate the abnormal load trucks delivering materials and equipment to the construction sites.	and final decision on access road strategy.	
Sub-regional electricity distribution may be more viable given the investment supply to the dam sites. Local power supply could be used as a catalyst for SMME development, let alone for stimulating domestic demand.	Detailed design, Construction	Implementing Agent, design team, Eskom
Off-set funding and Counter Trade may offer some opportunities for the regional (or even Provincial/National) benefit. The foreign purchase or investment "make-up" of the project needs to be determined and matched against SA needs and opportunities. If opportunities are identified, the modus operandi needs to become part of the tendering process. This will require considerable up front preparation.	Preliminary design, Detailed design, tender	Implementing Agent, design team, project economics team TI, IDC, merchant banks.

The purpose of this report is to identify development opportunities that would maximise the benefits of the proposed dams and aqueducts to the local region. The motivation for identifying such opportunities originates from the realisation that large-scale projects such as the TWP, should endeavour to create the environment in order to encourage a long-term sustainable impact on the local region.

In order to maximise the impact of the proposed TWP it is important that the local and regional authorities and the local entrepreneurs be alerted to and motivated to take the initiative in pursuing the development opportunities identified in this analysis.

The Project Team is pleased to inform the reader that local business in Ladysmith and Estcourt, together with the uThukela District Municipality, have recently formed the uThukela Economic Development Initiative which is intent on stimulating socio-economic activity in this region by various means. This Initiative has together with the KwaZulu-Natal Department of Economic Development and Tourism and with the full support of the KwaZulu-Natal Cabinet, identified the Thukela Water Project as a potential flagship to rejuvenate the regional economy should this project be constructed.

THUKELA WATER PROJECT FEASIBILITY STUDY

REGIONAL DEVELOPMENT SUMMARY REPORT

CONTENTS

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

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SECTION ONE: INTRODUCTION

THUKELA WATER PROJECT FEASIBILITY STUDY
REGIONAL DEVELOPMENT MAIN REPORT

INTRODUCTION

1.1 Background

The Directorate: Project Planning, in conjunction with the Directorate: Water Resources Planning of the Department of Water Affairs and Forestry (DWAF) is responsible for the planning of water resource development in South Africa. As part of its ongoing provision of adequate supplies of water to the Vaal River System, DWAF commissioned the Vaal Augmentation Planning Study in 1994. Four possible source catchments were investigated, including the Thukela River Catchment.

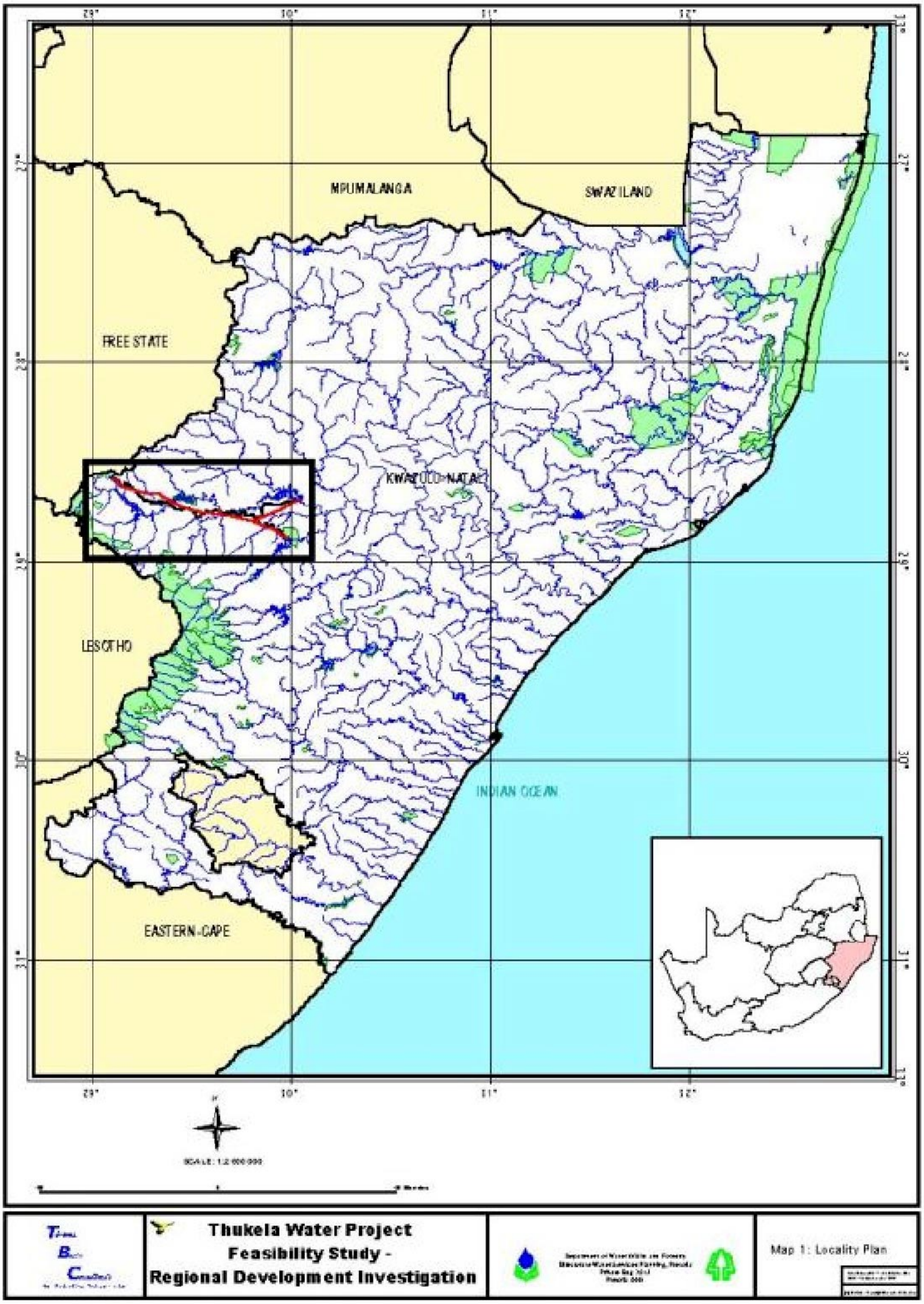
Following the completion of the pre-feasibility studies for the four catchments it was concluded that the Thukela River Catchment seems to hold more promise than the other three. Within the framework of the study, DWAF has indicated that regional development within the source catchment should receive special attention. To give effect to this, DWAF has included the identification of regional development opportunities as a component of the terms of reference of all studies commissioned as part of the TWP Feasibility Study.

Against the above backdrop, DWAF has also indicated that, at this stage, it can make no commitments other than those required for planning purposes. DWAF recognises that there are many and varied institutions in the Thukela River Catchment responsible for various aspects of development. It is not the desire or intention of DWAF to usurp these responsibilities but rather to work in partnership with provincial, regional and local institutions to optimise whatever benefits can and may accrue to the catchment.

The TWP Feasibility Study commenced in November 1996 with the appointment of the Project Management Team (PMT), PMT Specialists and the Public Involvement Consultants. For most of 1997 these teams were involved in the mobilisation of Study Teams to undertake investigations within the various technical, environmental and financial/economic modules, which comprise the feasibility study. Although regional development was given attention, this was in an *ad hoc* manner and not against clearly articulated aims, objectives and proposed products. Given its importance, PMT deemed it necessary to revisit the concept of regional development within the TWP and to give special attention to this matter. A specialist project team consisting of five members were consequently appointed to investigate and report on the regional development opportunities that may be initiated through the Thukela Water Project.

Although this report is intended to initiate discussion and optimism about the development implications of the TWP, caution should be exercised with respect to investment or other decisions that are based on this or any other reports. The TWP is in its feasibility study stage and there is no assurance that the project will continue to implementation.

MAP NO 1: THE TWP IN PROVINCIAL CONTEXT



1.2 Specific Objectives

Building on the notion of optimising the benefits to the Thukela River Catchment area of its water resource development, the aims of regional development in the context of the TWP are essentially four-fold:

- to align infrastructure needs of the TWP with infrastructure requirements and planning presently undertaken by provincial, regional and local institutions/agencies (public and private sectors);
- to unlock development potential in order to prepare catchment stakeholders for an anticipated investment of more than R5 billion over a projected eight-year period;
- to provide assistance to catchment communities and role-players (sectoral) in instances where such involvement has both immediate and long-term benefits for the role-players and the TWP alike;
- to quantify opportunities for economic evaluation.

1.3 Approach and Methodology

A cornerstone of regional development within and beyond the TWP Feasibility Study consists of partnerships with institutions/agencies already operating within the Thukela River Catchment. To this end, the approach is one of collaboration with responsibility vested with the appropriate and correct institutional authority. Specific actions, which are required to unlock the potential of the Thukela River Catchment, include:

- determination of the TWP development footprint;
- determination of other public/private sector organisations' footprint of proposed development initiatives;
- gap analysis between the TWP and other development footprints;
- stakeholder testing through workshops and other means of communication;
- model development and reporting together with the TWP Economic Evaluation Study Team.

In considering the development opportunities a broad perspective is taken of the impact of the TWP. The following components were therefore considered in identifying regional development opportunities:

- Economic
  - agriculture
  - tourism
  - construction, mining and quarrying
  - housing
  - commerce, retail, warehousing, manufacturing
  - transport
  - government and services
  - SMMEs
- Social
  - health and medical services
  - education and training
  - sport and recreation
  - welfare
- Infrastructure Services

  - roads (national, provincial, district, local)
  - water (bulk and reticulation, domestic and industrial)
  - electricity
  - telecommunication
  - materials requirements and supply services
  - labour intensive
- Other considerations
  - environmental aspects
  - housing and urban development
  - land reform and community development
  - financial services
  - security.

The methodology adopted was to consult with the relevant key role-players and interested parties on individual and group inputs. A regional development workshop was held to which all the key role-players in the region had been invited. Development opportunities leading from the TWP project were identified during the workshop.

The development opportunities recorded in this report represent an amalgamation of a number of small opportunities. The section dealing with tourism development, for example, records both the strategic nature of the opportunity and, as far as possible, indicates some of the specific and detail opportunities that could be identified. It must, however, be recognised that it is not possible at this early stage to identify and investigate all the specific opportunities that might emerge from the TWP. It is and remains the responsibility of entrepreneurs to identify and initiate further development opportunities. The dynamic and interactive relationship between such opportunities and the design and construction of the dams and adequate systems must receive careful attention. A concerted effort has been made by the project team to record those opportunities that may have an impact on the design and execution of the TWP.

The report deals with the regional development opportunities that are created as a result of the TWP. The term “region” is used in this context in a general sense and, although it could in most instances be assumed to represent the uThukela Region, this will not be so in all cases. The regional impact of the TWP will vary with respect to the specific aspects considered. It should, for example, be fairly obvious that the impact of the TWP on agriculture will not necessarily cover the same spatial area as its tourism impact. The reference to the regional development impact should, for the purposes of this project, be understood to coincide approximately with the uThukela Region of KwaZulu-Natal.

1.4 The Thukela Water Project (TWP)

1.4.1 Overview of the Proposed TWP

The proposed TWP as defined at feasibility level, is being planned to deliver 15m^3/s to the Kilburn Dam for transfer to the Vaal River System and comprises the following development components:

- Two large storage dams configured to supply a total of 15m^3/s
  - Jana Dam in the Thukela River approximately 7km downstream of the confluence of the Thukela and Klip Rivers

  - Mielietuin Dam in the Bushmans River immediately upstream of the western boundary of the Weenen Nature Reserve
- Aqueducts linking the proposed dams and the existing Kilburn Dam from which water will be transferred to the Vaal River System via the existing Drakensberg Pumped Storage Scheme. Three options for aqueducts are under investigation:
  - Open canals (with limited tunnels, pipelines and inverted siphons)
  - A pipeline ranging in size from 1.6 to 3m diameter
  - A combination of open canals and pipelines
- Appurtenant infrastructure including pump stations, access roads and bulk electricity supply.

1.4.2 Proposed Time Scale of the Project

The construction of the scheme could take up to ten years to complete commencing between the years 2004 and 2010, or later depending on Vaal River user water demands and the implementation of alternative schemes.

The assumption is that the first water will flow from the TWP to the Vaal River System during 2011, which, at this stage of planning, is the best available timing estimate at time of writing. Revision of this date will materially affect the programming of all the work. The proposed timetable is therefore indicative and is subject to modification resulting from the outcomes and or requirements of the TWP Feasibility Study and the management of the Vaal River System.

1.4.3 Jana and Mielietuin Dams

a) Dam Sites and Yield

Preliminary indications are that the provision of the ecological reserve will have a significant impact on the yield of Jana Dam. However, it is not possible to finalise the reserve allocation at present and, as a consequence, it has been necessary to undertake the engineering investigations for a range of dam sizes and yields. Until the ecological reserve is finalised it will not be possible to optimise the size of dams and aqueducts. A range of dam heights from 160m to approximately 190m is being considered for Jana Dam.

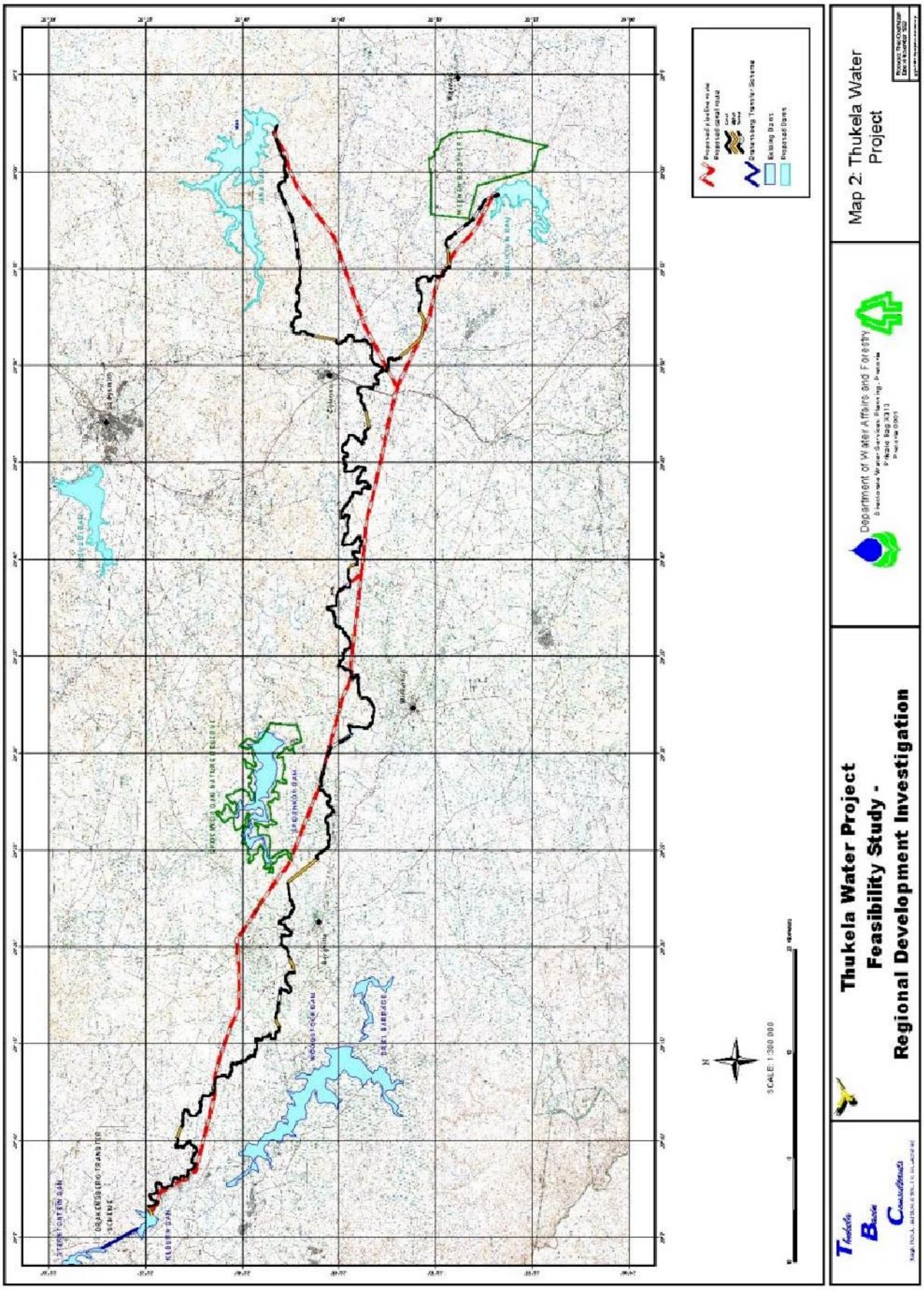
A similar situation exists at the Mielietuin site, where the height could be affected by the need to compensate for a reduced yield from Jana. At this site, attention is being given to a Full Supply Level (FSL)[1] range of 1010 to 1030 above mean sea level, representing a range of dam heights from approximately 75 to 95m.

b) Dam Construction

No detailed construction planning has been undertaken for either the Jana or Mielietuin Dam sites and only basic concepts have been considered to date. The final dam types selected will determine the impact of construction activities, as those requiring more cement will require more access roads, and will receive larger volumes of external traffic than other types of dams. The quarries for both dams will be located relatively close to the dam walls (certainly within the dams basins), and the related major movement of materials will not affect areas outside the respective valleys.

[1] Dam height is defined and measured as FSL above river bed level. This definition is used by the Planning Directorate of the DWAF.

MAP 2: FOOTPRINT OF THE TWP IN REGIONAL CONTEXT



1.4.4 Aqueducts

The aqueduct routes identified in the pre-feasibility and interim phases were evaluated during the initial period of the Feasibility Study. This process resulted in the identification of the two alternative types of aqueducts (canal or pipeline) and possible route options, as well as a third alternative representing a combination of these two aqueduct types.

a) Canal Type Aqueduct

The overall length of the proposed canal from Jana and Mielietuin Dams to Kilburn Dam would be approximately 110km. This length includes a 6.7km long tunnel on the section between Jana Dam and the aqueduct junction south of Colenso, and a 6.4km long tunnel on the section between an outlet tower in Mielietuin Dam and the aqueduct junction.

A fenced construction servitude width of 100m would be required if this alternative is implemented. On completion, permanent servitude widths of 40 to 80m would be required, depending on cross-slopes and bends in the canal alignment. A permanent service road would be provided within the servitude and the servitude would be security fenced, except at crossings. Construction camps of approximately 4ha would be located at 20km intervals and a water and electricity supply would be required at each camp. Each camp would typically include:

- a construction plant yard;
- workshops and welding plant;
- concrete batching plant and materials stockpiles;
- concrete precasting yard;
- stores building; and
- contractors and engineers offices.

The construction time to complete the whole route is likely to be four years, with the task being divided into five contract sections and each contractor working at a rate of 10km per year. Separate contracts would be required for the construction of each pump station and associated pumped pipeline and for the supply and installation of pumping plant and valves. Eskom power would be required at each pump station.

Borrow areas for selected soil fill would be at intervals of between 5 and 10km, and would only be chosen after detailed geotechnical investigations, including soil profiling and sampling are complete. Rock quarries for concrete aggregate, including a rock crushing, screening and washing plant, would be required. Sand borrow areas for concrete fine aggregate and filters would be located where sand deposits occur and at intervals of from 10 to 40km, depending on the size of the sand deposits. A sand fractionating, screening and washing plant would be centralised for each contractor.

b) Pipeline Type Aqueduct

The overall length of the pipeline type option from Jana and Mielietuin Dams to Kilburn Dam would be 121km. This length includes a deep cut or tunnel (approximately 1km long and 20m deep) approximately 12km east-south east of Kilburn Dam. A requirement of approximately 30m fenced construction servitude is envisaged. A permanent unfenced servitude of approximately 20m would be required after construction, although this would not require a permanent service road. Concrete marker beacons will be located along the pipelines at intervals. The pipeline will be covered by approximately 1.8m of backfill. Construction camps of approximately 4ha each will be required, located at 30km intervals.

The construction time associated with the pipeline aqueduct is likely to be three years, with the route being sub-divided into two main pipeline sections of approximately 60km each, with pipe laying proceeding at a rate of about 3 weeks per kilometer of pipe. The construction of the pipeline type aqueduct would include the construction of valve chambers, culvert type crossings under roads and railways, scour outlets and concrete erosion/corrosion protection under rivers, together with the fitting of values, waterhammer protection devices, flow metering equipment and inspection access facilities. There would be a pumping station at each dam plus two intermediate pumping stations along the route of the aqueduct.

1.4.5 Supporting Infrastructure

a) Jana Dam Access Road

The initial route location for the Jana Dam access road was largely determined by the alignment of an existing gravel road and the topography over the remainder of the route to the dam site.
Adjustments were made to the horizontal and vertical alignment of the existing road to conform to the requirements of the KwaZulu-Natal Department of Transport for a Type 4 (7m wide surfaced) road.

b) Mielietuin Dam Access Road

The route location for the Mielietuin Dam access road was mostly determined by the mountainous rolling topography, between Main Road 13 and the proposed dam site.

The heaviest traffic, in terms of heavy vehicles, will occur during the construction phase of the dam walls. Thereafter it is envisaged that the road will predominantly be used by light vehicular traffic.

c) Realignment of Weenen to Estcourt Road in Mielietuin Dam Basin

As a result of the 1:50 year flood level of the Mielietuin Dam it is found that a short 1.7km long section of the existing Main Road 13 will encroach into the Mielietuin Dam basin. It is therefore proposed that this section of road be realigned to the north to fall outside the 1040m contour.

d) Pumping Station Access Road

The route location for the seven proposed pumping station access roads was largely determined by the alignment of the existing gravel roads. Adjustments were made to the horizontal and vertical alignments of the existing roads to conform to the requirements of the KwaZulu-Natal Department of Transport for a 7.5m wide type 5 gravel road.

It is envisaged that the roads will only be used by heavy vehicles during the pumping station construction phase. Thereafter the roads would mainly be used by predominantly light vehicular traffic.

e) Service Link Roads

Node links to proposed aqueduct route service roads from existing main roads could be located at intervals of 40km or less along the proposed routes.

f) Rail Road

No new rail road facilities are required. Existing facilities which are reportedly under-utilised at present, will most likely be used. A storage facility and loading yard may be established at the existing Colenso Station, within the existing station boundaries, for handling of materials and equipment transported by rail.

g) Other Services

- Existing services – No major re-routing of existing services will be necessary as these do not fall within the proposed dam basins.

- Services required by contractors – The contractors will require engineering services both at the dam sites (construction sites) and at the camps accommodating construction staff.

1.5 Report Outline

Development opportunities have been amalgamated or categorised into thirteen major groupings, arranged into six major parts of the report. Since one of the objectives of this regional development investigation is to benefit the disadvantaged groups, the first part deals with community development and welfare issues. The second part deals with economic development opportunities and consists of four sections, dealing with tourism, commercial, industrial and agricultural development opportunities.

The third part deals with labour, materials, procurement and logistical supply of the input materials to the project. The second to last part deals with opportunities related to the physical construction and infrastructure provision to the Jana and Mielietuin dams, aqueducts, access roads and electricity supply. The last part relates to the opportunity of off-set funding and the possible impact thereof on the region.

The last and final section of this report deals with a possible methodology by which the opportunities can be managed and implemented.

SECTION TWO:
COMMUNITY DEVELOPMENT

2. COMMUNITY DEVELOPMENT

2.1 Description

A number of community development benefits can be derived from the TWP if construction goes ahead. The following opportunities are described in the report:

- provision of electricity;
- potable water – increased assurance of supply;
- access roads;
- transfer of physical infrastructure;
- transmittable diseases (HIV/AIDS) awareness;
- recreational facilities.

2.2 Electricity

2.2.1 Description

The provision of electricity to rural households can be linked to the construction of the dam or the generation of local electricity through mini hydro or solar systems.

2.2.2 Assumptions

The following assumptions can be made:

- Rural households, small business and service delivery points in the region need access to electricity.
- The provision of electricity to rural small consumers is a priority for the national government.
- Electricity will be available during the construction of the project/after the project has been constructed.
- The capital cost of providing power supply to neighbouring communities could be significantly reduced through the provision of electricity to the construction phase or even through limited hydro power generation at the dams.

2.2.3 Project Type

The construction and operation of an electrical "reticulation" network to households, small businesses and service delivery points in the sub region.

2.2.4 Population

At the Jana-Mhlumayo complex – 21 543 people; and at Mielietuin-Tembalilhle, Cornfields and Weenen complex – 8 445 people.

2.2.5 Responsible Role-Players

- Design
  - Electricity provider (Eskom)
  - uThukela District Municipality
- Implementation
  - Electricity provider (Eskom)
  - uThukela District Municipality.

2.3 Potable Water

2.3.1 Description

Potable water could be provided to rural communities close to the dam sites.

2.3.2 Assumptions

The following assumptions can be made:

- The provision of potable water to rural households is a priority for DWAF and the local authority.
- The provision of potable water to rural households close to the dams will not consume large amounts of water.
- Water sourced from the dams for household use will be relatively cheap.
- A number of households can be reached in this manner.
- The assurance of supply to downstream domestic water users who rely on run of river will inevitably increase as a result of the implementation of the Reserve (for basic human needs).
- Politicians and other domestic users (rural communities and land reform projects) adjacent to the proposed dams have indicated that they would like access to supplies directly from these impoundments. Given the relatively small quantity of water required, DWAF will have to give serious consideration to these requests.

2.3.3 Project Type

The sourcing of water from the dams or run-of-river, purification and reticulation to households in the vicinity of the dams.

2.3.4 Population

Jana-Mhlumayo complex (design has been completed for Thukela estates community) – 21 543 people
Mielietuin-Thembalilhle, Cornfields – 4 741 people.

2.3.5 Responsible Role-Players

- Design
  - uThukela District Municipality
  - DWAF (KZN)

- Implementation
  - uThukela District Municipality
  - DWAF (KZN)

2.4 Access Roads

2.4.1 Description

Better road access for rural communities close to the dam sites using the high quality roads that has to be built for access during construction and operation.

2.4.2 Assumptions

The following assumptions have been made:

- The construction of the TWP will require roads to source/deliver materials and human resources.
- To reroute such roads marginally for the benefit of local communities will not add major costs to the TWP.
- To upgrade some community roads to allow such people access to the work site will not add major costs to the TWP.
- Improved road access to the region will stimulate the local economy positively. These approach routes must be carefully planned to maximise economic benefit to these local communities.

2.4.3 Project Type

The construction of access roads to dam sites in such a way that those local communities benefit optimally.

2.4.4 Geographical Location

- Land reform communities
- Partner for Rural Advancement (PRA) restitution group (land east of Colenso)
- Gannahoek
- Ekuthaleni
- Jana (Northern bank)
- Mziyonke and Mankandane communities – 2 000 people
- Mhlumayo complex – 21 543 people
- Although the aqueduct route are relatively short and are located in commercial farming areas, efforts during the detailed design phase of the project should try to optimise the location of these roads in order to benefit local communities where possible.

2.4.5 Responsible Role-Players

- Planning/Design
  - Feasibility Study Engineering Team
  - TWP.

- Implementation
  - TWP
  - Road construction contractors.

2.5 Transfer of Physical Infrastructure

2.5.1 Description

Some of the physical infrastructure to be constructed and used during the construction of the TWP can be transferred to service delivery agents for use as clinics and community centres.

2.5.2 Assumptions

The following assumptions were made:

- Facilities to be used as recruitment centres, health centres, site offices, construction camps, etc will be needed during the TWP construction phase.
- There is a need for physical infrastructure, for example clinics in the communities neighbouring the dam sites at certain sections along the proposed aqueduct routes.
- The neighbouring communities will have access to better services if such facilities are transferred to a relevant authority and are utilised productively.
- Service delivery agents should have the budget, will and energy to utilise such infrastructure to serve the relevant beneficiary communities.

2.5.3 Project Type

To construct physical infrastructure for the TWP in such a manner (design and spatial placement) that it can be used for the benefit of communities by service delivery agents after the completion of TWP.

2.5.4 Geographical Location:

- In the vicinity of Jana
  - Mhlumayo complex (21 543 people)

- In the vicinity of Mielietuin
  - Tembalilhle, Cornfields and Weenen complex (8 445 people)
  - Bergville communities

2.5.5 Responsible Role-Players:

- Planning:
  - TWP
  - uThukela District Municipality
  - Department of Health
  - Other relevant service delivery agents e.g. Eskom

- Implementation:
  - TWP
  - uThukela District Municipality
  - Contractors
  - Relevant service delivery agents.

2.6 Awareness of Contagious Illnesses

2.6.1 Description

An HIV/AIDS awareness project will need to be launched amongst construction workers and community members in the vicinity of the sites where the project is to be constructed.

2.6.2 Assumptions

- Construction workers are likely to be affected by or affect local people with sexually transmitted diseases.
- Legislation is being drafted which will force employers to launch AIDS awareness programs in the work place.
- Construction companies can be required through contractual agreements to extend their awareness programs to include communities likely to be affected by construction.

2.6.3 Project Type

Launch a comprehensive AIDS awareness program amongst construction workers and affected communities.

2.6.4 Population

Ladysmith/Ezakheni	(111 000 people)
Colenso	(3 900 people)
Mhlumayo complex	(21 500 people)
Weenen complex	(3 700 people)
Thembalihle and Cornfields	(4 700 people)
Estcourt complex	(35 800 people)
Winterton	(4 500 people)
Bergville	(5 000 people)

2.6.5 Responsible Role-players

- Planning and Design
  - TWP
  - uThukela District Municipality
  - Department of Health.

- Implementation
  - uThukela District Municipality
  - Department of Health
  - Construction companies.

- Benefits
  - Reduced AIDS distribution/infection.

2.7 Institutional Organisation and Capacity

2.7.1 Description

The development of institutional organisation and capacity amongst affected communities to enable them to better manage civic responsibilities as well as to unlock development opportunities which would be available as a result of the construction of the TWP.

2.7.2 Assumptions

- Opportunities for community and economic development will arise from the construction of the TWP.
- Well-organised and skilled communities benefit more from development opportunities than disorganised and uninformed groups.
- Programs can be launched to develop institutional organisation and capacity in communities.

2.7.3 Project Type

An organisational and awareness project should be launched to make communities aware of potential benefits of the TWP and assist them to unlock such opportunities

2.7.4 Population

Ladysmith	(111 000 people)
Mhlumayo complex	(21 500 people)
Colenso	(3 900 people)
Weenen complex	(3 700 people)
Thembalihle and Cornfields	(4 700 people)
Estcourt complex	(35 800 people)
Winterton	(4 500 people)
Bergville	(5 000 people)

2.7.5 Responsible Role-Players

- Project design
  - uThukela District Municipality
  - TWP

- Project implementation
  - uThukela District Municipality
  -
- Benefits
  - Optimal unlocking of potentials for local communities.

2.8 Recreational Facilities

2.8.1 Description

Preparation of sports fields and other recreational facilities for construction workers and their transfer to communities after the completion of the TWP construction.

2.8.2 Assumptions

- Construction workers will need recreational facilities during the construction phase.
- Existing facilities will probably be inadequate in terms of quantity and quality.
- Local communities could use such facilities after the completion of the TWP.

2.8.3 Project Type

Sports fields and other recreational facilities are constructed and upgraded during TWP construction phase.

2.8.4 Geographical Location

Mhlumayo complex
Colenso
Weenen complex
Cornfields and Thembalihle
Bergville

2.8.5 Responsible Role-Players

- Planning
  - Thukela Water Project
  - uThukela District Municipality

- Execution
  - uThukela District Municipality
  - Construction companies

- Benefits
  - Improved (quality and quantity) sports fields for use by communities in the region.

SECTION THREE: REGIONAL TOURISM OPPORTUNITIES INITIATED BY THE TWP

3. REGIONAL TOURISM OPPORTUNITIES INITIATED BY THE TWP

3.1 Purpose of the Section

In this section the regional tourism development opportunities that can be initiated during the construction and operation phases of the Thukela Water Project are investigated. Opportunities are identified in this report at a pre-feasibility level and it is necessary that developers themselves consider the viability of the projects.

The methodology followed in this section is first to consider international and national tourism trends and patterns influencing the development of the tourism industry. Secondly, existing regional tourism plans are reviewed to form an understanding of the region and possible linkages to the dams. Finally opportunities that are expected to flow from the Thukela Water Project are investigated. In this section attention is therefore given to:

- defining and classifying tourism;
- describing trends in the tourism sector internationally and nationally;
- outlining some of the existing tourism facilities and attractions in the uThukela region;
- quantifying the existing tourism activities and expected future activities after implementation of the Thukela Water Project;
- identifying and describing the benefits that can be derived during implementation of the Thukela Water project;
- analysing the infrastructural developments and required assistance to stakeholders and communities to unlock such tourism opportunities and benefits.

3.2 Defining and Classifying Tourism

Tourism can be defined as encompassing all travel with the exception of commuting. Tourism activities can therefore be taken to include any activity concerned with the movement of people to destinations not related to their daily existence. The definition includes all journeys for the purposes of recreation (Strategic Framework for Tourism Development in South and Southern Africa, June 1991).

The tourism industry is multi-sectoral, including various subsectors and components. Although traditionally excluded from tourism definitions, the role of local communities is becoming increasingly important.

The different types of services offered to tourists can broadly be classified as:

- accommodation
- attractions
- travel
- entertainment
- business
- catering
- information
- transport
- infrastructure.

Tourism can furthermore be classified on the basis of the experience and activities sought, such as:

- Mass tourism which includes organised packaged tours and tourists who travel to popular commercial destinations where facilities and services tend to be standardised according to first world values.

- Alternative tourism which includes small scale tourism developed by local people based on local nature and culture. This type of tourism could include:
  - nature tourism;
  - cultural tourism;
  - historical tourism;
  - agro-tourism;
  - adventure tourism;
  - educational tourism; and
  - scientific tourism.

3.3 International and National Tourism Trends

Tourism is one of the world's fastest growing economic sectors. The forecasts of the World Trade Organisation (WTO) in 1997 was that world tourism will double in the 20-year period from 1990 to 2010. The WTO predicted an increase of 4.2% p.a. in tourist arrivals on a global scale. Cultural tourism has always been an important form of tourism but is increasingly becoming more important. Adventure tourism, backpacking, nature based/ ecotourism and cruise tourism are also becoming important forms of tourism.

Travel and tourism in South Africa was worth R60.5 billion in 1997 and is set to grow at a rate of 12.2 percent per annum between 1997 and 2010. The strongest attractions for foreign tourists to South Africa are, in descending order (Bennet, 1995):

- scenic beauty;
- wildlife;
- climate;
- value for money;
- diversity of attractions;
- African culture; and
- curiosity relating to the new South Africa.

Domestic tourists find the following attractions important, in descending order of importance:
- beaches;
- beautiful scenery;
- quiet, tranquil surroundings;
- general accommodation;
- water sports;
- game viewing; and
- health facilities.

3.4 The Status Quo of Tourism In The uThukela Region

The uThukela region abounds with natural resources, has a mild climate, has a fairly well developed infrastructure and has a long recreational history. A large number of diverse tourism attractions are also found within the region. The area provides the following types of tourism:

- nature tourism – with its rivers and valleys, mountains, wildlife, canyons, natural vegetation and wilderness the region is ideal for nature trails and walks, scenic drives and bird watching;
- eco-tourism and adventure tourism – with its rivers and valleys, canyons, wilderness and mountains the region is suited for activities such as bird and game watching, hunting, fishing, horse riding, river rafting, canoeing, abseiling, mountain biking, hiking, rock climbing and swimming;
- cultural tourism – with the indigenous Zulu culture, farming culture and small town culture the region is a popular destination for tourists in search of a cultural experience; and
- historical tourism – with its historical sites related to the Anglo-Zulu and Anglo-Boer Wars, Bushman paintings and archaeological sites from the iron-age, the region is a popular historical tourism destination.

Tourism themes that are offered by the uThukela region include:

- The Battlefields Route

The area between Estcourt and Ladysmith has many historical tourism attractions related to the Anglo-Zulu, Boer-Zulu and Anglo-Boer Wars. In addition to historical attractions, museums, national monuments and a number of battlefields and cemeteries of the Anglo-Boer War and Anglo-Zulu War are located in the area. Some of the more prominent ones being the Ambleside Military Cemetery, Bloukrantz Monument, Vaalkrantz Battlefields, Veglaer, Spioenkop Battlefields, Battle of Colenso, Chieveley Military Cemetery and Battle of Thukela Heights, and the siege of Ladysmith.The area also has historical and cultural links with other areas of Zulu culture.

- The N3 Corridor and its linkages to the Midlands Meander

The N3 links the region to Gauteng and Pietermaritzburg/Durban and passes through the Midlands Meander from Mooi River to the Van Reenens Pass at Harrismith, bypassing Ladysmith, Winterton and Estcourt. As the busiest inter-provincial highway in the country, and the route of most domestic tourists to the coast, the N3 is an important tourism corridor.

Bergville and Winterton benefit considerably from the tourism trade, and also provide in some of the commercial needs created by the tourism industry. Weenen is also experiencing some growth as a commercial centre, providing a stop over point for taxis travelling from Johannesburg to the North Coast. Moves are underway to develop Van Reenen as the gateway town.

- The Thukela Biosphere Reserve

The Thukela Biosphere is located around the confluence of the Thukela, Bushman's and Bloukrans Rivers between the Thukela River to the north, Colenso to the west, the Weenen Game Reserve to the south and Muden to the east. The biosphere focuses on conservation and community upliftment and accommodation in the biosphere includes guesthouses, cottages, lodges and activities such as hiking, hunting, white water rafting and canoeing are provided for. Cultural tourism and game farming are particularly strong in these areas.

- The Mountain Meander

The Mountain Meander area is more commonly known as the Central and Northern Berg areas. The areas are rich in environmental attractions and host a variety of accommodation types including hotels, guest houses, bed and breakfast accommodation, as well as tented, hutted and normal camp sites and a major resort and recreation area. A number of nature parks, reserves, state forests and resorts are located in the Berg areas within the uThukela region

The Berg hosts a number of culturally interesting attractions, based mainly on the Bushmen and Zulu cultures. Other tourist attractions are the Amphitheatre (the most photographed in KZN) and Tugela Falls, the second highest waterfall in the world.

Other activities include scenic drives, bird and game watching, trout and bass fishing, horse riding, rock climbing and hiking. Winterton, Bergville and Estcourt provide in the majority of the commercial needs of the Drakensberg tourists.

- Bushman’s River Meander

The Bushman’s River Meander is an initiative developed by the Bushman’s River Tourism Association in Estcourt. The initiative focuses on providing outdoor adventures, battlefield excursions, factory shop tours, wildlife trails and safaris, and Zulu culture in and around Estcourt to tourists. It also features events such as canoeing, swimming, hiking and cycling along a route marked out along the Bushman’s River between the Drakensberg and the Weenen Nature Reserve. The Bushman’s River Meander could be linked to the popular Midlands Meander in future.

- Other key features

The uThukela region has an abundance of water and four large dams, namely the Spioenkop Dam, Wagendrift Dam, Quedusizi Dam and the Woodstock Dam. Two of the dams have been proclaimed as parks or reserves. These and other parks and reserves in the region include:

- Wagendrift Dam Resort south of Estcourt. Activities include water sports such as angling, sailing, boating and skiing. Camping and caravan sites and picnic facilities are provided.
- Spioenkop Reserve between Ladysmith and Winterton adjacent to the Spioenkop Anglo-Boer War Battlefield. Activities include water sports such as angling, yachting, skiing and power boating. Provision is made for battlefield tours and self guided trails. An Anglo-Boer War museum, sports facilities and a curio shop are located in the reserve. Accommodation facilities are provided at campsites and caravan parks.
- Royal Natal National Park, situated in the northern Berg area. Activities include bird and game watching, hikes and walks, water sports and fishing. Bungalows, cottages and campsites are located in the park.

- Rugged Glen Nature Reserve, adjacent to the Royal Natal National Park in the northern Berg area. Activities include horse riding, nature trails, mountaineering, game and bird watching activities. Campsite accommodation is provided.
- Giants' Castle Game Reserve is situated in the central Berg area. The reserve has Bushmen paintings and bird and game watching activities. Campsites, caravan sites and chalets are located in the reserve. This venue also boasts the Main Caves Museum.
- Moor Park Nature Reserve is situated in close proximity to the Bushman's River and Wagendrift Dam. Activities include game watching.

A new tourism initiative in the uThukela region, the Mweni development, proposes a range of facilities such as a resort, hotel, lodges, campsite, a cable car and pony trekking.

This development will form part of the "Western Development Corridor" along the "Roof of Africa" route. The "Roof of Africa" route, an initiative by the uThukela District Municipality, is a scenic route through Lesotho, Eastern Free State and KwaZulu-Natal, with parts of the route passing through the uThukela region along the Drakensberg mountains.

Tourist Information Offices are situated in the uThukela District Municipality, Bushmans River Tourism Association (Estcourt), Ladysmith Local Municipality, Drakensberg Tourism Association (Winterton), Cathkin Peak Local Municipality, the Thukela Biosphere (Weenen) and the Ultra City on the N3 Highway near Estcourt.

3.5 Tourism Development Opportunities of the Thukela Water Project

The Thukela Water Project will impact on three components of tourism development on a regional level.

First the construction of the dams and canals/pipelines creates opportunities for the establishment of larger tourism initiatives or theme developments and the formation of links with existing facilities and attractions in the region. Secondly the construction initiates opportunities around the dams and thirdly opportunities on the dams themselves could be exploited after the project has been constructed.

The Thukela Water Project will be developed in three phases: the design/tender phase, the construction phase and the maintenance and operational phase. The design/tender phase does not impact significantly on tourism development. Tourism opportunities can be initiated during the construction and maintenance phases of the Thukela Water Project. During the construction phase facilities and infrastructure that would be utilized as tourism facilities in the future could be established at and around the dams. It is expected that the tourism sector will expand significantly during the maintenance/operational phase of the project when the dams and canals/pipelines are completed. As was experienced on the Lesotho Highlands Water Project, significant increases in tourists may be anticipated during the construction phase of the project.

3.5.1 Tourism Theme Development

The implementation of the Thukela Water Project and construction of the Jana and Mielietuin dams will generate significant potential to develop and market the uThukela region as the "**BIG DAMS**" area. Linkages can be created with the Katse and Sterkfontein dams and St Lucia Lake in surrounding regions and with dams and rivers within the uThukela region, i.e. Woodstock, Spioenkop, and Wagendrift, the proposed Mielietuin and Jana dams.

For example, a proposed Floatplane route could be considered as one of the opportunities initiated by the Thukela Water Project, to provide water adventure tours to the different dams. The following tourism opportunities initiated by the Thukela Water Project could be developed:

- developing packaged water adventure tours and centres at the Jana, Mielietuin and other dams in the region, enhancing existing white water rafting opportunities in the region and linking these experiences;
- developing the recreational value and natural environment at the Woodstock, Spioenkop, Wagendrift, and proposed Jana and Mielietuin dams;
- the development of various facilities at the dams including accommodation facilities, picnic spots, cultural elements, fishing, boating, canoeing, educational facilities and house boats;
- developing infrastructure and services that link the Woodstock, Spioenkop, Wagendrift, and proposed Jana and Mielietuin dams and activity corridors between the dams and along rivers, such as good access roads, electricity and water services and linkages between services such as restaurants and roadhouses in towns and in the vicinity of the dams; and
- tourism activity nodes at the Woodstock, Spioenkop, Wagendrift, and proposed Jana and Mielietuin dams and activity corridors between the dams, along rivers and between regions with arts and crafts, cultural, historical, nature, educational and adventure activities;
- Information dissemination points.

3.5.2 Opportunities around the Dams

Recreation activities are closely associated with dams, creating the potential for the development of a range of activities on and around the dams. In general, dams, especially large dams with well-developed facilities and a range of activities, are considered important tourism attractions. In certain instances game reserves have been developed around dams quite successfully.
The areas surrounding the dams would lend themselves to a number of outdoor adventure pursuits such as mountain bike trails, hiking, fishing from the shores of the dams, sports such as swimming, a golf course (developed at the Mielietuin dam), hang gliding, abseiling and even rock climbing using the dam wall could be a possibility. It is anticipated that types of tourism experiences and activities that can be initiated by the Thukela Water Project will to be resort related and these are described in more detail below.

- Accommodation facilities

Accommodation facilities may be developed at the Jana and Mielietuin dams, which will encourage tourists to stay for longer periods at the dams and in the uThukela region. Self–catering facilities, chalets and camping sites could be developed on the northern bank of the Jana dam. Hotels, guesthouses and lodges could be provided on the southern bank. Houseboats could be considered.

The Mielietuin dam site is suited for the development of game lodges, guesthouses and hotels (including a golf course). The construction camp facilities could be sited and constructed (permanent structures not prefabricated materials) in such a way that the camps at the two dams could be converted into some of the above-mentioned facilities. The possibility of developing such infrastructure on the northern bank of Jana Dam is seriously being considered.

- Adventure Tourism Centre

The Jana dam is situated in a rugged area and is considered to be suitable for the development of an adventure tourism centre with houseboats, up-market tourism facilities and various adventure activities such as climbing, mountain biking, abseiling, hangliding, rafting, canoeing, swimming and sport activities such as tennis.

Local farmers, land reform communities and investors could become involved in developing these activities. The bank of the Mielietuin dam is considered to be suitable for the development of a golf course.

- Nature reserves and vantage points

The natural aesthetically pleasing environment of the dams should be developed and promoted as interesting nature related experiences. Existing tourism products in the area should be enhanced where possible (eg the Thukela Biosphere).

The Mielietuin dam is specially suited for nature and game viewing and game lodges that will appeal to the middle to high-income tourism market. Nature related tourism activities to be developed at the Jana dam and more especially the Mielietuin dam include trails, bird and animal watching, scenic viewpoints (eg the Little Niagra Waterfall at the top end of the Jana dam reservoir), and scenic drives. The possibility to proclaim a river park/nature reserve site at the proposed Jana dam (extending many kilometres downstream of the dam), or to extend the boundaries of the Weenen Game Reserve at Mielietuin should be investigated.

- Cultural, arts and crafts centre

With the rich Zulu culture in the uThukela region and various tribal authority areas in close proximity to the Jana and Mielietuin dams opportunities will be established to develop cultural activities and attractions at the dams. The Klein Niagara waterfall with its scenic landscape (in close proximity to the Jana dam) has potential for the establishment of an arts and crafts centre. Local traditional communities at Mzinyonke and Mankandane areas in close proximity to the dam create opportunities to initiate cultural activities at the dam. Activities could include cultural concerts or festivals, curio or arts and crafts shops, cultural educational activities and the cultivation of traditional plants and herbs. Facilities and attractions at the dams could have a traditional cultural theme with, for example beadwork, wire work, baskets and other traditional ornaments could be displayed. Should a road and other construction related infrastructure (offices, clinics, etc) be constructed north of the Jana dam site, these communities will have easier access to these facilities and will benefit from the proposed development in the long term. Another cultural opportunity that has to be investigated is the development of a cultural heritage site on the northern bank of the Jana dam.

- Educational museum and conference facilities

Conference and educational facilities to accommodate groups could be provided at the Jana and Mielietuin dams. Various educational experiences could also be developed at the dams, for instance the establishment of a research/conservation unit on fauna and flora species found at the dams. Linking this to a water rafting team building experience below the dam would be very attractive.

Educational tours can be developed to provide the public with access to the unit. The planning and construction of the Thukela Water Project could be documented and displayed in visitor centres at the dams. It would be viable to combine this with a proposed arts and crafts/cultural centre at the Jana dam.

- Water festival

Various annual festivals or events have been very successful in the KwaZulu-Natal province. Annual events such as the Duzi canoe race, the Midmar Mile (swimming race) and the Gunston 500 are examples of successful water related events in KwaZulu-Natal. It is anticipated that opportunities for the development of an annual water festival will be created with the development of a “Big Dam” area. The festival can feature events such as canoeing, swimming, white water rafting, hiking, fishing and boating events together with other entertainment such as cultural and musical shows.

- Marketing

Another important opportunity initiated by the Thukela Water Project is that media coverage during the planning and construction phase of the project will be high. The media coverage of the project could be utilised to market the area and developments at the dam. This can play an important role in promoting the uThukela region as a “Big Dam” area.

3.5.3 Tourism Opportunities on the Dams

The construction of dams creates opportunities for various adventure sports such as fishing, canoeing, swimming and boating. There may be specific demands for fishing at the Mielietuin dam and boathouses at the Jana dam. It is believed that there is potential for the development of fauna and flora conservation areas on the islands created within the Mielietuin dam. An international slalom canoeing training centre could be established in Estcourt and international teams could then train in the rivers below or even on the existing and proposed dams during European winters.

To unlock tourism potential initiated by the Thukela Water Project the following factors should be attended to:

- The water quality should be of a good standard to enable the development of a range of fauna and flora species at the dams;
- The size and depth of the dams should enable boating on the dams;
- Conservatories for fauna and flora species at the Mielietuin dam;
- The stocking of fish in the dams and establishment of a range of fauna and flora activities should be encouraged within parameters agreed to by KwaZulu-Natal Conservation Services and the Departments of Agriculture and Environmental Affairs;
- Access for boats from the water’s edge should be provided;
- Facilities should be provided to encourage water sports and other activities on the dams (power boat racing may, however, not be an option due to the nature of the neighbouring tourism activities); and

- Existing canoeing courses should be and water regularly released from the Wagendrift into the Mielietuin dam in order to develop an international slalom canoe training centre.

3.5.4 Synopsis of Opportunities

Table 3.1 provides a summary of all the anticipated tourism opportunities that could be initiated by the Thukela Water Project.

Table 3.1: Tourism Opportunities that could be initiated by the Thukela Water Project

TOURISM DEVELOPMENT	OPPORTUNITIES
	"BIG DAM" area.
Floatplane route	Link Woodstock dam, Spioenkop dam, Wagendrift, proposed Jana and Mielietuin dams and Katse dam, Sterkfontein dam and the KwaZulu-Natal North Coast.
Adventure centres	Water adventure tours at dams and rivers enhance white water rafting.
	Tourism nodes and corridors at and between dams.
	International slalom canoeing training centre and course between Wagendrift dam and the Mielietuin dam.
	Houseboats, adventure activities such as rock climbing, mountain biking, abseiling, river rafting, canoeing, swimming, hang gliding and sport facilities on the banks of Jana dam.
Recreation	Golf course at Mielietuin dam.
	Fishing at the Mielietuin dam, in particular, but also the Jana dam.
	Picnic and braai spots at both dams.
	Road stalls, restaurants, eating houses, pubs, beer halls and roadhouses.
Cultural nodes	Klein Niagara waterfall in close proximity has potential for arts and craft centre and cultural centre at the Jana dam.
Historical interest site	Cultural heritage site on the northern bank of Jana dam.
Education/cultural	Conference and education facilities on the northern bank of Jana dam and at the Mielietuin dam.
	Visitor centre and museum providing information on the Thukela Water Project and the dams.
	Cultivation of craft plants and making crafts, specifically at the Jana dam and establishing fauna and flora research unit at dams.
Water festival	Water festival, including swimming, canoeing, white water rafting, swimming, boating and fishing.
Accommodation	Boathouses on the banks of the Jana dam.
	Self-catering units, chalets and campsites on the banks of Jana dam.
	Hotels (including golfing weekend packages), guesthouses, lodges and health spas on the banks of Jana dam.
	Game lodges, health spas and timeshare facilities at Mielietuin dam.

TOURISM DEVELOPMENT	OPPORTUNITIES
Nature	Conservation of fauna and flora on the islands at the Mielietuin dam.
	The Mielietuin dam is suited for nature and game viewing, walking, scenic drives, 4 x 4 drives, scenic viewpoints.
Other	Establishment of infrastructure at the dam utilised to provide services to tourists.
	Marketing of the tourism attractions as general exposure of area increase.

3.6 Requirements to Unlock Opportunities Created

An important consideration is the identification of actions necessary to unlock the above-mentioned tourism opportunities created by the Thukela Water Project. A summary of the type of actions, funding requirements, partnerships, phases of the project and the responsible body for realising these opportunities is shown in Table 3.2. The possibility of forming a section 21 type development company to facilitate these development initiatives should be seriously considered.

Table 3.2: Requirement for unlocking tourism opportunities of the TWP

TYPE OF REQUIREMENTS	PARTNERSHIP	PHASE OF PROJECT	RESPONSIBILITY
Pleasant view of dams from road and at resort areas	Engineering, tourism organisation	Planning and construction	Department of Water Affairs
Size and depth of dams sufficient to enable float planes, boating and water activities	Engineering, tourism organisation	Planning and construction	Department of Water Affairs
Good quality of water for establishment of fauna and flora species and water activities	Engineering, tourism organisations	Planning, maintenance	Department of Water Affairs
Stock dams with fish	Environmentalists, developers	Maintenance	Environmentalists
Establish fauna and flora species and conservation on islands. Sell islands at Mielietuin dam to developers	Environmentalists, developers	Maintenance	Environmentalists
Develop scenic view points	Engineers, environmentalists	Planning, construction	Environmentalists
Develop walking trails	Environmentalists, developers	Planning, maintenance	Environmentalists

TYPE OF REQUIREMENTS	PARTNERSHIP	PHASE OF PROJECT	RESPONSIBILITY
Develop canoe training centre and course at Mielietuin dam	South African Canoeing Association, developers	Planning, maintenance	South African Canoeing Association
Develop museum and educational centre at Jana dam	Department of Education, SA Museum Services	Planning, operation	SA Museum Services; AMAFA
Develop 4 x 4 drives and scenic drives	Environmentalists, developers	Maintenance	Environmentalists
Develop infrastructure surrounding dams including roads, water, electricity, communication and sanitation services	Engineering, Department of Water Affairs, developers	Construction	Department of Water Affairs
Develop historical and cultural centre at Jana dam	Department of Water Affairs, uThukela District Municipality, CTO's	Planning, construction, maintenance	uThukela District Municipality; AMAFA
Utilise housing and other facilities of workers for tourism development	Department of Water Affairs, uThukela District Municipality, CTO's, Tribal Authorities	Planning, construction, maintenance	uThukela District Municipality; Tribal Authorities
Develop recreation, nature, cultural, educational, accommodation and other facilities at the dams	Department of Water Affairs, uThukela District Municipality, CTO's	Construction, maintenance	Developers
Marketing and exposure to area	Department of Water Affairs, uThukela District Municipality, CTO's	Planning, construction, maintenance	uThukela District Municipality; KZN Tourism Association
Development of a theme	Department of Water Affairs, uThukela District Municipality, CTO's	Planning, construction, maintenance	uThukela District Municipality
Develop traditional and water theme image at dams	Department of Water Affairs, uThukela District Municipality, CTO's	Construction, maintenance	Developers
Landing strips	Developers	Maintenance	Developers

SECTION FOUR: COMMERCIAL OPPORTUNITIES

4. COMMERCIAL OPPORTUNITIES

4.1 Introduction

This section of the report deals with *commercial opportunities* that could emanate from the development of the Thukela Water Project. Commercial activities comprise the following sectors: trade, transport and finance. Each of these three sectors consists of further sub-sectors. Trade consists of wholesale and retail trade, real estate and repair of personal and household goods. Transport consists of transport, storage and communication while finance comprises business, office and personal services, and financial services. These divisions can be broken down further into small, medium and large-scale enterprises. Small, medium and micro enterprises (SMMEs) cross-cut the above sectors.

In analysing the economic composition of the uThukela region it is evident that the manufacturing sector makes the largest gross geographic product (GGP) contribution to the economy of the uThukela region (33.3%). Table 4.1 shows that almost 30% of the contribution to the GGP of the uThukela region is made by commerce related activities.

Table 4.1 indicates that the uThukela region's commerce contribution to the GGP is 9% less than that of the province. The uThukela region contributes 3.2% to the KwaZulu-Natal GGP. With a population size of 7% of KZN it stands to reason that the population of this region is relatively poorer than the provincial average. Table 4.1 implies that further commerce-related development will be welcomed in the region.

Table 4.1: Composition of the Regional and Provincial Economies (% GGP contribution)

ECONOMIC SECTORS	UTHUKELA REGION	KWAZULU-NATAL PROVINCE
Trade	10.83	16.03
Transport	11.74	11.14
Finance	6.51	10.87
Sub–total: Commerce	29.08	38.04
Agriculture, forestry, fishing	8.08	6.16
Mining, quarrying	0.42	2.02
Manufacturing	33.29	30.73
Utilities	12.09	2.19
Construction	3.21	3.64
Services	13.84	17.22
TOTAL	100	100

Source: DBSA 1995

Table 4.2 shows that the bulk of commerce-related activities within the uThukela region lies within the trade sector.

Table 4.2: Approx. total formally listed commercial activities prevalent in the uThukela region

FORMALLY LISTED COMMERCIAL ACTIVITIES IN UTHUKELA REGION	
TYPE	TOTAL
Wholesale and Trade	820
Business/office and personal services	165
Private transport, storage and communication	85
Financial intermediation and insurance	202
Real estate services	50
Repair of personal and household goods	70
TOTAL	1 392

Source: Urban-Econ, Telephone Directory Survey, 1999

The informal sector plays an increasingly important role in both larger and smaller urban and rural centres throughout the uThukela region and is expanding throughout the KwaZulu-Natal province. It has been estimated by the uThukela Regional Development Plan that approximately 34 000 informal entrepreneurs were established in 1993. The majority of these entrepreneurs were involved in trading, hawking and other activities such as crafts, services and transport. These informal, commercial activities provide essential incomes to uThukela residents in various urban and rural areas.

It is envisaged that the local authorities would facilitate the development of small businesses. This may be done through local authority procurement policies, revision of town planning schemes and other legislation which may still be overly restrictive to informal (home) businesses, the promotion of infrastructural development, the facilitation of training programmes and financial support to entrepreneurs. The establishment of a Local Business Advice Centre could provide SMMEs with advice on, amongst others, business start-ups, business planning, assistance in premise allocation, marketing, professional and legal matters, taxation and accounting. Table 4.3 indicates the regional economic growth trend of the uThukela region from 1990 to 1995.

Table 4.3: Percentage economic growth trend for uThukela region from 1990 to 1995

ECONOMIC SECTORS	% GROWTH 1990-1995
Trade	0.3
Transport	2.6
Finance	3.4
Agriculture, forestry, fishing	0.5
Mining	-9.8
Manufacturing	3.1
Utilities	4.7
Construction	0.3
Services	1.5
TOTAL (WEIGHTED AVERAGE)	0.4

SOURCE: DBSA, 1995

The existing commercial profile in this region could change over the following years as a result of the Thukela Water Project development, SMME development as well as the increased or decreased income of the rural population. The most notable changes will take place in the areas that have been identified as having the greatest potential to develop into nodal areas. These areas have been identified as:

- the Bergville complex;
- the Estcourt/ Wembezi complex;
- the Limehill complex; and
- the Zwelisha complex.

Towns such as Bergville, Estcourt, Ladysmith, Winterton and the Loskop area are all situated on the main tourist routes and therefore have the potential to increase their commercial output as the tourism market expands. Tourism activities will influence the nearby facilities such as the informal arts and crafts industry, which will have a direct impact on the commercial activities which are aimed at marketing these products.
Due to the smaller agricultural contribution (8.1%) of the uThukela region, the establishment of irrigation schemes, emanating from the constructed dams, will significantly increase agricultural production. The marketing and selling of these products will result in the growth of retail and therefore the commercial component.

4.2 Opportunities Identified

The majority of commerce activities will commence during the construction phase of the dams and pipelines/canals.
During the operational and maintenance phase almost all of the commerce-related activities will subside. When identifying the opportunities, focus falls on the construction phase (see Table 4.4).

Table 4.4: Commerce related opportunities identified according to TWP triggers

TUGELA WATER PROJECT TRIGGERS	COMMERCE OPPORTUNITIES
1. Procurement of materials ▪ Steel ▪ Cement ▪ Building materials ▪ Stationery ▪ Working uniforms and protective gear	▪ Transportation of goods ▪ Warehousing ▪ Retail in stationery, protective gear and uniforms ▪ Trade in waste and scrap materials ▪ Renting of heavy duty machinery
2. Manpower supplies ▪ Number of skilled and unskilled labourers ▪ Buying power ▪ Health, education and recreational facilities ▪ Labour recruitment and provision	▪ Retail in civilian clothing supplies ▪ Wholesale ▪ Transportation of passengers (private) ▪ Warehousing ▪ Personal services (e.g. repair of household appliances) ▪ Estate agents ▪ Pharmaceuticals ▪ Furniture movers/transport ▪ Catering services

TUGELA WATER PROJECT TRIGGERS	COMMERCE OPPORTUNITIES
	▪ Retail ▪ Shops ▪ Bakeries ▪ Medicinal/Health services ▪ Liquor stores ▪ Canteens, shebeens and bars ▪ Take-away shops
3. Administration and management functions ▪ Professional services ▪ Computer-related services	▪ Legal offices ▪ Insurance brokers ▪ Business planning and management services ▪ Engineering consultancy ▪ Security companies ▪ Computer hardware, software and networking retail ▪ Research companies
4. Supporting services ▪ Telephones ▪ Electricity ▪ Financial intermediation ▪ Private transport	▪ Telecommunications ▪ Retail in household appliances ▪ Cash loans/personal loans ▪ Motor vehicle suppliers ▪ Automotive fuel suppliers ▪ Renting of motor vehicles and other transport ▪ Airport development ▪ Linkage with tourism ▪ Retail in hunting, fishing and boating equipment

Table 4.5 shows the breakdown of the commerce-related activities that could link opportunities into the uThukela region.

Table 4.5: Possible commerce-related opportunities emanating from Thukela Water Project during construction phase.

TRIGGER	COMMENT	CONSTRUCTION PHASE					
		TRADE		TRANSPORT		FINANCE	
		Wholesale and retail	Personal repairs	Transport, storage, communication	Financial services	Business services	Real estate
DAM CONSTRUCTION	Large labour force attracted to the area An increase in personal income per capita Large amounts of capital brought to region in terms of salaries paid out Strong links with tourism sector	▪ General shops and wholesalers ▪ Café's and take-away food shops ▪ Liquor stores ▪ Clothing and footwear suppliers ▪ Catering services ▪ Restaurants, bars and canteens with liquor license ▪ Motor vehicles and parts sales and range of maintenance services ▪ Automotive fuel suppliers ▪ Entertainment ▪ Pharmaceuticals ▪ Waste and scrap dealers/trade ▪ Computer retail ▪ Bakeries ▪ Leather and travel accessories ▪ Household furniture retail ▪ Hardware retail ▪ Retail trade in sports goods ▪ Welding	▪ Repair of footwear and leather goods ▪ Repair, servicing and installation of household and personal appliances ▪ Other repair services for the general public ▪ Vehicle towing service providers	▪ Urban, suburban and inter-urban bus and coach passenger lines ▪ Taxi services ▪ Safari's and sight seeing tours ▪ Renting of motor vehicles ▪ Furniture transport ▪ Existing airports developing further ▪ Operation of toll roads ▪ Courier services	▪ Central banking ▪ Discount houses ▪ Cash loans ▪ Lease financing ▪ Other credit granting ▪ Life insurance services ▪ Pension funding ▪ Medical aid schemes ▪ Security companies ▪ Renting of transport equipment ▪ Renting of other machinery ▪ Renting of personal and household goods	▪ Computer services – software, hardware, networking. ▪ Research services ▪ Legal services ▪ Accounting ▪ Auditing ▪ Maintenance and office repairs ▪ Tax consultancy ▪ Hardware consultancy ▪ Software consultancy ▪ Data processing ▪ Data base activities ▪ Research–related companies ▪ Professional consultants ▪ Advertising agencies ▪ Labour recruitment and provision of staff ▪ Building and industrial plant cleaning services ▪ Photographic	▪ Houses built for contractors, engineers and labourers ▪ Property owning and letting ▪ Developing and subdividing real estate ▪ Rent collecting agencies ▪ Rent collectors ▪ Appraisers and valuers ▪ Subletting of fixed properties

TRIGGER	COMMENT	CONSTRUCTION PHASE					
		TRADE		TRANSPORT		FINANCE	
		equipment suppliers ▪ /indigenous plants in the area can be sold commercially				activities ▪ Duplicating services	
PIPELINE / CANAL		▪ Catering services ▪ Mobile homes ▪ Vehicle maintenance ▪ Breakdown services ▪ Food and liquor retail shops ▪ Automotive fuel services	▪ Repair of footwear and leather goods	▪ Private taxi services ▪ Renting of motor vehicles ▪ Furniture transport ▪ Transport of equipment services ▪ Courier services	▪	▪ Labour recruitment and provision	▪ Rent collectors

Table 4.5 continues on next page

	COMMENT	OPERATIONAL AND MAINTENANCE PHASE					
		TRADE		TRANSPORT	FINANCE		
		Wholesale and retail	Personal repairs	Transport, storage, communication	Financial services	Business services	Real estate
DAMS	The assumption is made that all construction activities have been completed. All to most of the labourers and contractors have left the area. During this phase tourism-related activities have been established and attract a number of visitors to the area. These could include holiday resorts in the area; water sports related activities, e.g. boating and fishing. What is needed is a nucleus of activities that will be able to sustain their economic survival after the "buying power" has left the area. Commerce-related enterprises situated in Ladysmith and Estcourt will experience a decrease in annual turnover, but will have higher probability to sustain turnover than enterprises erected near construction sites due to locational advantage to established markets.	▪ Small shops selling necessities ▪ Possibly wholesalers ▪ Tourism-related activities such as arts and crafts, boating, fishing and hunting supplies. ▪ Automotive fuel suppliers		▪ Private taxi services to provide transport to residents next to connecting roads		▪ Computer maintenance services – hardware, software and networking	▪ Real estate offices ▪ (Real estate market will show decrease due to out movement of labourers and contractors who paid levies) ▪ Focus of real estate might shift towards tourism-related housing
PIPELINE/ CANAL		Automotive fuel supplies Hardware retail Automotive repair services				Monitoring pipeline/canal for defaults	

SECTION FIVE: INDUSTRIAL POTENTIAL ANALYSIS

5. INDUSTRIAL POTENTIAL ANALYSIS

The impact of the project on the industrial sector in the uThukela region and KwaZulu-Natal may be divided into three components. The first is the impact of the **construction** of the dams. The second is the impact of the **availability of water**. This process involves the location factors attracting certain water intensive industries to locate near water. The last impact is that of **economic agglomeration advantages**, and the indirect influences involved with the forward and backward linkages of industrial development during the operation and maintenance of the dams.

The towns and urban settlements in the region are currently focusing on local economic development initiatives. Local economic development can be defined as the process or strategy in which locally based individuals or organisations use resources to modify or expand local economic activity to the benefit of the majority in the local community. The local authorities of Ladysmith, Bergville, Winterton and other small towns are, for example, in the process of introducing local economic development initiatives to their communities. Investment in the industrial sector in these areas, as well as in Ladysmith and surrounds, takes place in small and micro enterprises in order to develop in the local community and produce products that would appeal to the local, as well as the national, market.

5.1 The Current Situation

The manufacturing sector is mainly situated in two localities in the uThukela region; Ladysmith-Emnambithi (including the Pieters Industrial Estate) and Estcourt. The major industrial sectors within these areas are clothing and textiles, metal products and agro-industry (e.g. food and timber processing). Most industries in the region are urban based, while some agro-industries are located on the outskirts of the towns. Factories are mostly owned by South Africans, Taiwanese and investors from the People's Republic of China. There are thus a number of diverse interests within this large and complex sector. The manufacturers are represented by the Ladysmith Chamber of Commerce and Industry (CCI), the Estcourt CCI, the Taiwanese CCI, the Chinese CCI and various sectoral associations.

A number of industrial centres such as Ladysmith and Emnambithi served as points for the old Regional Industrial Decentralisation Programme (RIDP), offering relatively high levels of incentives.
Nonetheless, despite the incentives, and the availability of water, labour and well-serviced industrial areas, the area has not succeeded in attracting a significant number of industries away from the major metropolitan centres in the country, and its outlook remains modest in this respect.

The structure of the 1993 industrial sector in uThukela is shown in Table 5.1. The analysis shows that the textile and food industries dominate the other industries in the area. Agglomeration advantages can be assumed to exist in these two sectors in terms of the skills of employees and the backward linkages of the industries.

Table 5.1: Employment percentages in the different industrial sectors in Emnambithi, Estcourt, Bergville and Klip River/Ladysmith

MANUFACTURING SECTOR	ENAMBITHI	ESTCOURT	BERGVILLE	KLIP RIVER
Food, beverages and tobacco	3,09	19.98	18.47	3.18
Textiles Wearing apparel Footwear and leather	64.17	50.64	46.83	54.87
Wood products and furniture	1,52	10.04	0	1.56
Paper and printing	0,63	1.30	1.27	1.57
Industrial chemicals Other chemicals Rubber & other plastics	12.72	3.84	7.65	11.25
Non-metallic products	0.76	1.64	3.82	0.53
Basic Iron & steel Basic non-ferrous metals	1.04	1.34	3.82	1.74
Fabricated metals Machinery & equipment Electrical machinery Motor vehicles Transport equipment	15.30	9.80	14.35	24.0
Other industry	0.68	1.39	3.82	1.29
TOTAL	100.00	100.00	100.00	100.00

Source: Urban-Econ economic database, 1998
Note: Rounding-off data errors

5.2 The Key Industrial Attributes of the uThukela Region

The key attributes of the uThukela region as far as the manufacturing sector are concerned, are:

- the availability of agricultural products from commercial farming;
- availability of water;

- agglomeration advantages of the existing industries;
- bigger buying power as more people are working;
- bigger offset for the manufactured products;
- linkages between industries and the commercial sector;
- materials sourced within the region;
- accessibility to railway sidings;
- the availability of unskilled labour;
- the availability of industrial land and buildings;
- the presence of development organisations; and
- supporting services provided by the authorities.

5.2.1 The Availability of Agricultural Products

The potential of attracting agro-industries to the area is high regarding the existing and potential agricultural products being produced in the region. Some of the most prominent industrial sectors in this respect are:

- abattoirs;
- processing of meat;
- dairy products;
- grain mill products;
- bakery products;
- beverages; and
- leather products.

5.2.2 The Availability of Labour

Labour exerts a locational pull in as far as it contributes to the total cost of the industry. In order to take advantage of a particular pool of available labour it is necessary for the firm to locate where this labour is available. In the South African context skilled labour is mostly concentrated in the metropolitan regions.
Unskilled labour, on the other hand, is available in the rural areas, usually at some distance from the metropolitan regions. The uThukela region is characterised by the availability of semi-skilled labour.

The labour orientation of a firm may be the result of a number of different factors such as wage levels, productivity, turnover and supply of labourers.
New labour legislation has an impact on the demand for unskilled labour in the rural areas, as the cost of this labour has become more expensive. The cost of the labour has a direct implication on the demand for unskilled labour, which has an effect on the locational factor regarding the availability of labour. The classification by industrial sector includes the following major manufacturing sectors: prepared animal feeds, nut foods, yarns and fabrics of vegetable fibres, clothing, tanning and leather products.

5.2.3 Agglomeration Advantages of the Existing Industries

The agglomeration advantages of existing industrial complexes make a significant contribution to the locational decisions of industrialists. In this study the concept of agglomeration advantages is used in its narrow meaning and refers to the direct forward and backward linkages which might exist between industries.

In order to identify the agglomeration advantages of the existing industries in the district, an estimation was made of the existing industries in Ladysmith, Estcourt, Bergville and Colenso. There are eight major and five secondary industries presently located in Estcourt of which only two are principally non-agriculturally based industries. These two factories are textile-based industries. Estcourt has a relatively high emphasis on textiles, agricultural processing and food and beverages.

Estcourt	Smaller industries
Nestlé	Texcourt/ Bergnette/Vepaknit
Tongaat Milling	Procorn Precast
Estcourt Bacon Factory	Ultra Badge
Glamosa Glass	J W Smith & Sons
National Co-operative Dairies	Bunji Toys
Narrowtex	
Burhose SA	
Masonite	

Colenso	Bergville
Tugela Steel	Berg Brick & Block Concrete Block
Amazon Footwear	National Sorghum Breweries Ltd
Ludewig Plastic Moulding Enterprises	Nestlé (SA) (Pty) Ltd

Most of the industries produce goods which are aimed at final consumer markets. The type of products produced includes items such as furniture, bakery products, textiles, clothing, carpets and rugs and footwear. This means that the opportunities to use the products as intermediate inputs to other industries are limited. The exception to this rule is the textile industries which provide inputs to the clothing and furniture industries. Waste materials produced by the industries also appear to be limited and mainly include wood, fabric, metal and leather off-cuts and sawdust.

In terms of the backward linkages of the industries, the following major groups of material inputs have been identified:

- steel tubing;
- wood (mainly for the furniture industries);
- fabrics which includes wool, acrylic, hessian, polyester and threads;
- leather;
- packaging materials;
- paints;
- glues; and
- foam.

5.3 Construction Linkages with Industrial Sectors

The construction of the dams will require the supply of manufactured products. These products could be provided by the existing industries or could result in the location of new industries in the district. The industrial sector will therefore have forward linkages with the construction of the dams and aqueducts. The South African input-output table was used to identify the possible impact the construction process will have on the manufacturing sector. A summary of the different industrial sectors involved, both directly and indirectly, with the construction sector is given in Table 5.2.

Table 5.2: Inputs needed by the construction process

LINKAGE TO OTHER SECTOR IN THE CONSTRUCTION PHASE OF THE DAMS AND PIPELINE	DIRECT OR INDIRECT IMPACT	INDUSTRIAL SECTOR
Agriculture	Indirect	Fertilisers, etc.
Construction	Direct	Industrial chemicals
Construction	Direct	Non-metal products
Construction	Direct	Iron and steel
Construction	Direct	Machinery renting, etc.
Construction	Direct	Industrial machinery
Construction	Direct forward linkage	Wood products
Construction and housing	Direct	Structural metal products
Construction and housing	Direct and indirect	Cement
Construction and housing	Direct forward linkages	Paint and varnishes
Construction and housing	Direct forward and indirect forward linkages	Plastic products
Construction materials	Indirect	Transport and storage
Construction process	Direct forward and backward linkages	Other chemical
Employees	Indirect	Wholesale, retail
Employees	Indirect	Business services
Employees	Indirect	Financial and insurance
Housing	Direct	Bricks and tiles
Housing	Indirect forward	Glass products
Housing	Indirect	Carpets, rugs, etc.
Human consumption	Indirect forward, direct backward linkage	Meat processing
Human consumption	Indirect	Agriculture, forestry, etc.
Human consumption	Indirect	Bakery products
Human consumption	Indirect	Dairy products
Human consumption	Indirect	Canning of fruit, etc.
Human consumption	Indirect	Other foods
Human consumption	Backward linkage to agriculture, forward to commerce	Sugar factories and refineries
Human consumption	Forward linkage to commerce sector	Canning of fish, etc.
Human consumption	Indirect forward linkage	Soap and cosmetics, etc.

Source: Extract from the South African Input-output table, 1993

5.4 Water Availability And Water Based Industries

The construction of the dams will increase the availability of water in the region, which could appeal to those industries which are large water consumers. However, it is debatable whether the building of the Jana and Mielietuin dams in itself will lead to further industrial development to take place as it has been argued that the dams are not making more water available than what is already there.

On the other hand, effective marketing by the Thukela Basin interest groups of the availability of water may lead to a growth in water intensive industries. It must be noted that, although the water in the dams is primarily intended for export from the province, local demand must first be met. Industrial sectors which consume more than 50m^3 water per day were identified in an independent study on behalf of the Water Research Commission. Table 5.3 lists industries with a water intake of more than 50m^3/day.

Table 5.3: Major water consumption industries

1985 INDUSTRIAL CLASSIFICATION NUMBER	INDUSTRY	AVERAGE WATER INTAKE (M^3/DAY) FOR INDUSTRIES SURVEYED
314	Tobacco products	359
342	Printing and publishing	50
351	Chemicals	1221
362	Glass and glass products	257
371	Iron and steel	410
372	Non-ferrous metals	118
384	Motor vehicles	138
3112	Dairy	133
3113	Fruit and vegetables	899
3115	Vegetable oils	740
3116	Grain	300
3117	Baking	74
3134	Soft drinks	531
3119,3121	Food miscellaneous	342
3231	Tanning and leather	2455
341,3411	Pulp and paper	339
341,3412	Paper products	787
3691	Bricks, tiles, clay and pipes	219
3909	Synthetic diamonds	148
311100	Meat	680
313300	Malt brewing	4 563
313310	Sorghum beer	189
335,356	Rubber and plastic	171
361000	Pottery	159
369910	Concrete	58
381950	Planting	142
410210	Gas	229
610190	Photographic	150
622	Motor trade	58
711200	Vehicle depots	91
95200	Laundries	313

Source: Steffen, Robertson and Kirsten Inc., 1991. National Industrial Water and Wastewater survey.

5.5 Comprehensive Assessment of the Industrial Sectors

Table 5.4 compares the result of the preceding analysis of existing established industries, construction linked industries and water consumption industries, to each other. Table 5.4 therefore represents a composite table listing industrial “opportunities” identified through the criteria of:

- the existing industrial profile;
- industries with a direct or indirect linkage with the construction sector; and
- water intensive use.

Table 5.4: composite table listing industrial opportunities

EXISTING INDUSTRIES	CONSTRUCTION LINKAGES	WATER CONSUMPTION INDUSTRIES
Agriculture, forestry, etc.		
Bakery products	Bakery products	Baking
Beer		
Bricks and tiles	Bricks and tiles	Bricks, tiles, clay and pipes
	Business service	
	Canning of fish, etc.	
	Canning of fruit, etc.	
	Carpets, rugs, etc.	
	Cement	
		Chemicals
Clothing		
Concrete		Concrete
Corrugated iron		
Dairy products	Dairy products	Dairy
	Fertilisers, etc.	
	Financial and insurance	
		Food miscellaneous
Footwear		
		Fruit and vegetables
Furniture		
		Gas
Glass	Glass products	Glass and glass products
		Grain
	Industrial chemicals	
	Industrial machinery	
	Iron and steel	Iron and steel
		Laundries
	Machinery renting, etc.	
		Malt brewing

EXISTING INDUSTRIES	CONSTRUCTION LINKAGES	WATER CONSUMPTION INDUSTRIES
Meat processing	Meat processing	Meat
Metal products		
Milling		
Mineral water manufacturers		
		Motor trade
		Motor vehicles
	Non-metal products	Non-ferrous metals
	Other chemical	
	Other foods	
Packaging manufacturers		
	Paint and varnishes	
		Paper products
		Photographic
		Planting
Plastic products	Plastic products	
		Pottery
Preserved foods		
		Printing and publishing
Protective clothing		
		Pulp and paper
Rubber and Tyre		Rubber and plastic
Sand and stone		
Security fencing		
	Soap and cosmetics, etc.	
Soft drinks		Soft drinks
Sorghum beer		Sorghum beer
Spice manufacturers		
Steel		
	Structural metal products	
	Sugar factories & refineries	
		Synthetic diamonds
		Tanning and leather
Textile		
Timber		
		Tobacco products
Toy manufacturing		
	Transport & storage	
		Vegetable oils
		Vehicle depots
	Wholesale, retail	
	Wood products	

From the information in Table 5.4, three categories of industrial potential may be identified:

- long- term sustainable opportunities;
- short to medium-term opportunities; and
- possible new development opportunities.

The **long-term sustainable industrial potentials** in the uThukela region are identified by comparing the existing industrial profile with those of industrial opportunities through linkages with the (i) construction phase and (ii) that of water based industries. These opportunities are :

- the manufacturing of baking products;
- textile and clothing manufacturing;
- processing of meat and meat products;
- manufacturing of preserved food such as canned fruit and vegetables;
- manufacturing of dairy products;
- glass and the manufacturing of glass products;
- manufacturing of rubber and plastic products;
- brick and tile manufacturing; and
- manufacturing of iron and steel.

Short to medium-term opportunities are determined by comparing the opportunities that exist through the linkages of industries with (i) construction with that of the (ii) existing industrial sectors in the uThukela region. These industries will experience a temporary surge in activity during the construction phase of the project.

These opportunities are:

- the production of metal products;
- cement and concrete manufacturing;
- timber and the manufacturing of wood products; and
- sugar factories and refineries.

The **new manufacturing opportunities** are those that (i) are **not currently present** in the region, (ii) show positive potential in terms of water intensive industries and (ii) construction related industries. It needs to be pointed out, however, that the potential of these industries need to be carefully evaluated by prospective investors. This category of industries includes:

- industrial chemicals and chemical production;
- production of sorghum beer;
- other soft drinks and mineral water; and
- footwear (at scale).

5.6 Implementation of opportunities

An outline of the implementation of the industrial opportunities identified in section 5.5 are given in this section. The implementation of these opportunities must be considered with caution as this outline serves as an indication only.

Table 5.5: Implementation Summary

TASK	PHASE OF PROJECT	RESPONSIBILITY
Identification of person or organisation undertaking the initiation of the implementation process	Planning	Economic forum of the uThukela region
Feasibility study of the opportunities outlined in the above section	Planning	Prospective investors
Prioritisation of the opportunities	Planning	uThukela District Municipality
Programme for the implementation of the opportunities	Planning	Economic forum
Identification of beneficiaries	Planning	Economic forum
Infrastructure requirements for additional industrial facilities and the expansion of existing industries	Planning, construction	Engineers of the uThukela District Municipality and TLCs
Water	Construction	Department of Water Affairs (Community Water Supply)
Roads and rail	Construction	Engineers of the uThukela District Municipality
Pollution control	Implementation	Department of Water Affairs
Waste management	Implementation	Department of Water Affairs

SECTION SIX: IMPROVED AGRICULTURE

6. IMPROVED AGRICULTURE

6.1 Description of the opportunity

The agricultural production of small scale farmers downstream of the dams are improved through share equity irrigation schemes and through the widening of the agricultural base by, for example, production of local herbs and indigenous plants. A potential small farmer irrigation scheme on the Sundays River near Ezakheni has been identified by the District Municipality and the Department of Land Affairs. It is hoped that some synergy between the TWP and this proposed irrigation can be realised. It is hoped that water from Jana dam can be harnessed for this purpose.

6.2 Assumptions

- The development of small scale farmers is a national priority for the Departments of Land Affairs and Agriculture.
- Financial institutions are eager to assist small scale farmer development through the funding of share equity schemes.
- The climate in the region is ideal for the production of high yield crops for example vegetables, sugar and fruit.
- Successful irrigation production can generate substantial monetary gains for the region after long-term liabilities have been met.
- Successful irrigation production assumes intensive farming which requires advanced management technology.
- Successful intensive farming practices generate a large number of jobs.
- The fact that successful irrigation does not take place at the moment places an additional onus on public role-players to address matters concerning crop selection, conflict management and access to land-use, in order to prevent them blaming the lack of planning of the dams in the future for failure in this regard.
- Agricultural production can include the production and harvesting of herbs and indigenous plants.

6.3 Project Type

share equity production at Thukela Estates and other areas with irrigation potential.

6.4 Potentials

According to the Department of Agriculture the following potential net income can be realised from 2000 ha with mixed crops under irrigation:

MAP 3: TWP RELATED TO AGRICULTURAL POTENTIALS

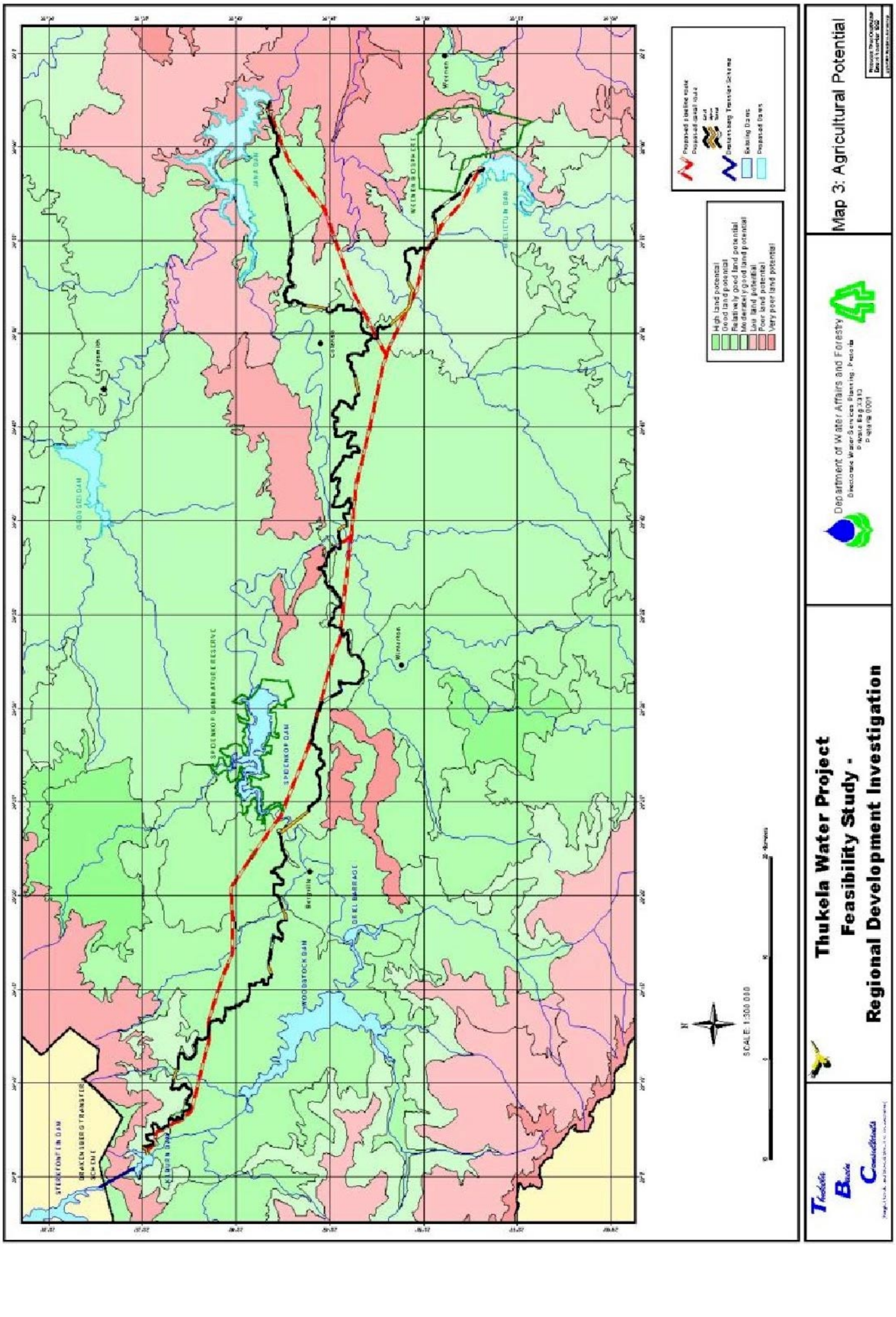


Table 6.1: Potential net income from undeveloped 2 000 ha

PRODUCTS	R/HA	HA	RAND
Maize	3 182.47	500	1 591 235.00
Tomatoes	31 131.54	500	15 565 500.00
Amadumbe	24 694.35	500	12 347 000.00
Dry beans	3 684.43	500	1 842 000.00
Total/Average	15672.87	2000	31 345 735.00

6.5 Issues to be Addressed

The following issues need to be addressed before optimal agricultural production can be realised:

- identification of share equity partners;
- the marketing of produce and technological inputs;
- the rights and gains of existing small scale users of land; and
- the conflict amongst land users.

6.6 Key role-players

- Awareness and education
  - District Municipalitys
  - Department of Agriculture
  - KwaZulu-Natal Agricultural Union (KWANALU).

- Implementation
  - Commercial farmers
  - Department of Agriculture.

- Herbs and indigenous plants growing in the area may be commercialised and grown on land not used for irrigation.

6.7 Potentials

The projects can result in the following benefits:

- indigenous products are produced commercially and becomes available for public consumption;
- income is generated by producer communities;
- employment is created; and
- if the Mhlumayo complex is earmarked for such a project, 21 543 people can benefit from it.

6.8 Key role-players

- Product identification and awareness
  - Agricultural consultants

  - Conservation Services
  - uThukela District Municipality
  - Department of Agriculture.

- Implementation
  - Agricultural consultants
  - Nature Conservation Services
  - Department of Agriculture.

- Harvest and market natural resources in the dam basins.

6.9 Potentials

This project can result in the following benefits:

- fire wood;
- natural plants for consumption;
- seed plants of endangered and other plants through relocation to other areas;
- sensitising participating communities with regard to biodiversity of the region;
- +/- 2 000 people neighbouring Jana can benefit;
- +/- 4 700 people neighbouring Mielietuin can benefit.

6.10 Key role-players

- Awareness and planning
  - Environmental Impact Assessment Team
  - Agricultural consultants
  - Nature Conservation Services
  - District Municipalitys
  - Department of Agriculture.

- Implementation
  - Agricultural consultants
  - Nature Conservation Services
  - Department of Agriculture

SECTION SEVEN: LABOUR TRAINING AND CAPACITY BUILDING

7. SECTION SEVEN: LABOUR TRAINING AND CAPACITY BUILDING

7.1 Introduction

This section deals with the labour training and capacity building opportunities that could result from the TWP. It should be clear, however, that the full participation and involvement of role-players other than DWAF, such as the Department of Labour and District Municipalitys, would be necessary to realise this opportunity.

The training of the labour force is one of the most important long-term sustainable impacts that the TWP will have on the region. This opportunity is therefore seen to be one of the most important means by which long-term sustainable poverty alleviation could take place.

Community participation and liaison should identify, amongst other social indicators, the nature and extent of training and capacity needs in the region. The labour intensive construction investigation should, from the identification of the construction tasks required, establish the types of skills that are necessary for implementation of the project. Appropriate training programmes could be devised and structured to best satisfy both the community and labour intensive requirements. The procurement system should then be geared to enable the beneficiaries of training programmes to participate in contracts at various levels. Capacity building and entrepreneurial development could be investigated from two separate perspectives:

- directly related to contracts funded by the Thukela Water Project, such as training of semi-skilled labour, materials supply, canal construction, pipe laying contracts; and
- indirect service/business entities that either serve, or emerge as a spin-off from the TWP funded contracts, such as health services, workforce accommodation, catering and irrigation schemes.

The former could entail investigations into training, packaging of contracts, procurement of contracts and other related aspects. The success of the latter will depend on the extent to which local conditions and expertise are researched and incorporated into development options. The feasibility of establishing an independent group to co-ordinate the various inputs in the initial stages and thereafter facilitate implementation and monitoring of development proposals should also be investigated.

7.2 Main Issues: Training Programmes And Procurement System

7.2.1 Training Programmes

The types of training programmes that should be in place prior to and during the project construction phase, need to be investigated and the requirements and conditions of each type of programme need to be determined.
A preliminary list of structured training programmes that could be investigated is outlined below:

- literacy and numeracy training for contract workers and local residents, life skills training, personal hygiene, AIDS awareness, financial management etc;
- engineering skills training for execution and completion of contract works;

- entrepreneurial skills training and technology transfer for emerging contractors and sub-contractors;
- capacity building in communities to develop organisational skills and leadership and to address conflict resolution and other aspects of long-term benefit to the community; and
- structured and unstructured training for small, medium and micro enterprises (SMMEs).

7.2.2 Procurement System for SMMEs and previously disadvantaged individuals (PDIs)

The objectives and framework of a procurement system need to be established. The feasibility/merits of establishing an institutional vehicle with various roles and responsibilities to promote and facilitate the success of the procurement system through its various stages should be investigated. Some of the issues to be investigated could include:

- defining the types of SMMEs and PDIs eligible for the procurement system;
- structuring a tender system for contracts so that they will be transparent and provide equal access and opportunity;
- specifying appropriate procurement conditions with which tenders should comply ;
- establishing prequalification criteria for SMMEs and PDIs;
- investigating the types of contracts and engagements that SMMEs and PDIs can procure;
- determining appropriate communication and support systems for the tender preparation and submission process and establish appropriate criteria for tender evaluation; and
- proposing a system of monitoring and evaluation of SMMEs and PDIs during contract implementation.

7.3 Analysis of Training Programmes

7.3.1 Training Programmes

It is essential that the TWP engage with the community at all stages of project development to ensure agreement and understanding of the project facets and objectives, and to build synergy between the community and TWP.

The main aims of community participation and liaison could be:

- to aim at unemployed urban or tribal area persons and not to infringe on the employed farming community labour market;
- the social commitment to inform communities of forthcoming construction activities and to provide a mechanism for their participation in the project;
- to develop a procedure for effective consultation with communities and other stakeholders for transfer of knowledge concerning the project, training programme implementation, general liaison and problem resolution;
- to create public understanding and build community support for the project;
- to determine skills and resource levels within communities and the needs and priorities of those communities with regard to social infrastructure, skills and long term development;
- to provide for capacity building and empowerment wherever possible; and
- to develop procedures for identifying candidates for training programmes.

Community participation and liaison could be implemented in stages as outlined below:

- Stage 1

  - Situation analysis, involving identification of areas impacted by the project.
  - Identify all stakeholders, and directly and indirectly impacted communities.
  - Develop a system for disseminating information to impacted communities.

- Stage 2

  - Hold workshop sessions and interviews with relevant communities to obtain support for the community liaison and participation programme.
  - Agree on processes to establish working committees, identify key discussion issues, decision making procedures and mechanisms for conflict resolution.

- Stage 3

  - It may be appropriate at this stage to gather relevant information to help analyse community needs and identify potential capacity building opportunities. Data to be collected would typically include:

    - number of residents in target communities;
    - age cohorts;
    - literacy levels;
    - average income per household;
    - mobility of the population (vehicle ownership, public transport);
    - level of basic services (potable water, sanitation, electricity, roads);
    - number of schools and clinics serving target communities;
    - existing skills in communities (including levels);
    - existing businesses, small contractors in communities;
    - availability of raw materials, transport, funding.

  - The main activities of Stage 3 should include the following:

    - Collect and collate community input into training and empowerment programmes.
    - Identify existing project-related skills within relevant impacted communities.
    - Identify candidates for human resource development.
    - Establish how local entrepreneurs could become involved in projects.
    - Identify areas of improvement for training programmes.

- Stage 4

  - Ongoing consultation with community groups and relevant authorities.

7.3.2 Generic Training (local residents)

An open invitation could be extended by the Department of Labour to residents of relevant communities to attend courses in literacy, numeracy and life skills training up to a minimum recognised level. Through the community participation and liaison programme, the following process should be followed:

- determine skills and education levels within communities and identify community needs and priorities with regard to improvement of social and life skills;
- identify suitable adult basic education training programmes from recognised institution(s);
- identify suitable training providers and venues for courses; and
- implement, monitor and evaluate training programmes.

7.3.3 Generic training for contract workers

From the commencement of a contract, the contractor could implement a structured training programme for workers throughout the duration of the contract. The contractor's generic training programme:

- would be based on a recognised institution's programme/curriculum;
- would include adult basic education training in numeracy and literacy;
- would focus on life skills, covering at least problem solving, conflict resolution,
- communication, time management, handling stress, assertiveness, budgeting and money management, job interviews, interpersonal relationships, personal hygiene, AIDS awareness; and
- would be conducted by suitably qualified and experienced trainers.

The contractor could provide full details of the structured training programme with his tender. The following details would have to be included:

- the name of the training institution/programme/curriculum;
- the various aspects of each type of training contained in the programme;
- the manner in which the training is to be delivered; and
- the numbers and details of trainers to be utilised.

The contractor should ideally provide the following for the delivery of the generic training programme:

- sufficient skilled and competent trainers to deliver the training programme to all local workers;
- a suitable venue with adequate transport (if required);
- tools, equipment and teaching aids;
- stationery and other necessary support materials; and
- comprehensive records of the training given to each worker – certificates should be issued to show course content, proof of attendance and completion of course
- acredited courses/programs
- skills developmental.

7.3.4 Engineering skills training for execution and completion of contract works

From commencement of the contract, the contractor could implement a structured training programme in which various skills required for execution and completion of the works are imparted to the workers.
Workers could be trained progressively through the various stages of a particular type of work, throughout the duration of the contract. Where applicable, subcontractors could also be engaged in a programmed and progressive manner.

The skills training programme could be accredited by the Sector Education and Training Authorities (SETA) or other appropriate institution recognised by the

Department of Labour. Suitably qualified and experienced trainers should deliver the programme.

Modules for which workers (and possibly subcontractors) could receive training are suggested below:

Surveying	Supply of materials
Bush clearing	Plant handling and hire
Fencing	Sewage and stormwater pipes
Site security	Grassing
Steel reinforcing: bending and fixing	Culverts construction
Formwork and scaffolding	Open drains
Bricklaying and plastering	Trucking and transport
Construction carpentry	Road surfacing
Excavations/shoring/backfill	Erecting rails and signs
Concreting	Materials storage and handling
Stone pitching	Team leadership
Gabions construction	Subsoil drain construction
Measuring skills	

Details of the contractor's accredited structured programme should include:

- name of accredited training institution and programme;
- various aspects of each type of training contained in each module;
- the manner in which training is to be delivered; and
- numbers and details of trainers to be utilised.

The contractor should provide the following for the delivery of the engineering skills training programme:

- sufficient skilled and competent trainers to deliver the training programme to all local workers;
- a suitable venue with adequate transport (if required);
- tools, equipment and teaching aids; and
- stationery and other necessary support materials.

The total duration of training is likely to vary between 5 and 10 full working days per module. All members of the workforce should be entitled to receive training in at least one module; the total amount of time spent by a worker in training should not exceed 5% of the total time that the worker is engaged on the contract.

All skills-related training should take place during normal working hours. The contractor should make adequate allowance in his work programme to accommodate the training without unduly compromising overall progress of the works. Comprehensive records should be maintained of the training given to each worker, as well as the nature and number of tasks executed by each worker. All workers should be remunerated in respect of time spent undergoing training at an agreed rate. The contractor should, as far as possible, use workers on those aspects of the works for which they have been trained.

7.3.5 Entrepreneurial skills training for emerging contractors and subcontractors

Small emerging contractors and subcontractors should be entitled to receive a structured training programme comprising management skills and business development skills. Through close performance monitoring of all small subcontractors, the contractor should identify all subcontractors who, in his opinion, show the potential to benefit from structured training.

The training could be delivered by trainers accredited by the Sector Education and Training Authority (SETA) or other institution recognised by the Department of Labour. The contractor should facilitate the delivery of the training, by instructing and motivating the subcontractor regarding his attendance and participation. The contractor should also make all reasonable efforts to co-ordinate the programming of the subcontractor's work with that of the delivery of structured training. The training courses could possibly cover several modules, each of which could be covered in a minimum of five days. Typical modules are listed below:

- starting a small business, basic business concepts
- measurement in the metric system, use of electronic calculator
- calculations for builders
- setting out and levelling
- concrete technology
- interpreting building/construction drawings
- measuring quantities from drawings
- practical building knowledge
- planning, estimating and costing
- tendering and pricing
- contract documentation
- interpreting documentation
- forms of business ownership
- material management
- project programming
- business management and administration
- construction management
- financial management
- human resource management
- progress control
- budget control
- business planning
- builders bookkeeping
- leadership.

Small contractors and subcontractors who have demonstrated understanding of and competence in the training material should be appropriately certified by the accrediting body. Full details of the structured training programme should be supplied by the contractor, including:

- name of training institution and programme;
- names of modules and aspects of each type of training in each module;
- the manner in which the training is to be delivered; and
- the numbers and details of the trainers to be utilised.

As with engineering skills training, the contractor could provide the necessary trainers, venue, transport, tools and supporting material for the training programme. Detailed records of the training given to each subcontractor should be maintained. No remuneration in respect of time spent undergoing training should be made to any of the subcontractors.

Consideration could also be given to setting up appropriate institutional structures to assist emerging contractors with financial support, as well as programming and cash flow aspects of their business operations.

7.3.6 Participation and skills transfer for emerging consultants and subconsultants

It is anticipated that a significant measure of capacity development and technology transfer could occur through the close association and co-operation between emerging/subconsultants and lead consultants. To this end, the engineering team should comprise a consortium, with an equitable distribution of work between the lead and emerging consultants.

A policy committee consisting of one member from each consortium consultant could be formed to facilitate uniformity in all aspects of planning, design, construction, supervision and monitoring.

7.3.7 Training for Small, Medium and Micro Enterprises (SMMEs)

With regard to structured training, SMMEs should be able to participate in and enjoy the benefits of the same structured training programme offered to small contractors and subcontractors, as outlined above.

With regard to unstructured training, the contractor could (at his own cost) train, mentor, guide and assist each SMME in all aspects of the management, execution and completion of his subcontract. The extent and level of such training, mentoring, guidance and assistance could be commensurate with the basic level of subcontract applicable, and could be directed at enabling the SMME to achieve the successful execution and completion of his subcontract.

The training, mentoring, guidance and assistance could include issues such as:

- setting out the relevant portion of the works (if applicable);
- appropriate work techniques and procedures;
- organising, motivating and managing employees;
- record keeping;
- materials handling, storage and wastage; and
- programming and achievement of targets.

The contractor could advise and assist the SMMEs with regard to their statutory obligations pertaining to the requirements and procedures of:

- site tax/income tax deductions from the amounts due to their employees;
- Compensation for Occupational Injuries and Diseases Act (COID);
- value-added tax and other taxes for which the small subcontractor may be liable;
- occupational safety; and
- status as an employer.

Where the delivery of structured training to SMMEs is provided for in a contract, the contractor could monitor the performance of all SMMEs in the execution of their contracts, and identify all SMMEs that show potential to benefit from structured training that may be provided for elsewhere in the contract. The contractor could facilitate delivery of structured training by instructing and motivating SMMEs regarding attendance and participation therein. The contractor should also make all reasonable efforts to co-ordinate the work programmes of SMMEs with that of the delivery of structured training.

7.4 Analysis of Procurement System for SMMEs, Previously Disadvantaged Enterprises (PDEs) And Previously Disadvantaged Individuals (PDIs)

The procurement system or strategy could be targeted to provide opportunities for participation by targeted enterprises, even though they may not have all the necessary resources, capability or expertise to perform contracts in their own right. Some of these may already be in existence, and others may wish to start entering into contracts after receiving appropriate training.

It is suggested that the Targeted Procurement Programme of the Department of Public Works could be used as a basis for the procurement strategy for this project. The programme is based on an Affirmative Procurement Policy whose primary focus is to redress the skewed business ownership patterns in South Africa by developing small businesses owned and controlled by previously disadvantaged persons and by creating employment in a targeted manner.
The Targeted Procurement Guide for Responsible Agents summarises the essential components of the programme, including key target groups, classification of contracts, resource specifications (TP1 to TP6), tender submission documents, tender adjudication, monitoring, penalties, resource substitution, etc.

7.4.1 Possible Objectives of the Procurement System

The procurement system is not aimed at creating an artificial business environment for SMMEs but rather to ensure that they become sustainable business entities fully integrated into the subregional economy. The main objectives of the procurement system should include the following:

- fairness, transparency, competition and equitability;
- measurable, auditable and cost-efficient;
- provide employment opportunities for SMMEs, PDEs and PDIs;
- achieve empowerment targets set for all types of involvement;
- ensure appropriate institutional and financial support for establishment, operation and development of SMMEs; and
- provide mentorship to SMMEs.

7.4.2 Definition of SMMEs, PDEs and PDIs

The definition of an SMME should be reviewed in the context of the value of work packages available, the type of contracts and the size of existing SMMEs. There will also be a need to define the categories of micro, small and medium for allocation of contracts.
It is proposed that the guidelines for these definitions be drawn from the Department of Public Works APP or TPP documents. It is also proposed that the Public Works document(s) be used for guidelines for the definition of PDEs and PDIs.

7.4.3 Open and Targeted Procurement

It is proposed that the open tender system be used for all subcontracts. The open tender system allows for transparency and equal access to tender information and gives the opportunity to contractors that do not prequalify to tender for work.

It is also proposed that, through a point scoring evaluation system, targeted procurement is effected through recognition of PDIs (including women and disabled people), SMMEs (size and ownership), affirmative action and locality (preference given to local establishments).

7.4.4 Conditions of Procurement

It is proposed that procurement conditions comply in principle with the standard business contract conditions, subject to review of specific conditions where necessary, for example, insurance, guarantees, performance bonds, preliminary and general conditions. The conditions of tender and contract should be tailored to:

- achieve targeted procurement;
- reduce unnecessary onerous conditions; and
- suit the type of work being tendered for.

In general, it would be preferred that SMMEs operate in a normal business environment as far as possible. Where possible, the relaxing of conditions such as sureties, performance bonds etc will be allowed only if institutional and financial support is not available or has not been obtained.

7.4.5 Pre-qualification

All SMMEs and PDIs, including those that have graduated from any training programme(s), should undergo a prequalification before being registered on a database from which they can subsequently tender for work as preferred tenderers. Criteria for prequalification should be in line with training programme targets and what the contracts entail. It is recommended that the prequalification process be conducted on an annual or two-yearly basis, or as necessary.

7.4.6 Types of Engagements

- Prime contractor: The contractor is the sole contracting party to execute the work but may be assisted institutionally and financially.
- Joint venture: Entails a legal agreement between an established contractor and emerging contractor to execute the work. All legal, financial and work responsibilities are to be carried out by the joint venture. The established contractor is to provide assistance to the emerging contractor. It is recommended that the Department of Public Works documents APP2 and APP3 (structured joint ventures) be used as guidelines for joint venture contracts in conjunction with standard business contracts.
- Subcontract: Where SMMEs are considered appropriate as subcontractors, the General Conditions of Sub Contract will be reviewed for use. Certain specific clauses such as insurance, guarantees, performance bonds, preliminary and general, will be reviewed for application to SMMEs.

7.4.7 Types of contract

Contracts should be classified into categories to facilitate tendering by SMMEs. If successful, SMMEs should execute the work they are capable of handling in terms of capacity and contractual obligations, while at the same time fulfilling the aims of empowerment, employment, training and development.

The following types of contract are proposed:

- Prime contract (major): medium to large businesses;

- Prime contract (minor): small to medium businesses;
- Prime contract (micro): micro to small businesses;
- Joint ventures;
- Sub-contracts.

To allow equal opportunity for all SMMEs and PDIs to participate in the tender and contract process, some adjustment to the way in which the firms are categorised may be necessary.

7.4.8 Tender communication and support

Tender support and communication is considered an essential component of the procurement process. In the first instance, it is recommended that the communication of tender information be made using as wide a range of media as possible, e.g. newspapers (regional and local), telephonically, community participation programmes, agencies etc. Secondly, it is proposed that tender advice/support centres be set up to assist tenderers with tender applications, to manage the tenderer database and the prequalification processes, and to handle queries related to tender appointments and evaluation. The advice centres should also be equipped to deal with matters relating to financial and institutional support.

7.4.9 Tender evaluation

Tenders should be evaluated in a fair and transparent manner that, within the State Tender Board regulations and the South African Constitution, allows the empowerment targets to be achieved. In order to apply a targeted procurement system, an evaluation system favouring PDIs (including youth, women and disabled persons), PDEs and SMMEs would have to be adopted. The criteria for such a system should include (but not be limited to):

- experience
- training
- price
- affirmative action
- location.

It is proposed that a point scoring system be used where points are allocated to the above criteria on the basis of the type, value and term of the contract.

7.4.10 Monitoring and evaluation

A system of monitoring and evaluation of SMME training, development and progress should be implemented. It is proposed that a standardised progress reporting system be implemented, which reports on a regular (monthly) basis on the involvement (type and value), development and achievement of targets. The mechanism of operation and structure/format of the system will have to be defined.

SECTION EIGHT: PROCUREMENT OF GOODS AND SERVICES

8. PROCUREMENT OF GOODS AND SERVICES

The implementation of a procurement strategy that is aimed at maximising local regional benefits involves the considerations of a number of in-principle decisions. For this reason the Department of Water Affairs and Forestry would have to consult widely before introducing the suggestions contained in this section. The regional development opportunities could, however, be significant and require careful consideration.

8.1 Description

The focus of a procurement strategy should be to maximise the extent of supply from local businesses, without adding to the project cost or prejudicing the rights of the main contractors to source the lowest priced products or services nationally or internationally. Procurement has many facets, including (i) the form of procurement (e.g. quotation, tender, negotiation, etc.); (ii) the type of procurement (e.g. lease, rental, cash purchase, hire purchase, etc.). Categories of goods and services would include the following:

- materials;
- plant;
- tools;
- fuel;
- manpower;
- facilities; and
- services (e.g. medical, security, catering, waste removal, etc.).

It is obvious, therefore, that research would have to be undertaken before the most appropriate opportunities for local businesses can be identified. With due consideration, it could be stipulated to main tenderers that certain commodities or services have to be locally sourced. In order for this to happen most efficiently, a local advice centre could be established which would provide contact details for businesses offering relevant goods and services. Before any kind of stipulation for local goods procurement can be included in the contract documentation, the sustained availability of such goods has to be determined. This will require time, focus and vision, and will rely totally on the initiative of local role-players for its success.

8.2 Role-Players

The Project Team would need to identify the commodities and services that could be locally procured, and then workshop these with the local Chamber of Commerce and Industry and local councils to develop a procurement strategy.

It is proposed, that ultimately, the uThukela District Municipality (or such relevant district councils as may exist), the provincial Department of Economic Affairs and the chambers of commerce contribute to the funding of a Commercial Opportunities Bureau (COB). Offices of the bureau would be based in Estcourt and Ladysmith, to address enquiries from contractors and direct them to appropriate businesses or service centres in the region. The idea of a COB needs to be given serious consideration, to enable its identity, function, databases and personnel to be timeously established. Lack of coordination and mobilisation of the local industry response to such a project would result in many business opportunities being lost to the more established hubs in Johannesburg and Durban.

8.3 Possible Actions

Research into appropriate categories and types of local commodity or service procurement should be undertaken. Due consideration would have to be given to the opportunities for affirmable business enterprises.

The up-front work could include enhancement of the existing databases and calls for submission of information from businesses in certain identified categories. This process, and the on-going work during the tender and construction periods, would be best managed by the dedicated commercial opportunities bureau, funded by the provincial government, District Municipality, local councils and the business chambers. It is also possible that the District Municipality levies accruing as a result of the construction alone, could meet some of the personnel and running costs of the bureau.

SECTION NINE:
ACCESS ROADS AND LOGISTICS

9. ACCESS ROADS AND LOGISTICS

9.1 Description

Access roads will by necessity be constructed to both the Jana and Mielietuin dam sites, as well as to the pump stations along the aqueduct, and to key entry/exit points along the aqueduct itself. From a regional planning and development perspective, the objective would be to maximise the benefit of these access roads to the sub-region or area in which they are built. The issue of "logistics" in respect of the access roads relates directly to transportation economics, and therefore needs to be considered when decisions are being made about the optimal routing of the access roads. Route selection is therefore part of the process ensuring that the project is optimally serviced and supplied in all respects. The access roads to the dam sites will be used for the importation of the single most voluminous commodity on the project, cement, and must therefore be considered as part of the larger supply chain or logistics network. The "linkage" to the railways and sufficiently large sidings for the storage/loading of cement, is therefore critical. Another issue that impacts on the logistics and access roads considerations, is the type of dam to be constructed, i.e. roughly three times more cement will be needed for a Roller Compacted Concrete (RCC) dam at Jana than for a composite earth/rockfill/RCC dam. Estimates of the transportation requirements of cement are as follows:

- for an RCC dam at Jana: 42 x 50 ton trucks per day for 20 months;
- for an earth/RCC dam at Jana: 15 x 50 ton trucks per day over 11 months. The railway trucks are rated between 37t and 52t capacity per wagon. A daily supply train for an RCC dam at Jana would therefore comprise ±30 wagons

This highlights the significant heavy vehicle usage of the access roads, without taking all the other vehicles into account and the fact that where alternatives exist, the selection of a preferred alternative will be a complex, multi-faceted analysis.

9.2 Access Roads

9.2.1 Access Roads to Dam Sites

a) Jana Dam:

Two alternatives exist, *viz*:

- access from Colenso to the south bank, via the Gannahoek community; or
- access from Ladysmith/Ezakheni to the north bank, via the gravel district road
- ZM 212-2.

b) Mielietuin Dam:

- Access from the Estcourt-Weenen main road (MR 13) to the north bank of the Bushman's River (±3,7km). An additional road (±0,8km) to the Mielietuin Pump Station site would be required (leading off the main access road).

9.1.2 Access Roads To Pumping Stations

a) Rustenburg Pumping Station (pipeline aqueduct):

- Access (±5,5km) from the Winterton-Spioenkop road (MR 181).

b) Bethany Pumping Station (pipeline aqueduct):

- Access (±0,4km) from the Bergville-Ladysmith road (MR 30).

The other pumping stations (*viz*. Shelly, Rietfontein and Woodford) are required for the canal system, lifting the water to progressively higher canal sections. The access roads do not have much significance for regional development issues.

c) Shelly Pumping Station:

- Access road (±8,0km from turn-off from the Rustenberg pump station road, which is in turn ±3,9km from the Winterton-Spioenkop road (MR 181).

d) Rietfontein Pumping Station:

- Access road (±2,0km) from the Winterton-Spioenkop Dam road.

e) Woodford Pumping Station:

- Access road (±1,1km) from the Bergville-Oliviershoek Pass main road (MR 340).

9.1.3 Access to the Aqueduct

This issue is often neglected in the planning of long, cross-country pipelines/canals. While not much of a concern to regional development issues, it can have a significant impact on local landowners (e.g. farmers) and local small businesses (e.g. farm stalls).

Depending on the speed of construction, the need for aqueduct route access is a relatively temporary one, but it can cause major disruptions while in use.

The pipe sizes envisaged on this project are large (diameters of ± 1,8m to 3,0m) and will require heavy vehicles and equipment for their transport to the route and their laying. It is normal practice to use the pipeline right of way (or servitude), but appropriate access to the established road network will be required at least at 15km intervals. These access roads will require upgrading and maintenance during use, and with due consideration, may have some longer term benefit.

9.3 Key Focus Areas: Access Road to Jana Dam Site

It is apparent from the details in section 9.2 that the routing of access roads to the various dam and pump station sites is largely a straight forward technical exercise for all, but one, the road to Jana Dam. Access to the Mielietuin Dam in particular is relatively simple and therefore does not require further consideration in this section. Attention will, however, need to be given to the factors affecting the selection of the preferred alternative access route to the Jana Dam. While it is not the objective of this assignment to undertake such an analysis, the key focus areas are presented for consideration. Essentially, the issues relate to a major regional benefit realised from the “north bank access route” and the likely improved transportation economics achieved with the “south bank route”. Key focus areas for the analysis are, *inter alia*:

- Construction issues

  - The status, condition, gradient suitability and current traffic loading of existing roads, used in addition to the new roads.
  - The “linkage” of the new access roads to the main supply centre of Ladysmith, as well as to railway sidings capable of handling long trains and high volume cement transfers. In this respect, Ladysmith has “excellent” facilities, while those at Colenso are “adequate” and would also require a permanent shunting locomotive.
  - The selection of an appropriate road surface specification.
  - The topography along the route and gradient analysis.
  - Route length: In this instance there are two considerations, *viz.* the total road distance from Ladysmith, and the length of road sections that will be newly constructed or upgraded.
  - The suitability of the land for establishment of the site camp and facilities on the respective north or south bank.
  - The location of the aggregate quarry will directly affect where the crushing plant and concrete batching plant will be located, in that the quarried ore must be transported to the crushing plant – these two facilities will be the largest activity centres at the site after the dam .
  - All materials, plant and equipment that constitute the site camp and facilities will themselves require transportation to the site along suitable access roads.
  - Access to labour and their homes, given that the operation will probably run 24 hours per day during construction.

- Regional development issues

  - The north bank route will have a significantly greater positive impact on rural communities, improving the road access to Ladysmith for a population exceeding 20 000 people. It is likely that a significant proportion of the labour to be employed on the project will be from the “north bank” communities, and as such would have much easier access and shorter travelling times to the site via the north bank access roads.
  - The “south bank” route would improve access for the Gannahoek community to Colenso and the old N3 route between Ladysmith and Estcourt, as well as easily incorporate them into the daily labour pool on the project. Similarly, the communities at Colenso itself would have shorter, easier access to the site via the “south bank” access roads.
  - In terms of long-term usage, the northern routes would continue to serve a larger growing population, while the “south bank” road could also service potential wildlife or conservation areas developed adjacent to the dam.
  - If the “south bank” access road is developed, Colenso will become an important hub in the supply and service chain, and the wisdom of this in the long-term regional economy needs to be considered.
  - In terms of national supply hubs, supply of goods from Pietermaritzburg/Durban would be more costly via the “north bank” route than the “south bank” route, purely because of the increased distance.

9.4 Role-Players

- Implementing Agent and the design team: dam type, site facilities and requirements;
- KZN Roads Department;
- South African National Roads Agency;
- Spoornet;
- Community development agencies; and
- Land owners.

9.5 Possible Actions

The Project Team Implementing Agent would need to relate the site camp and quarry requirements to the regional development objectives in a specially commissioned economic and environmental cost-benefit study. This would relate project costs of road construction, road maintenance and goods transportation to the long-term regional benefits. It might well transpire that access would be required from/to both banks for the construction activities, in a scenario where the north bank road might have a lower vehicle usage, and consequently lower specification, but not lose its long-term regional benefit.

SECTION TEN: PHYSICAL INFRASTRUCTURE AT THE JANA AND MIELIETUIN DAMS

10. PHYSICAL INFRASTRUCTURE AT THE JANA AND MIELIETUIN DAMS

10.1 Description

During the construction stage, the following facilities will be established in the near vicinity of the dam site:

- offices;
- communications centre (including lecture hall);
- worker training centre (induction, basic skills, safety, labour relations policy, literacy, etc.);
- accommodation and ablutions;
- canteen;
- vehicle and plant service centre;
- stores buildings;
- recreational facilities (halls, fields, etc);
- primary/emergency medical centre;
- ore crushing plant; and
- concrete batching plant.

These will in turn require appropriate services as follows:

- access roads;
- electricity supply;
- telephones (land lines and cell phone base stations/repeaters);
- potable water supply;
- effluent treatment facilities; and
- solid waste removal and disposal.

It is therefore proposed that as many of these facilities and services as possible be utilised after dam construction for community or local authority use. In the case of Jana Dam, there are many factors impacting on the location of the site facilities, other than those related to their future use and benefit to the sub-region. These are, *inter alia*:

- transport economics: the access road to Jana is considerably shorter from Colenso to the dam site (south bank) than it is from Ladysmith/Ezakheni to the dam site (north bank);
- access road longitudinal profile: this will affect transport costs, particularly of heavy vehicles (e.g. cement tankers) - the "Colenso" access road is also less severe topographically;
- daily logistics: supply of sundries, transport of labour, daily commuter traffic;
- suitable terrain for site layout;
- proximity to the labour pool;
- proximity to the aggregate quarry: where best to locate the crushing plant and concrete batching plant relative to the quarry;
- electricity supply issues; and
- a bridge over the dam wall has been mooted, but it adds considerably to the dam cost, particularly in the influence it has on spill hydraulics, and will obviously only have benefits once the project has been completed.

It will be necessary therefore to develop some understanding of the residual value of facilities and services once construction is completed, and not simply to focus on the minimum up-front cost only. Initial sentiment may well lean towards the minimum cost scenario, which on early indications, would leave little for long-term community benefit. When residual values are brought into the equation, this perception may well change.

In the case of Mielietuin Dam, the local support centre will be Estcourt, and while the same factors apply, the decision is more clear-cut, with an obvious preference for the north bank.

10.2 Future Needs

The facilities listed above would be ideal for re-use as a tourist resort linked to the Weenen Nature Reserve community service, administration, development and training node in the sub-region. This would however require considerable planning and the commitment of financial and human resources to manage the general operation, administration and maintenance of such facilities. Such facilities have also been used for tourist related activities, *viz.* tours of the dam site, establishment of a construction museum including audio-visual shows.

In terms of the Jana site, the community needs are prevalent on the north bank, while the current landowners on the south bank would most likely support a minimum-intervention, minimum long-term effect scenario. As a major tourist venue, the area would offer spectacular views, and be close to mooted game farms on the south bank.

It would seem, therefore, that there are valid reasons for locating the Jana camp on the north bank. The possible bridge over the dam wall would not be viable, but tourists could use boats or ferries to cross the dam to visit the game farms on the south bank. Combining use of the camp facilities for both tourist and community use would be the most sustainable scenario and could be a source of much needed job creation in the area.

In the Mielietuin Dam area, the local needs are primarily located on the north bank and would tend to be more tourist-related, but a mixed approach could once again be the optimum.

10.3 Role-Players

The District Municipality would have to facilitate such development, networking with the Department of Health, Department of Housing and KZN Nature Conservation Services on the public sector side, as well as interested private sector operators.

10.4 Possible Actions

The TWP Planning team should give serious consideration to the appropriate layout design for the respective site facilities, so that they may be easily converted to community/tourist facilities after construction of the dams has been completed.

SECTION ELEVEN: ELECTRICITY SUPPLY

11. ELECTRICITY SUPPLY

11.1 Description

11.1.1 Hydro-Electricity

The most significant drawback to the development of a hydropower plant at the dam sites is the need to release water to generate electricity. A true pumped storage scheme entails that water is released to generate power during peak demand times and then pumped back from a holding dam into the primary impoundment, and therefore the release of water is not a problem. This scenario is however only suited to peak power supplementation and not sustained delivery into a local supply grid. Once the downstream flow requirements in the Thukela River have been determined, a more informed decision on the sustainable generating capacity from the constant release can be taken, and an assessment made of the viability of hydropower plants supplying local and/or national demand. It is however acknowledged that hydropower is a “clean” form of electrical energy, and in the cases of the proposed dams, may serve the local domestic needs or even be developed to power any micro-irrigation schemes abstracting water from the dams.

The other concern about hydropower plants in South Africa is that the prolonged droughts typical over much of the country, render the total reliance on hydropower very risky. Once the impoundments upstream of the hydropower plant are drawn down below a certain level, the generation of electricity is no longer possible. Given the surplus generating capacity in the Eskom system at present, which is likely to delay the construction of major new power stations by five to eight years, and the fact that a major investment will be made in providing electrical power to the construction sites, for later use in the regional grid, it is likely that the viability of a hydropower plant at the dam sites will be dependent on the minimum flow released for environmental reasons and the storage level variation characteristics of the dams.

11.1.2 Domestic Supply

There is considerable opportunity for Eskom to plan extended domestic supply grids into areas (mainly rural) near the dam sites or pump stations, on the back of their power supply for construction purposes to the sites themselves. The site construction camps for the dams for example will require suitable electricity supply for, *inter alia*, the ore crushers, concrete batching plant, lighting, general small, medium and heavy electric plant, offices, accommodation, workshops and service yards. It is, however, the surrounding areas that hold most long-term potential.
The consumer density or power demand are critical parameters for Eskom in their viability studies, but supply into the north bank area at Jana for example, following the possible north bank access road, could also supply small industries, schools and clinics.

As part of the economic development initiatives, the supply of electricity should be linked to “added value enterprises”, viz. if households are not able to increase their disposable income, domestic electricity supply fails on affordability grounds. SMME projects related in some way to electricity consumption therefore need to be stimulated, which would provide sustainable employment, increase household income and also increase demand for electricity supply. The trigger event could well be the go-ahead of the TWP.

11.2 Future Needs

While the rapid growth in electricity generating capacity in SA has diminished significantly in recent years, it is a long-term business and requires massive capital investments many years in advance of the actual demand manifesting itself. Risk mitigation strategies should therefore be devised - the risk to Eskom being either over-capitalisation in terms of generating capacity, or alternatively, under-capitalisation and unable to meet demand. There would therefore appear to be a need for “clean”, peak power supplementation. Depending on the reliance of Eskom on this power from either Jana or Mielietuin, attention would have to be given to the water allocation and yield-reliability characteristics of each dam, as well as the minimum releases for environmental reasons.

There is a need for electricity supply expansion into rural areas – the difficulties primarily are affordability and perceived costs. Careful, integrated planning related to the dam construction requirements, would maximise the opportunities to extend a primary supply to Mziyonke, Mhlumayo, Thembalithle, Cornfields, Weenen and Thukela Estates. Eskom has commenced long-term planning of systems to augment the existing grids.

11.3 Role-Players

- Project team and implementing agent;
- Eskom (Mkondeni, Pietermaritzburg): Mr Clinton Carter-Brown.

11.4 Possible Actions

The viability studies underway at present, evaluating the entire TWP at a detailed feasibility level, will provide some indication of (i) the selection of the Thukela System as the preferred development, and (ii) the most likely development schedule. Eskom should continue to plan and implement their regional network development, making due allowance for the power requirements stipulated in the TWP technical studies. The viability of existing Eskom projects (planned or implemented) should however not be adversely affected by any re-routing or re-scheduling. Eskom should also engage in pro-active initiatives in communities surrounding the proposed dams etc., with the primary aim of developing sustainable SMMEs and power demand. This would in turn lead to a more viable domestic supply system.

SECTION TWELVE: OFF-SET FUNDING AND COUNTER TRADE

12. OFF-SET FUNDING AND COUNTER TRADE

12.1 Description

The extent of financial investment in this project (±R5 billion) should create an opportunity for international participants to consider off-set funding or counter trade deals in their tenders.

In simple terms, off-set funding entails the tenderer participating in investment deals outside of the actual contract, but in related fields in the country, that stimulate manufacturing capacity, sustainable employment and possibly, export opportunities.

Counter trade entails “payment in kind” for goods, e.g. if Siemens pump motors are imported from Germany, these could be “traded” for rolled and coated aluminium coils manufactured by Hulett Aluminium in Pietermaritzburg.

These ideas need to be evaluated against the type and value of goods and services that are expected to be imported to the country for the project. The primary entities will be mechanical and electrical equipment for the dam operation and pump stations, certain plant and equipment for pipe manufacture and the pipeline and dam construction, as well as professional expertise for design, tendering and construction supervision.

One aspect worthy of attention would be the re-employment of trained workers on a sustainable basis after the project is completed. This would require the contractors or suppliers to enter into agreements with other industries to allocate suitably trained personnel to their businesses after construction. The pipe manufacturing component may be a case in point, where South African pipe could be made for other projects off-shore, on contracts directly sourced from counter trade requirements on this project.

Unlike the recently completed arms refurbishment and replacement deal, where off-set funding gearing of two to three time was achieved, the nature of this project will demand considerably more ingenuity in conceiving of appropriate and feasible off-set funding and counter trade opportunities. It is nevertheless worthy of consideration.

12.2 Role-Players

- Project Team and DWAF
- Department of Trade and Industry
- Industrial Development Corporation
- SACOB, etc.
- Potential pump and motor manufacturers, e.g. Sulzer and Siemens respectively for “generic” discussions.

12.3 Possible Actions

The project team need to give some thought (based on the experiences at Katse and Mohale Dams) of the international services and commodity make-up of the TWP. Based on the outcome of this study, the role-players listed above should be engaged to confirm certain principles and assumptions. If, thereafter, the principle appears feasible, the identification of potential local participants should proceed. Once the possible linkages have been established between the direct TWP requirements and off-set/counter trade opportunities, attention would have to turn to the forms of tender and contractual and timing considerations.

SECTION THIRTEEN: CONCLUSION AND IMPLEMENTATION STRATEGY

13. CONCLUSION AN IMPLEMENTATION STRATEGY

13.1 The Nature of the Development Opportunities

The TWP will probably lead to the greatest socio-economic impact that the region has ever experienced. The size of the investment, employment, material requirements and local income generated by the TWP is likely to bring about many changes in the region, even if only during the construction period. This report focuses on the positive development opportunities that could materialise as a result of the TWP being implemented in the region. It is hoped that the findings of this investigation will lead to the implementation of actions and strategies that will maximise the development opportunities in the region.

A large number of development opportunities have been identified in this report and have been categorised into eleven groups which were then grouped into four sets of related opportunities. These four sets deal with opportunities related to community development, the economy (tourism, commerce, industry and agriculture), labour and procurement inputs and physical aspects such as roads, electricity and buildings. Some of the opportunities identified are of a strategic nature which will have an impact on the region as a whole, while the remaining opportunities are of a more localised or limited nature. The most important regional opportunities that the TWP may trigger are set out below

The TWP has the potential to influence the spatial composition of the region. The scale of the TWP compared to the rest of the regional economy is such that it could have an impact on the growth of urban nodes, settlements and corridors in the region. The TWP could consequently be used to strengthen those spatial patterns that would support and advance the region as a whole. The regional development plan formulated for the uThukela region identified, for example, Ladysmith and Estcourt as significant development nodes in the region. The TWP should therefore be implemented in such a manner that it strengthens the nodal position of these two nodes.

The TWP has the potential of being a major employer in the region during the construction phase. However, employment opportunities would cease once the project has been completed. The construction phase of the project will therefore not create long-term sustainable employment to the people of the region. However, one of the most important long-term regional impacts that the TWP could have is on basic adult education and training of local people to be employed on the project.
The project could be implemented in such a manner that local people are taught new skills and gain experience. Such education, skills and experience will be of long-term benefit to the people of the region.

It is therefore important that special attention be given on how the TWP could be implemented so that the education, skills and experience levels of the local labour components are maximised.

The physical infrastructure that will be created through the TWP would have a lasting impact on the region. It is therefore important that the buildings and infrastructure are provided in such a manner that the benefits to the region and the local communities are maximised. The planning of the location and the design of the buildings and infrastructure should therefore take place in consultation with the regional people and the local communities.

The TWP could have a lasting impact on the tourism, commercial, industrial and agricultural development opportunities in the region. These opportunities will mostly be initiated and developed by private sector investors and business interests. It is therefore important that special attention be given to the development environment that will be established by the TWP. That environment could either promote or restrict the long-term regional investment opportunities. One of the most important mechanisms that could be applied by the TWP to benefit the local economy and create an environment that is conducive to regional investment and development is the implementation of contractual agreements and procurement policies that are to the advantage of local investors and suppliers.

The development opportunities identified through this study have not been subjected to any form of feasibility or viability study. It remains the responsibility of the potential investor to undertake detail feasibility investigations. There are a number of risks associated with the opportunities identified through this research. The most important risk is related to the fact that the current TWP investigations are only conducted at feasibility study level. For instance, it may be found that the project should only take place in the long term, rather than the medium term as is currently anticipated. A further risk relates to the fact that, should the project be implemented, it is still about six to eight years before construction on the project will commence. The socio-political and the economic environment within which the current planning takes place will have changed considerably by that time. The long lead time means that many changes will have taken place that renders anticipated opportunities meaningless while opening new ones not thought of before.

13.2 The Need for Intervention

The basic need for this study to identify regional development opportunities originates from the realisation that large infrastructural projects, such as the TWP, often have a limited sustainable impact on the region in which it is located. The outputs of such large projects are usually intended for markets outside the local region while the inputs to the project are usually imported from external suppliers.

The forward and backward linkages of such projects with the local economy are therefore restricted. The linkages of the project with the local region are usually at its optimum during the construction phase after which it declines rapidly with little long-term benefits remaining in the region.

The above scenario would under normal conditions also develop in the case of the TWP. The water that will be produced by the project is earmarked for the Vaal River System while most of the raw material inputs such as the cement and steel, will be imported from elsewhere in the country, or even internationally. Although the region will benefit during the construction phase from the inflow of new capital and the employment of local labour, these positive development impacts will largely cease once the construction phase comes to an end. The normal expenditure levels and employment component of the operating and maintenance phases of the project will be relatively small, having little direct impact on the region.

In order to counter the above pattern of development of large scale infrastructural projects, this study identifies local regional development opportunities that can be initiated as a result of the TWP. It will, however, not be sufficient to only identify the development opportunities. Mechanisms will have to be implemented in the region and by the regional role-players, if the maximum impact of the development opportunities is to be realised. The region itself will therefore be responsible to take up the challenge for making the opportunities happen. The most important of the mechanisms are discussed below.

13.2.1 Intervention structures

It is in the first instance necessary that a network of responsibilities be implemented by the regional role-players to manage and facilitate the opportunities. It must be realised that many of the opportunities would not materialise without pro-active intervention. Since the opportunities are multi-sectoral and should be implemented in an integrated manner for maximum impact, it will be necessary for all the role-players in the region to co-ordinate their efforts.

There are a number of different forms of structures that can be used to establish the networks of responsibilities. Each one of the structures have a different set of advantages and disadvantages that must be considered in deciding on a preferred format. Some of the more obvious structures are indicated below.

a) District Municipality

The regional planning, development and co-ordination functions of the District Municipalitys (which is soon to be changed into district councils) probably makes it the prime candidate to facilitate the implementation of the development opportunities.

The uThukela District Municipality in particular has already taken the lead in establishing a number of co-ordinating forums such as the Service Providers Forum, an Economic Forum and a Social Services Co-ordination Committee. The District Municipality is therefore ideally positioned to interact and liaise with most of the economic, social and infrastructural role-players in the region. The District Municipality may be the best vehicle to facilitate the TWP development interventions. The District Municipality is responsible for a large number of municipal functions and may as such not have the capacity or the resources to give sufficient attention to the management task.

b) A Dedicated Development Company

A dedicated section 21 development company (not for gain) could be established to manage and facilitate the implementation of the development opportunities. The development rights surrounding the dams could, for example, be made available or transferred to such a development company on an agency basis. The company would manage those assets to the best of its ability. The benefits of the developments would accrue to the shareholders that could include, amongst others, the local communities through their representative structures such as the TLCs, tribal authorities, trusts and community property associations (CPAs). The establishment of a development company would probably operate most effectively as far as the commercially viable opportunities are concerned. The social and bulk infrastructural opportunities would best be managed through a different structure such as the District Municipality.

c) A Dedicated Multi-Sectoral Development Forum

A multi-sectoral development forum involving all the key role-players in the region, together with national and provincial government departments, could be constituted to facilitate and direct the implementation of the regional development opportunities. The leadership structure of such a forum could be elected from the participating members while its funding could be sourced from the participating corporate and individual members. Such a forum would probably function as a co-ordinating body and it would be unlikely that it would act as a developer in its own right.

d) Appointment Of A Dedicated Project Manager

A dedicated project manager could be appointed through any of the above structures to oversee and manage the regional development opportunities. In this respect the project manager could function on a similar basis as the project manager to the Spatial Development Initiatives operate. The project manager is assigned a prescribed budget and appointed for a specific period with the task to implement economic development projects in the area under consideration. The funding for the project manager could be sourced from all the interested parties including national and provincial departments with an interest in effecting co-ordinated development.

13.2.2 Important Functions Of The Regional Development Structure

One of the most important functions of the suggested development structures will be the networking of the development opportunities between the interested parties. This function should include aspects such as the identification of potential investors and the arrangement of partnerships between government departments, the private sector, communities, NGOs and between suppliers and markets, producers and distributors and funders and lenders.

Public/private partnerships are important mechanisms that can be used to promote sustainable development. The proposed regional development structure should be playing an active role in the facilitation of such partnerships.

A second important function which is closely related to the facilitation of partnerships is the distribution of relevant and up to date information about the TWP and the development opportunities. Information is crucial to decision makers, potential investors and suppliers of goods and services. The TWP will be focused on the construction of the dams and the aqueducts and will not be responsible for the identification of the direct or indirect development opportunities that emerge from the project. It will be the responsibility of the regional role-players through a regional structure to continuously identify and provide information about the development opportunities during and after the construction phase.

13.3 Conclusion

This report is not intended to present an exhaustive list of direct and indirect development opportunities, but is meant to start a process within the region through which action and initiative will be taken by the relevant role-players to maximise the benefits of the project for themselves. It is in this light that the Department of Water Affairs and Forestry makes this report available so that it can lead to creating local regional linkages between the TWP and the region.

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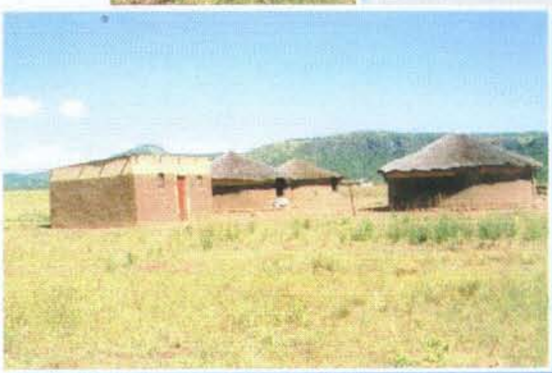
Republic of South Africa
Department of Water Affairs and Forestry

Thukela Water Project Feasibility Study

Social Impact Assessment

March 2001



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THUKELA WATER PROJECT FEASIBILITY STUDY

SOCIAL IMPACT ASSESSMENT

MAIN REPORT

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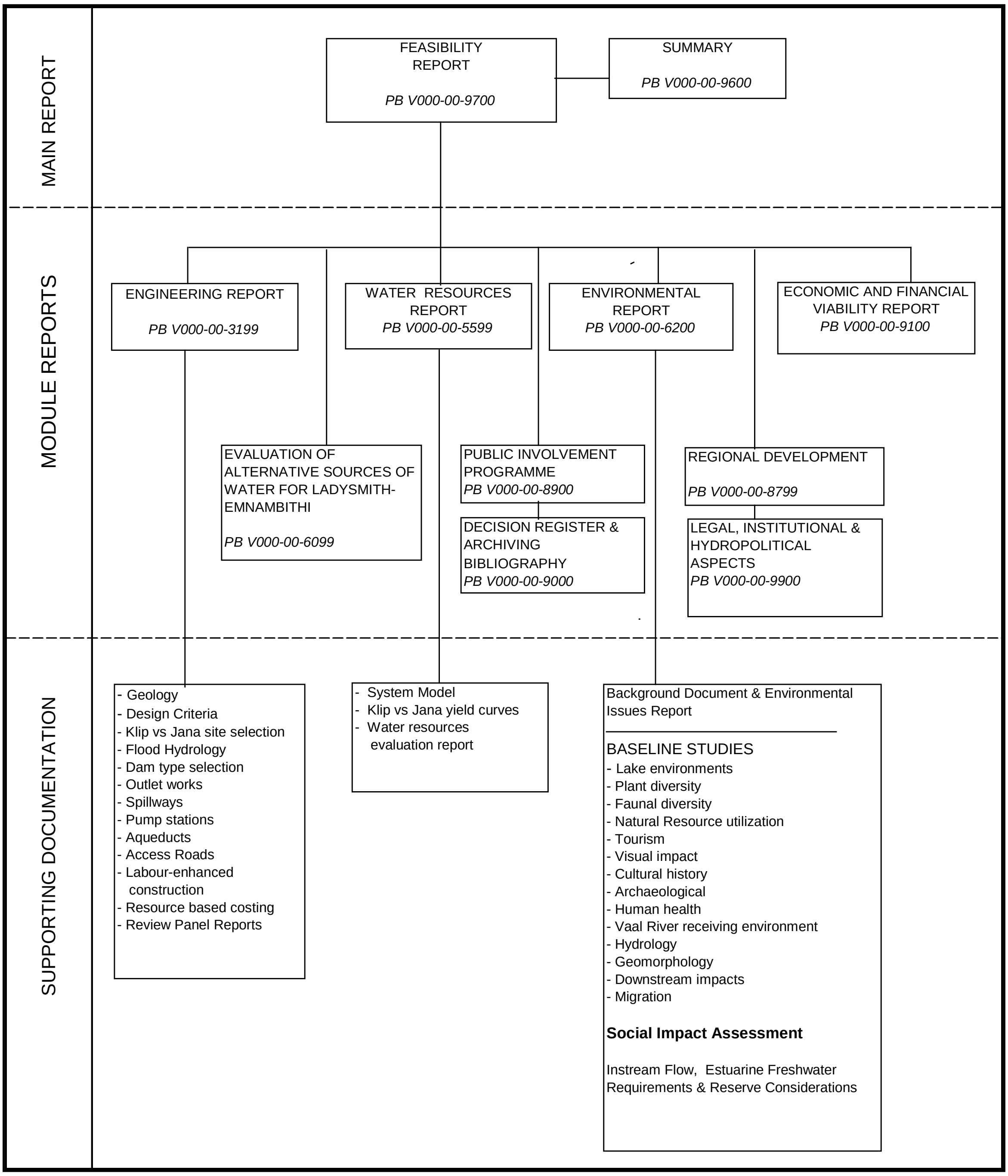


THUKELA WATER PROJECT FEASIBILITY STUDY
SOCIAL IMPACT ASSESSMENT MAIN REPORT

SCOTT WILSON **MARCH 2001**

Approved for Scott Wilson by:

..	**..**
GB Huggins	**MJ Wright**
Team Leader	**Director**

PREFACE

This Module Report on the Social Impact Assessment associated with the Thukela Water Project proposals emanating from the Feasibility Studies was prepared by Scott Wilson. The authors were appointed to undertake one of 15 modules in the Feasibility Study and obtained information from and liased, inter alia, investigating teams assigned to the other modules. The report was prepared under the direction of the Project Management Team.

The report has been accepted as representing the outcome of the terms of reference assigned to Scott Wilson and has been used as an important source document for the preparation of a Main Feasibility Report on the Thukela Water Project. All views, findings, interpretations and recommendations of the authors may not necessarily have been included in full in the Main Feasibility Report. Deviations from this report are noted in the Main Feasibility Report.

SUMMARY

As part of the overall Thukela Water Project Feasibility Study, the Department of Water Affairs and Forestry (DWAF) commissioned a study to examine the social feasibility of the development options mooted for the proposed scheme.

The specific aims of this study, known as the Social Impact Assessment, were:

- To prepare a literature and preliminary fieldwork based background statement on the priorities and scope of the project.
- To generate a synopsis of the regional and sub regional socio-economic environment and the relationship of the project to this environment.
- To carry out fieldwork in the affected areas and among the directly and indirectly affected population. This culminated in a profile of an assessment of the issues, claims, and concerns of those people regarded as affected.
- To identify and assess possible compensation and mitigation strategies.
- To identify positive impacts and make recommendations as to how they should be optimised.

The report concludes that the TWP has a socio-economic impact at a number of levels. Firstly, at the national level the scheme will assist in assuring a water supply for the Vaal Water Supply Area. As the industrial heartland of South Africa, and indeed the African continent, securing this supply is of critical economic importance. Secondly, at a regional level the TWP appears to have the potential to provide a much-needed economic boost for the area. As such the regional attitude towards the project appears to be a very favourable one. Although, as pointed out in the report some uncertainties appear to cloud the national and regional planning horizon e.g. the potential impact of HIV/AIDS and the complex issue of Land Reform, these need not prove to be critical threats. While the project does appear to have both implicit and explicit national and regional benefits there are some threats, certainly at a regional level.

Firstly the potential of the canal system to disrupt the established agricultural base and the emerging eco-tourism, game-farming initiatives in the Thukela Biosphere must be considered. Secondly, the potential impacts of reduced flows downstream of the dam need to be closely monitored in order to ensure that those people who have at least a part of their subsistence livelihood dependant on riparian resources are not adversely affected.

The bulk of the report however concentrates on impacts at the local level. At this level the negative impacts of the TWP, if not properly mitigated, will be more acutely felt. The most critical of these impacts are those potentially felt by the communities of Mziyonke and Mankandane and the landowners along the proposed canal route. The communities of Mziyonke and Mankandane are particularly vulnerable and the report demonstrates that:

- The land that will be lost to the Jana Dam basin at the 860m amsl Full Supply Level is important to the people of Mziyonke both for subsistence farming and for cattle grazing. Agricultural activity also provides a social security safety net that allows marginal households to survive. At the 880m amsl Full supply Level the impact is even more marked.

- The land that will be lost provides a base for additional resources that are important for the community and for people of the sub-region. Medicinal plants that will be lost as well as materials for handicrafts are important resources.
- Homesteads will have to be relocated. If the area proves not to be agriculturally sustainable, given the amount of land that will be lost, then the entire community may have to be resettled. This could lead to the severe disruption of intricately woven social networks.
- A relocation action plan that is acceptable to the residents of Mziyonke and Mankandane will have to be generated. This could incorporate plans for resettlement of all of the community or some of it. It would also have to consider options for the development of the remaining resource base in the Mziyonke and Mankandane area and/or in the new resettlement area.

The report ***strongly recommends*** that a relocation action plan (RAP), designed to at least the World Bank guidelines, should form an integral part of the Environmental Management Plan. This should start in the phase leading up to detailed design. In terms of the TWP the RAP should include the following features:

- Detailed situation report of socio-economic status prior to project implementation. This culminates in a database that includes details for each household impacted upon. This SIA provides the core of this database.
- Organogram of consultative and negotiating structures at local, sub-regional and regional level.
- Detailed description of the magnitude and significance of impacts. This is also done at a household level.
- Detailed design of mitigation strategies and compensation measure. This usually culminates in a suite of options.
- Detailed description of the mitigation measures (by household) that will be undertaken to ensure that the impacts are managed.
- Detailed description of compensation packages available and agreed upon by each impacted household.
- Step by step plan for resettlement and the handing over of compensation. This should detail individual responsibilities for when, what and who, and should be precise.
- Detailed plan for monitoring and evaluating the socio-economic status of impacted households over the duration of the project.
- Detailed plan for the mitigation of negative sub-regional impacts (e.g. containment of spread of social pathologies).
- Detailed plan for the optimisation of potential sub-regional impacts.
- Detailed plan for monitoring and evaluation of sub-regional impacts.

The freehold farmers on the Right Bank of Jana Dam are not as vulnerable to the impacts as the people of Mziyonke and Mankandane. Nevertheless the possibility that the Emaneni Game Farm will have to be expropriated in its entirety exits. Furthermore, the farmers on remaining farms will expect to be compensated fully and fairly.

In terms of Mielietuin Dam it appears as if little resistance to construction can be expected from the landowners. Most see the Dam (particularly as close to the 1020m level as possible) as a potentially positive development. This view appears to be predicated upon the following:

- Property prices have declined (partially as a result of the uncertainly around the dam but probably more directly as a result of pressures on diary farming and perceptions of crime) and interest in the area, driven by decisions around the dam, might be re-stimulated.
- The move from diary to game means that many farms may actually aesthetically benefit from the presence of the artificial lake. This will particularly come to pass if the dam remains full for much of the time. Under these circumstances property prices might very well increase with developers and speculators entering the market. The presence of the Thukela Biosphere, the Weenen Nature Reserve and the Gongolo Conservancy Game Farming initiative means that impetus for this kind of enterprise is in place.

The report indicates that the small number of landowners actually active in the area, the degree of relative good will, and the potential positive impacts of the dam means that the foundations for “win-win” negotiations with stakeholders have been laid.

The aqueduct route is however more problematic. Vigorous opposition to the optimised canal route can be expected from a number of quarters. These would be:

- Farmers in the Thukela Biosphere who maintain that the canal route will threaten the viability of their entire enterprise.
- The Department of Land Affairs and the people of Labuschagnes’ Kraal (Ekuthuleni) who consider the canal route to be a threat to their safety.
- Farmers and landowners affected by the canal route who consider it disruptive to farming and a threat to humans and livestock.

In this regard the steel pipeline route is considered to be a much better alternative, and from a social impact perspective is **strongly** recommended as the more favoured option. In terms of the steel pipeline the landowners’ concerns are largely with impacts associated with the construction period and with the terms of compensation for servitudes registered.

Although the report concludes that no fatal flaws appear to be associated with the TWP, in terms of the socio-economic impacts the impacts of potential resettlement at Mziyonke and Mankandane will almost certainly be difficult to manage**. As such a well formulated and locally acceptable Resettlement Plan is vital.** Furthermore the canal-based aqueduct will almost certainly give rise to a great deal of opposition to this section of the project.

THUKELA WATER PROJECT FEASIBILITY STUDY

ENVIRONMENTAL FEASIBILITY STUDY SUMMARY REPORT

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

DAEA	KwaZulu-Natal Department of Agriculture and Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DPSS	Drakensberg Pumped Storage Scheme
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
EMC	Environmental Management Class
FSL	Full Supply Level
GDP	Gross Domestic Product
GGP	Gross Geographic Product
I&APs	Interested and Affected Parties
IEM	Integrated Environmental Management
IFR	Instream Flow Requirements
KZN	KwaZulu-Natal
LHWP	Lesotho Highlands Water Project
M AMSL	Metres Above Mean Sea Level
MAR	Mean Annual Runoff
NWA	National Water Act
NWRS	National Water Resource Strategy
PIP	Public Involvement Programme
PMF	Probable Maximum Flood
RCC	Roller Compacted Concrete
RDP	Reconstruction and Development Programme
RMF	Regional Maximum Flood
SADC	Southern African Development Community
SEA	Strategic Environmental Assessment
TVTS	Thukela-Vaal Transfer Scheme
TWP	Thukela Water Project
VAPS	Vaal Augmentation Planning Study
VRS	Vaal River System
VRSA	Vaal River Supply Area
VRSS	Vaal River Supply System
WCD	World Commission on Dams

SECTION 1: INTRODUCTION

THUKELA WATER PROJECT FEASIBILITY STUDY
SOCIAL IMPACT ASSESSMENT MAIN FEASIBILITY REPORT

1. INTRODUCTION

1.1 Background and Scope of Study

The prior stages of the Vaal Augmentation Planning Study identified inter-basin transfer (in association with demand management strategies) as the most viable and cost effective way of augmenting water to the Vaal River System. The prior stage of the VAPS was conducted at pre-feasibility level and concluded that the Thukela River and associated development options should be studied at feasibility level.

Feasibility studies require that the full range of project dimensions be assessed in detail. An increasingly critical dimension of dam projects is an assessment of the associated social impacts. To this end the Department of Water Affairs and Forestry (DWAF) commissioned a study to examine the social feasibility of the development options mooted for the Thukela Water Project (TWP). This report is the outcome of the investigation. As such it is part of a broader suite of studies co-ordinated by an already appointed Project Management Team. In particular the study is designed to be read in conjunction with the reports that make up the Environmental Impact Assessment, the Regional Development Report, the report on the Public Involvement Programme, and the various technical investigations.

The specific aims of the Social Impact Assessment (SIA) were:

- To prepare a literature and preliminary fieldwork based background statement on the priorities and scope of the SIA component of the project. This culminated in the inception report published as Department of Water Affairs and Forestry, South Africa. 1999. Social Impact Assessment: Inception Report. Prepared by Scott Wilson as part of the Thukela Water Project Feasibility Study. DWAF Report No. PB. V000-00-1998.
- To generate a synopsis of the regional and sub regional socio-economic environment and the relationship of the project to this environment.
- To generate a comprehensive stakeholder list and, in conjunction with the PIP consultant, make recommendations as to strategies for engaging with stakeholders.
- To carry out fieldwork in the affected areas and among the directly and indirectly affected population. This culminated in a profile of an assessment of the issues, claims, and concerns of those people regarded as affected.
- To identify and assess possible compensation and mitigation strategies.
- To identify positive impacts and make recommendations as to how they should be optimised.

1.2 Approach to Study and Methodologies Employed

The approach to the work favoured by the study team emphasised an integrated, holistic, and multi-disciplinary concern with problem-centred development issues. The team believed that this approach was necessary in order to ensure that the effects of development are not confined to an advantaged elite but also filter through to the people who are likely to be directly impacted upon by development. For the study team this meant an approach centred upon two fundamental principles.

Firstly, an integrated development planning (IDP) approach was adopted. This approach concentrated on analysing and addressing both negative and positive impacts. Therefore, as with the Integrated Environmental Management (IEM) approach, the potentially negative impacts of the dams and aqueducts are identified and plans for minimising them are devised. However, and equally importantly, the potentially positive impacts were also identified and strategies for the maximisation of these impacts were drawn up.

Secondly, the study team believed that this approach should be "people-centred". As such the bottom line belief is that the welfare of the people affected by the proposed Thukela Water Project should be afforded the very highest priority during all stages of project design. To this end the issues, claims, and concerns of the people of the areas that are impacted upon were identified, considered, evaluated and written up in a format that is both accessible to those affected and adds value to the planning and technical aspects of the project. This approach had to be grounded in effective fieldwork and was dependent upon the establishment and maintenance of good links with the affected population. This was, in large measure, accomplished by ensuring that a structured relationship with the Public Involvement Team was developed and that fieldwork was undertaken with the requisite degree of sensitivity and protocol.

Fieldwork commenced in April of 1998 and was on going until final report writing. The primary research method used by the Social Impact Team was to consult extensively with the relevant key role-players and interested parties. This was based on undertaking individual interviews and on co-ordinating group inputs. More specifically, fieldwork methodologies included the following:

- One on one interviews with landowners, community representatives, and key regional stakeholders.
- A household based questionnaire survey undertaken among the Mziyonke and Mankandani settlements.
- A mailed questionnaire survey among directly affected landowners.
- Telephonic interviews.
- Focus group interviews.
- Participatory Rural Appraisal discussions.

In addition to direct contact with interested and affected parities the SIA team also utilised the following data generation strategies:

- Analysis of aerial photographs, ortho-photos and topographical maps.
- Site visits.
- A literature survey.
- Integration meetings with other team members.
- Analysis of regional and sub-regional planning documentation.

1.3 The Thukela Water Project (as extracted from IEM Issues Report)

1.3.1 Overview of the Proposed Thukela Water Project

The proposed TWP as defined at feasibility level, is presently being planned to deliver $15m^3/s$ to the Kilburn Dam for transfer to the Vaal River System and comprises the following development components:

- Two large storage dams configured to supply a total of $15m^3/s$ of bulk raw water.
- Jana Dam in the Thukela River approximately 15 km downstream of the confluence of the Thukela and Klip Rivers (See Figure 2).
- Mielietuin Dam in the Bushman's River immediately upstream of the western boundary of the Weenen Nature Reserve (See Figure 3).
- Aqueducts linking the proposed dams and the existing Kilburn Dam from which water will be transferred to the Vaal River System via the existing Drakensberg Pumped Storage Scheme (See Figure 4). Three options for aqueducts are under investigation:
- Open canals (with limited tunnels, pipelines and inverted siphons)
- A pipeline ranging in size from 1.6 to 3m diameter
- A combination of open canals and a pipeline
- Appurtenant infrastructure including pumping stations, access roads and bulk electricity supply.

1.3.2 Proposed Time Scale of the Project

The construction of the scheme could take up to eight years to complete commencing between the years 2004 and 2010, or later depending on Vaal River user water demands and the implementation of alternative schemes.

The assumption is that the first water will flow from the TWP to the Vaal River System during the year 2011. At this stage of planning, this date is the best available estimate of timing. Revision of this date will materially affect the programming of all the work. The proposed timetable is therefore provisional and is subject to modification resulting from the outcomes and or requirements of the TWP Feasibility Study and the management of the Vaal River System.

1.3.3 Jana and Mielietuin Dams

a) Dam Sites and Yield

Preliminary indications are that the provision of the Ecological Reserve will have a significant impact on the yield of Jana Dam. However, it is not possible to finalise the Reserve allocation at present and as a consequence, it has been necessary to undertake the engineering investigations for a range of dam sizes and yields. Until the Reserve is finalised it will not be possible to optimise the dams and aqueducts or select a fixed dam level. A range of dam heights from 135m to approximately 190m is being considered for Jana Dam.

A similar situation exists at the Mielietuin site, where the height could be affected by the need to compensate for a reduced yield from Jana. At this site, attention is being given to a Full Supply Level (FSL)[1] range of 1015 to 1033

[1] Dam height is defined and measured as FSL above river bed level. The Planning Directorate of DWAF uses this definition.

above mean sea level, representing a range of dam heights from approximately 77 to 95m.

b) Dam Construction

Feasibility level construction planning has been undertaken at the Jana or Mielietuin Dam sites. The quarries for both dams will be located relatively close to the dam walls (certainly within the dams' basins), and the related major movement of materials will not affect areas outside the respective valleys.

1.3.4 Aqueducts

The aqueduct routes identified in the pre-feasibility and interim phases were evaluated during the initial period of the Feasibility Study. This process resulted in the identification of the two alternative types of aqueducts (canal or pipeline) and various possible route options, as well as a third alternative representing a combination of these two aqueduct types.

a) Canal Type Aqueduct

The overall length of the proposed canal from Jana and Mielietuin Dams to Kilburn Dam would be approximately 183km. This length includes a 6.7km long tunnel on the section between Jana Dam and the aqueduct junction south of Colenso, and a 6.4km long tunnel on the section between an outlet tower in Mielietuin Dam and the aqueduct junction.

A fenced construction servitude width of 100m would be required if this alternative is implemented. On completion, permanent servitude widths of 40 to 80m would be required, depending on cross-slopes and bends in the canal alignment. A permanent service road would be provided within the servitude and the servitude would be fenced, except at crossings. Construction camps of approximately 4ha would be located at 20km intervals and water and electricity supplies would be required at each camp. Each camp would typically include:

- a construction plant yard;
- workshops and welding plant;
- concrete batching plant and materials stockpiles;
- concrete precasting yard;
- stores building;
- contractors and engineers offices; and

The construction time for completing the whole route is likely to be of the order of four years, with the task being divided into five contract sections with each contractor working at a rate of 10km per year. Separate contracts would be required for the construction of each pumping station and associated pumped pipeline and for the supply and installation of pumping plant and valves. Eskom power would be required at each pumping station.

Borrow areas for selected soil fill purposes would be at intervals of between 5 and 10km, and would only be chosen after detailed geotechnical investigations, including soil profiling and sampling. Rock quarries for concrete aggregate purposes, including a rock crushing, screening and washing plant, would be required for each main contractor (5 in total). Sand borrow areas for concrete fine aggregate purposes would be located where sand deposits occur and at intervals of from 10 to 40km, depending on the size of the sand deposits. A sand fractionating, screening and washing plant would be centralised for each contractor.

b) Pipeline Type Aqueduct

The overall length of the pipeline type option from Jana and Mielietuin Dams to Kilburn Dam would be 121km. A requirement of approximately 30m fenced construction servitude is envisaged. A permanent unfenced servitude of approximately 20m would be required after construction, although this would not require a permanent service road. Concrete marker beacons will be located along the pipelines at intervals of about 100m and at changes in direction. The pipeline will be covered by approximately 1.8m of soil. Construction camps of approximately 4ha each will be required, located at 30km intervals.

The construction time associated with the pipeline aqueduct is likely to be of the order of three years, with the route being sub-divided into two main pipeline sections of approximately 60km each, with pipe laying proceeding at a rate of about 3 weeks per kilometre of pipe. The construction of the pipeline type aqueduct would include the construction of valve chambers, culvert type crossings under roads and railways, scour outlets and concrete erosion/corrosion protection under rivers, together with the fitting of values, waterhammer protection devices, flow metering equipment and inspection access facilities. There would be a pumpstation at each dam plus two intermediate pumping stations along the route of the aqueduct.

1.3.5 Supporting Infrastructure

a) Jana Dam Access Road

The initial route location for the Jana Dam access road was largely determined by the alignment of an existing gravel road and the topography over the remainder of the route to the dam site. Adjustments were made to the horizontal and vertical alignment of the existing road to conform to the requirements of the KwaZulu-Natal Department of Transport for a Type 4 (7m wide, surfaced) road. Every effort was made, even at feasibility level, to re-route roads so as to minimise socio-economic disruption and to maximise the potential positive impacts of the roads.

b) Mielietuin Dam Access Road

The route location for the Mielietuin Dam access road was mostly determined by the mountainous rolling topography, between Main Road 13 and the proposed dam site. The heaviest traffic, in terms of heavy vehicles, will occur during the construction phase of the dam walls. Thereafter it is envisaged that the road will be used by predominantly light vehicular traffic.

c) Realignment of Weenen to Estcourt Road in Mielietuin Dam Basin

As a result of the 1:50 year flood level of the Mielietuin Dam it is found that a short 1.7km long section of the existing Main Road 13 will encroach into the Mielietuin Dam basin. It is therefore proposed that this section of road be realigned to the north to fall outside the 1040m contour.

d) Pumping Station Access Roads

The route location for the seven proposed pumping station access roads was largely determined by the alignment of the existing gravel roads. Adjustments were made to the horizontal and vertical alignments of the existing roads to conform to the requirements of the KwaZulu-Natal Department of Transport for a 7.5m wide type 5 gravel road.

It is envisaged that heavy vehicles will only use the roads during the pumping station construction phase. Thereafter the roads would mainly be used by predominantly light vehicular traffic.

e) Service Link Roads

Node links to proposed aqueduct service roads from existing main roads could be located at intervals of 40km or less along the proposed routes.

f) Rail Road

No new rail road facilities are required. Existing facilities that are reportedly under-utilised at present, will most likely be used. A storage facility and loading yard may be established at the existing Colenso Station, within the existing station boundaries, for handling of materials and equipment transported by rail.

g) Other Services

- Existing services – No major re-routing of existing services will be necessary, as they do not fall within the proposed dam basins.
- Service required by Contractors – The contractors will require engineering services both at the dams sites (construction sites) and at the camps accommodating construction staff.

1.4 Report Outline

The following sections of the report consider the socio-economic impacts associated with the TWP in terms of context, major project elements, and recommendations for compensation and mitigation. As such the next section of the report, section 2, examines the project within its regional and sub-regional context and considers the suite of critical issues not necessarily directly bound to the infrastructural development associated with the project. Section 3 looks at impacts associated with Jana Dam. Section 3 also considers localised compensation and mitigation measures. Section 4 examines the impacts associated with the Mielietuin Dam and again considers localised compensation and mitigation measures. Section 5 looks at the aqueduct and compares the proposed canal based route with the pipeline alternative. Section 6 makes recommendations as to principles of compensation and mitigation. Section 7 provides a conclusion and summary of recommendations. Throughout the report major issues, impacts and recommendations for mitigation strategies are highlighted in text boxes.

SECTION 2: REGIONAL CONTEXT

2. THE REGIONAL CONTEXT

2.1 Demographic and Economic Context

The infrastructural elements of the TWP would all be located in the uThukela region of KwaZulu-Natal (see figure 1). With a population of about 650 000 residents the uThukela region makes up about 7% of the population of the province. For the most part the uThukela region is rural in its make up, with about 74% of the population living in designated rural areas. This is considerably in excess of the overall KwaZulu-Natal figure, which has only 55% of its inhabitants classified as living in rural areas.

For the most part the demographic profile of the area is typical of regions “underdeveloped” by the twin impacts of apartheid planning and the increasing geographic concentration of economic wealth in the major metropolitan areas. In terms of apartheid planning much of the uThukela region was designed to function as a labour reserve. As such it is noticeable that 54% of the population is female. The gender imbalance is largely the result of out (or oscillating)-migration of men working in other regions of the country.

Furthermore the most recently available census results (1996 figures) indicate that 44% of households in the uThukela Region have a monthly household level of below R840 per month, whilst only 12% have an income of above R3 650 per month. The comparative figure for the Durban Metropolitan Region, by contrast, is 34% below R840 per month, and 18% above R3 650 per month. Poverty is most acute in the areas demarcated as those under tribal tenure.

In terms of urbanisation it is anticipated that as a general rule there will be a trend towards de-population in the rural areas as the population shifts into the urban areas. Ladysmith and Ezakheni are anticipated to be the prime urban reception areas for the uThukela region. The trend towards depopulation of the commercial farming areas is expected to continue while the “tribal” areas will show a slowing of the population due to a decline in natural population growth and out-migration. These trends due not take into account the anticipated impact of HIV/AIDS. This issue is discussed in more detail in a separate section below.

In analysing the economic composition of the uThukela region it is evident that the manufacturing sector makes the largest contribution in terms of gross geographic product (GGP) to the economy of the uThukela region (33.3%). Table 2.1 shows that almost 30% of the contribution to the GGP of the uThukela region is made by commerce related activities. In terms of contribution to the KwaZulu-Natal GGP the uThukela region provides only 2.2%. Given that the population makes up 7% of the province it stands to reason that the population is, on average, somewhat poorer than the provincial norm. According to Urban Econ (1998) which sets out a development vision for the uThukela Region in the form of the **uThukela Regional Development Plan** this is the result of a number of factors. Critically, unemployment rates are larger than those for the province as a whole. In particular the Urban Econ report estimates that formal employment opportunities grew at only 0.4% per annum between 1980 and 1991.

Furthermore, the uThukela region does not form part of any development corridor identified by the KwaZulu-Natal Provincial Growth and Development

Strategy. This has important implications as industrial development within the region cannot rely on national or provincial priority funding. Ladysmith has, however, been identified as a provincial development node.

According to the report generated by the Regional Development component of the TWP the remainder of the towns and urban settlements within the uThukela region are currently focussing on local economic development initiatives. The report states that:

"Local economic development can be defined as the process or strategy in which locally based individuals or organisations use resources to modify or expand local economic activity to the benefit of the majority in the local community. The local authorities of Ladysmith, Bergville, Winterton and other small towns are, for example, in the process of introducing local economic development initiatives to the communities in the different areas. Investment in the industrial sector in these areas as well as in Ladysmith and surrounds is in small and micro enterprises. This is done to invest in the local community and produce a product that would appeal to the local as well as the national market." (TWP Regional Development Report 1999).

The economic core of the region, that of the manufacturing sector, is mainly focused within two localities in the uThukela region; Ladysmith-Emnambithi and Estcourt. The major industrial sectors within these areas are clothing and textiles, metal products and agro-industry. A number of industrial centres such as Ladysmith and Emnambithi served as points for the old Regional Industrial Decentralisation Programme (RIDP), offering relatively high levels of incentives. Nonetheless, despite the incentives, and the presence of plentiful water, labour and well-serviced industrial areas, the area has not succeeded in attracting a significant number of industries away from the major metropolitan centres in the country, and its outlook remains modest in this respect. While the manufacturing sector is reported to have grown at an acceptable rate of about 2.5% per annum the other key sectors, particularly agriculture were in something of a crisis (Urban Econ 1998). The Urban-Econ report also indicates that commercial agriculture is almost fully developed and little in the way of additional growth in employment can be expected in this part of the sector. Although there exists some possibility for growth in the traditional agricultural sector this too will only grow in the face of constraints. While much is expected of the tourism sector the relative performance of the KwaZulu-Natal province, in this regard, over the last number of years has not been heartening.

Table 2.1 indicates that the uThukela region's commerce contribution to the GGP is 9% less than that of the province. The Table nevertheless implies that there is room for further commerce-related development that will be welcomed in the region.

Despite a relatively negative recent economic history the Urban Econ report does make mention of one significant factor i.e. growth in the utilities sector. The utilities sector (water, electricity, gas) grew at 16% per annum between 1980 and 1991. It is the contribution of this sector (along with manufacturing) which is largely responsible for the region being able to maintain a 2.5% per annum growth rate in the value of GGP. Although, as evidenced by the marginal growth in employment opportunities, this sector has not been a bulk employer of labour it is evident that without the growth in utilities the recent economic past would have been very bleak indeed. According to Urban-Econ (1998) the growth in the utilities sector was largely due to the implementation of the Thukela-Vaal/Drakensberg water transfer project in the 1970's and early 1980's.

Table 2.1: Composition of the Regional and Provincial Economies (% GGP contribution)

ECONOMIC SECTORS	UTHUKELA REGION	KWAZULU-NATAL PROVINCE
Trade	10.83	16.03
Transport	11.74	11.14
Finance	6.51	10.87
Sub–total: Commerce	**29.08**	**38.04**
Agriculture, forestry, fishing	8.08	6.16
Mining, quarrying	0.42	2.02
Manufacturing	33.29	30.73
Utilities	12.09	2.19
Construction	3.21	3.64
Services	13.84	17.22
TOTAL	**100**	**100**

Source: DBSA 1995

The important contribution that the existing Thukela-Vaal/Drakensberg Pumped Storage Scheme has made to the region is implicit in many of the comments made by stakeholders during the course of research for this study. For many of the people of the region the currently proposed Thukela Vaal Transfer Scheme will be a much-needed economic boost for the area. As such the regional attitude towards the project appears to be a very favourable one.

Although potential regional disbenefits, (largely associated with the proposed canal system) were also identified these need to be considered against the background of the implicit benefits and around the potential to mitigate the negative local level impacts.

2.2 Contextual Social Issues

The SIA has examined a number of contextual issues, relevant to the project, that have come to the fore during the course of the investigation. Of these the most critical are the following:

- The potential impact of HIV/AIDS.
- Population trends in potential erodible areas and the potential impact of sedimentation.
- Land reform and restitution issues.
- Impact on the downstream environment.
- Impact on the receiving environment.

2.2.1 HIV/AIDS

A separate study of HIV/AIDS was commissioned and looked at the issue in some detail. This study was being undertaken by sub-consultants from the

CSIR and Medical Research Council. The report was made available in February 2000. However, the issue is critical enough to warrant some discussion in this report.

The problem of HIV/AIS is likely to have a significant effect on development throughout South Africa. Although no reliable figures are available for the incidence of HIV/AIDS in the uThukela Region some general comments can be made based on the state of the epidemic in the province. In this regard a number of crucial points can be made.

Firstly, the most recent official national figures released in the "**Department Of Health: Summary Report Of The Ninth National HIV Survey Of Women Attending Antenatal Clinics Of The Public Health Facilities In South Africa, October/November 1998"** indicate that KwaZulu-Natal is the worst affected province**.** The survey is based on 15 301 blood samples screened for HIV antibodies, of which an estimated 22,8% of women attending antenatal clinics nationally were reported to be infected with HIV. According to the report this translates into approximately 3,6 million South Africans or 8,6% of the total population. In simple terms, roughly one in eight adult South Africans (an adult is considered as a person from age 14 according to the report) were infected with the HIV in 1998.
The survey indicates the following trends:

- The prevalence rate in teenage girls (15 - 19 years) has risen from 12,7% in 1997 to 21% in 1998.
- A high increase in HIV prevalence amongst women in the twenties, 26,1% and 26,9% for the 20 - 24 and 25 - 29 year old groups respectively.
- HIV infection in the provinces has continued to rise.
- KwaZulu-Natal continues to be the province with the highest prevalence rate and has registered an increase of 20,8%. The report indicates that 33.1% of women in KwaZulu-Natal attending antenatal clinics of the Public Health Facilities who were screened for HIV antibodies tested positive.

Notable is that research suggests that the HIV/AIDS virus is transmitted with greater ease along major transport routes. The N3 that runs through the uThukela region is one such transport route. Anecdotal reports from organisations active in the area suggest that this is a major source of facilitating transmission and some sources report an annual mortality rate of about 10% of their labour force.

2.2.2 Land Reform

The history of the uThukela region is one of conflict over land. Although the TWP is fortunate in that the infrastructure that is being planned does not seem to fall into areas directly embroiled in land conflict, the context under which the state may acquire land for development of the project has a direct bearing on land reform issues (See Figure 5). As such a more detailed discussion of land reform is warranted. This is presented below.

In 1994, the National Department of Land Affairs agreed to the implementation of pilot land reform projects in each of the nine provinces. The Land Reform programme was developed as a result of colonial and apartheid dispossession that left millions of people landless, homeless and poor. The legislation that drives land reform is the White Paper on South African Land Reform Policy (1997). It outlines the strategic objectives of land reform as follows:

- to correct the injustices of racially based land dispossession of the past;
- to achieve an equitable distribution of land ownership;
- to ensure security of tenure for all; and
- to establish a system of land management which will support sustainable land use patterns and the rapid release of land for development.

These objectives will be achieved through the Land Reform Programme, which comprises three elements *viz.* redistribution, restitution and tenure reform. Various pieces of legislation and policy documents have been drafted to facilitate and provide the legal framework for the implementation of the Land Reform Programme.

a) The Redistribution Programme

This programme is intended to provide the poor, marginalised, and landless communities with access to land for residential and productive purposes and to improve their socio-economic conditions. The programme was designed to respond to a wide variety of land needs including farmworkers, labour tenants, emerging farmers and landless communities. Of importance to the redistribution programme are the following two Acts:

- *The Provision of Land and Assistance Act, Act 126 of 1993*
  This act is used as the mechanism for distributing land to the poor, and accessing financial support of labour tenants, farm workers, restitution communities, women and emerging farmers. The Act has primarily operated on the basis of a willing buyer/willing seller principle, although recent amendments to the act have now focussed it more on the provision of financial assistance to communities who acquire land through various mechanisms. The Act now facilitates financial assistance from the Department of Land Affairs to communities in the form of a Settlement/Land Acquisition Grant. The settlement of Labuschagnes' Kraal (potentially impacted upon by the Canal based aqueduct system of the TWP) is an example of a community to be settled under these provisions.

- *The Communal Properties Association Act, Act 28 of 1996*
  This legislation makes provision for groups or communities to acquire, hold, and manage property as a group with a written constitution.

b) The Restitution Programme

In November 1994. Parliament passed the Restitution of Land Rights Act as it was compelled to do in terms of the Constitution Act. Of importance is *The Restitution of Land Rights Act, Act 22 of 1994.* The goal of this Act is the restitution of land rights as required by the constitution to compensate or restore land to people dispossessed by racially discriminatory legislation and practices after 19 July 1913. The Act set out the powers and functions of two independent bodies: the Land Claims Commission and the Land Claims Court. The

Commission's task is to investigate claims and provided recommendations to the Land Claims Court after extensive negotiations with all key role players and affected parties.

The Court's role is to adjudicate land claims. Initially the Department of Land Affairs was not seen by the Commission as having a key role to play in the process. However a subsequent review of the Land Claims Commission and the Land Claims Court has seen a fundamental shift in the role that the Department of Land Affairs will play in the restitution process.

A restitution claim will be investigated where a claimant was dispossessed of a right in land after June 19, 1913. It is important, however, to note that there is a difference between restitution of a right in land and the restoration of land. The Act allows restitution to be in the form of either restoration of land OR compensation OR the provision of alternative land OR a combination of these. Although the details are unclear it appears as if some of the communities previously settled in the Thukela Biosphere (and potentially impacted by the TWP) are claiming restitution under these acts.

c) The Tenure Reform Programme

There are presently many laws which protect people who have bought land and have individual title deeds to it. There are however many people who have other kinds of land rights besides freehold title. The Department of Land Affairs is in the process of creating new laws which will recognise and protect the different forms under which people hold land. The aim is to extend security of tenure to all South Africans under diverse forms of tenure.

Tenure security is understood as the ability to hold and enjoy the benefits of land, homes and property without fear of arbitrary action by the State, private individuals or institutions. The purpose of tenure security is to contribute personal security, social stability, increasing levels of investment and sustainable use of land.

To achieve tenure security, the Department of Land Affairs intends extending registerable tenure rights to all landholders, establishing a unitary system of land rights within a diversity of tenure forms. To date the following tenure related legislation has been passed by parliament.

- *The Extension of Security of Tenure Act, Act 62 of 1997*
  Key to land reform is providing security of tenure to people who presently occupy land with no formal land rights. The purpose of this legislation is to provide a basis for adjusting the long-standing skewed relationships between land owners and land occupiers. In terms of the Thukela Water Project it appears as if labour tenants have largely already been cleared off of those farms that adopted this form of tenure. An analysis of the literature shows that labour tenancy was largely a feature of farms that had land of very mixed productivity and value. In terms of the Thukela Water Project labour tenancy appears only to have been a feature of land in the more eastern extremes of the project area i.e. Mielietuin environs. The act is however relevant to farms that may be declared economically non-viable as a result of the Thukela Water Project. In cases where farmers have their entire farm expropriated and they have labour living on their farms the developer needs to pay special attention to the fact that labourers may be vulnerable to loss of

employment. In terms of the Extension of Security of Tenure Act they cannot be summarily evicted.

- *The Land Reform (Labour Tenants) Act, Act 3 of 1996*
  This legislation provides for the purchase of land by labour tenants and the provision of subsidies to this end.

- *The Interim Protection of Informal Land Rights Act, Act 31 of 1996*
  This Act provides for the temporary protection of certain rights to and interests in land which are not otherwise adequately protected by law.

- *KwaZulu-Natal Ingonyama Trust Act, Act 3 of 1994*
  Whilst the Ingonyama Trust lands are home to many people the issue of security of tenure is one which needs to be addressed if the objectives of the government land reform programme are to be realised. The emphasis on land reform and tenure security may be at conflict with the views held by many Traditional Authorities. In recognition of this the Ingonyama Trust Amendment Act was passed in 1997.

- *The Kwazulu-Natal Ingonyama Trust Amendment Act (No. 9 Of 1997)*
  This Acts amends Act 3/94 and, inter alia, redefines the categories of beneficiaries of the Trust; creates a Board to administer the Trust; provides for the Trust to be subject to national land programmes and provides that the Act shall not apply to land in a township.

  In more detail, this Act provides that the Trust shall be administered for the benefit, material welfare and social well-being of the member of the tribes and communities as well as the *residents in such a district.*

  It is also noted that land formerly owned by the KZN Government shall be held in trust by the Ingonyama for and on behalf of the members of the tribes/communities *and the residents of the district.* The act shall not apply to land in a township or private land, or land used for State domestic purposes. Trust land combined with public places and used mainly for residential, industrial and commercial purposes may be proclaimed as a township. In addition, land or real rights that had not been registered in private ownership, shall, if located in a township, vest with the local authority/provincial/national government.

  In essence, this amended Act provides for the delegation of powers in respect of the administration and the implementation of the Land Reform programme as well as the transfer of land rights in respect of township developments. It is further understood that a variety of forms of tenure could be considered in the ambit of the Ingonyama Amendment Act. This could facilitate the development of former tribal land as well as the transfer of property rights, and in effect, access rights to investors/developer or government departments. In the case of the Thukela Water Project the Act will facilitate the development of remaining land in the Mziyonke and Mankandani area. In the Amendment Act, mention is also made that land is to be administered for the benefit of the residents in a district, by implication including people from outside tribal authority areas. Again the residents of the Left Bank of Jana Dam are affected by this Act and development has to take note of the fact.

Finally, and potentially critical to the project is The Distribution and Transfer of Certain State Land Act, 119 of 1993. This Act regulates the distribution and transfer of certain land belonging to the State and designated by the Minister as land to be dealt with in accordance with the provisions of this Act; and to provide for matters connected therewith. In effect land acquired for the TWP and not directly needed for the operation of the project (e.g. an entire farm acquired as a non-viable economic unit but of which only a portion is needed for the project) may be subject to redistribution in terms of this act. This creates an avenue for the redistribution "uitval grond" that may be acquired where whole farms are deemed not to be economically viable. However it may make negotiation for land in the commercial farming areas more sensitive.

Although the land reform programme does not currently appear to present any significant problems for the TWP (other than those associated with the canal and Labuschagnes Kraal) some areas of concern do emerge. These are:

- The changing nature of the land ownership base in the broader area and the impact this may have on a project that could only be implemented in some years time.
- The potential need for the state to dispose of additional land acquired for the project (e.g. purchase of non-viable farming units) and the impact that this could have on the relationship between commercial farmers in the proximity and the developers.

2.2.3 Impact on the Downstream Environment

Investigation of the impacts of the TWP also looked at the possible socio-economic effects of people living downstream of the proposed dams. In all eight, magisterial districts lie below the dams. These districts (with a brief description of their major socio-economic characteristics) are:

- Emnambithi: This area is immediately downstream of Jana Dam and is located on the Left Bank of the Thukela River. The area was part of the former KwaZulu. The majority of the area is under tribal tenure and given over to subsistence cultivation. The area also includes the Thukela Estates project that has encouraged the development of more intensive agricultural activity under irrigated conditions.
- Weenen: This is downstream of Mielietuin Dam and also includes the land on the Right Bank of the Thukela, downstream of Jana Dam. The area was part of the former Natal. The land is under freehold tenure and for the most part is either utilised for dairy and beef farming or is under a game-farming regime. There are also vegetables grown under irrigation and dependant upon water from the Thukela.
- Msinga: This area is immediately downstream of Emnambithi and Weenen districts and is located on both the Left and Right Banks of the Thukela

River. The area was part of the former KwaZulu. The majority of the area is also under tribal tenure and given over to subsistence cultivation. The area includes the Thukela Ferry area that is considered to be one of the poorest parts of KwaZulu-Natal.

- Nkandla: This area is immediately downstream of Msinga district and is also located on both the Left and Right Banks of the Thukela River. The area was also part of the former KwaZulu and is very similar in terms of economic profile to Msinga district.
- Inkanyezi: This area is downstream of Nkandla and includes the former Natal magisterial district of Eshowe. People living along the banks of the river are almost exclusively those living under tribal tenure. Again, the area is similar in profile to the Msinga and Nkandla areas. The area does however include the area of Sundumbili, which was developed under the "border towns" development initiative. Sundumbili has been zoned for industrial development and a number of small and medium size factories have been built in the area. A number of informal settlements have sprung up close to Sundumbili.
- Mtunzini: This district is located on the Left Bank of the Thukela River and is immediately downstream of Inkanyezi. The area is predominately under freehold tenure and includes the town of Mandini. Mandini borders on Sundumbili and is home to a large Pulp - Paper factory. The area downstream of Mandini is largely given over to sugar cane farming.
- Lower Thukela: This district is located on the Right Bank of the river and is immediately downstream of Inkanyezi. This area includes the Town of Tugela Rail and is also, for the most part, under freehold tenure. People previously classified as Asians farm some of the land. For the most part land is under sugar cane cultivation.

In order to generate a more comprehensive socio-economic profile of people living close to the Thukela, and downstream of the dams, and of the potential impacts of the TWP two methods were employed. The first involved GIS based analysis of census data.

The official 1991 Census data (as adjusted) was used to produce figures for the numbers of people likely to be reliant upon the Thukela River and its resources. Data was analysed at an Enumerator Area (EA) level. EAs are the smallest available "chunks" of aggregated census data. EAs are the building blocks of census districts. In terms of size EAs differ greatly. In urban areas some may be as small as a block of flats, while in rural areas others encompass entire tribal authority areas. For the purpose of this exercise it was decide to examine all EAs that fall within a 5km stretch on either side of the Thukela River (Downstream of Jana Dam) and of the Bushman's River (downstream of Mielietuin Dam).[2] EAs that fall entirely within the 5km strip where included in their entirety. EAs that fell only partially within the 5km strip were evaluated in terms of "percentage in – percentage out". The EA population was then divided by the percentage of the area deemed to be within the 5km strip. As such the final population figure generated may not be entirely accurate, as population is not distributed evenly within the EAs. However the margin of error was deemed to be acceptable for the purposes of this exercise.

[2] Although 5km was fairly arbitrarily ascribed it was assumed that this was a conservative estimate as people further than 5km from the river are highly unlikely to be reliant on resources within the river zone.

In all a figure of 22 435 people likely to be living within the demarcated zone was calculated. Of these:

- 17 965 lived in the tribal areas (This includes parts of the denser Sundumbili area)
- 697 lived in the demarcated urban areas of Tugela Rail and Mandini
- 1 773 lived in the commercial farming areas of Weenen, Mtunzini and Lower Thukela.

In terms of current water legislation, i.e. that encapsulated in the National Water Bill (1998) the current and projected reasonable needs of the donor catchment must be catered for before water may be abstracted for the purposes of transfer schemes. It was therefore assumed that the formal water needs would have been catered for, at appropriate assurances of supply, before the amount of water available for transfer was determined. As such formal downstream users would have been catered for in the hydrological assessment of available water. These formal downstream users would be, *inter alia*:

- Commercial and Industrial use at Sundumbili, Mandini and Isipingo Rail.
- Formal domestic water supply users.
- Irrigation users.

More vulnerable, however, are the informal users who make up the bulk of the approximately 17 965 people living along the banks of the rivers in the tribal areas. In order to generate a more comprehensive picture of resource use in the Thukela valley it was decided to undertake a series of fieldwork interviews. It was decided to concentrate efforts in the Nxamalala, Ngcolosi and Shange Tribal Authorities of the Nkandla and Inkanyezi areas. This was decided upon for two reasons:

- These three tribal authority areas were deemed to be generally representative of the informal users along the banks of the river.
- Members of the SIA team have worked in these areas over a number of years and have built up a rapport with people that allowed the team easy access into the field.

Central to the investigation was the utilisation of a Participatory Rural Appraisal (PRA) methodology. This involved group discussions with the following groups:

- Two group discussions with izinyanga (traditional healers who make use of the areas' fauna and flora). Discussions centred around resources found in or close to the riparian zone of the Thukela River.
- One group discussion with women who harvest flora along the river banks for handicrafts.
- Four group discussion with a cross section of residents who live along the banks of the river. Group discussions were held at, or as close to, the river as possible. This helped to stimulate and contextualise discussions.

- The objective of the research was to elicit information around the needs that have to be met to maintain the social environment. This involved determining:
- which requirements need to be met and,
- the amount of water required in the system to meet these needs.

At the outset it should be stated that determining which requirements need to be met is complicated by the tendency to adopt a static and ahistorical approach and to assume that current utilisation patterns replicate past patterns and represent a model of future requirements. This assumption becomes increasingly problematic when confronted with the realisation that an analysis of resource patterns concerns a dynamic social situation and not a static one. Problems around this concept became evident during the group discussions and consensus around needs was sometimes difficult to generate. However, the PRA methodology proved to be useful in stimulating discussion and in making people aware of the dynamics of social needs.

Socio-economic structures and relations largely determine the outcome of social-environmental relations. Patterns of social relations affect the ways in which natural resources are used; the value ascribed to nature and the importance attached to conservation and rehabilitation. These change as much over time as they do across socio-economic/cultural groups. Furthermore, access to, and use of, resources result from a variety of property regimes (management systems), policies and, tenure arrangements. Forms of social regulation define the boundaries of access.

Although people were generally happy with the quality of the riparian environment along the banks of the river there were reports of frequent problems expressed with the quality of water in the river itself. This emerged particularly when people were asked about the aspects of their water usage that they considered to be problematic in terms of water quality. Here it was stated that for drinking purposes, washing, religious and medicinal purposes, quality was often considered to be a problem. High levels of turbidity (associated with high flows) were considered to be the major water quality problem. At certain times of the year (and August- September 1999 was notable) water quality was deemed to be good by most of the respondents. This however, was seen to be the exception rather than the rule.

People were asked to list what they considered to be the uses of the river. It emerged that people use river water for:

- Drinking and domestic cooking
- Livestock watering
- Irrigation (bucket and hand carried variety)
- Building
- Washing (personal, clothes, vehicles)
- Fill the cattle dips
- Recreation (swimming/fishing)
- Religious purposes
- As an ingredient in medicines

It should be noted that the river is not the dominant source of domestic water. People rely more on springs, boreholes and streams. In the Shange and Nxamalala Tribal Authority areas the Middledrift Community Water Supply Scheme (recently completed as phase 1) was said to be the dominant source of domestic water. For people without access to the Community Water Supply Scheme the river is only used extensively when the springs and streams dry up.

People were then asked what the environment alongside the river (banks and floodplains) was primarily used for. The following resource uses were emphasised:

- Sand excavations for brick and block making
- Gathering of firewood and building material
- Medicinal plants
- Material for handicrafts

From a social perspective it appears that riverine environments commonly have both subsistence and a recreational value. Respondents regarded the gathering of firewood and building material and the harvesting of edible plants, small animals/reptiles and medicinal plants as being of importance. Similarly, activities such as swimming, playing, and even recreational fishing, are undertaken at various points along the river. However, respondents' primary concerns related to domestic water supply; stock watering, firewood and surplus water for agricultural purposes (vegetable gardens and irrigation). Issues of access and flooding were also regarded as a crucial issue with regard to the state of the river.

In general people were concerned that dams on the upper parts of the river could severely restrict the flow of water during dry periods and lead to the following maladies:

- *Inability of the Middledrift Community Water Supply Scheme (or other such schemes dependant on the Thukela River) to operate properly.*
- *Inability to draw from the river when boreholes and streams had dried up.*
- *Lack of access to river water for their stock.*
- *Damage to the vegetation along the banks of the river necessary for medicinal, building, handicraft and subsistence purposes.*
- *Great care was taken, during the course of discussions and interviews, to ally these fears and to emphasise the protection accorded people under the environmental and basic human needs reserve sections of the National Water Act. Nevertheless, a strict regime of monitoring of IFR releases and ensuring that the environment upon which so many people rely is not adversely affected must be part of the overall management of the TWP in its post implementation phase.*

2.2.4 The Receiving Environment

Two aspects of the receiving environment were considered. These are:

- The people and settlements along the sections of river downstream of Sterkfontein Dam and upstream of the Vaal Barrage. For the most part these are agricultural settlements that are home to commercial farming operations.
- The people in the greater Vaal River System Area (VRSA) who will be the recipients of the economic benefits of a greater assurance of water supply.

In terms of the people and settlements along the receiving stream the social impact was deemed to be less problematic than it might otherwise have been. This is so, as the proposed TWP will use the same delivery channels as the existing Drakensberg pumped storage scheme. In terms of this the DWAF already has registered servitudes in the receiving stream and the river courses are well used for the transfer of water already pumped from the Thukela.

Although servitudes of aqueduct have already been acquired by DWAF impacts in respect of increased flows both in terms of volume and duration might be expected. Impacts could include those associated with safety both to humans and animals and potential impacts in terms of access. This should be assessed in greater detail when the hydrology for the receiving stream is available. Assessment of impacts can then be undertaken as to potential economic impacts and impacts to safety.

In terms of the impact in the greater VRSA , this is considered to be considerable. However, the bulk of these benefits are strictly economic in nature and are considered in some detail in the economic cost benefit analysis which is being undertaken as one of the suite of other studies associated with the TWP.

2.3. Conclusion

The TWP is being planned within the context of a project area that generally finds itself in slow economic decline. The important contribution that the TWP could make to the region is implicit in many of the comments made by stakeholders during the course of research for this study. For many of the people of the region the currently proposed Thukela Vaal Transfer Scheme will be a much-needed economic boost for the area. As such the regional attitude towards the project appears to be a very favourable one. Although potential regional dis-benefits (largely associated with the proposed canal system) were also identified these need to be considered against the background of the implicit benefit and around the potential to mitigate the negative local level impacts.

Although some uncertainties appear to cloud the planning horizon e.g. HIV/AIDS and the issue of Land Reform these need not prove to be critical threats. From a project planning perspective both the development of the spread of HIV/AIDS and the manner in which the Land Reform programme unfolds need to be monitored. In the case of the Land Reform Programme on-going liaison between the TWP and the Department of Land Affairs, as is required by the spirit of co-operative governance, should be sufficient to ensure that both planning trajectories work in harmony.

SECTION 3: JANA DAM

3. JANA DAM

3.1 Introduction

In terms of its sub-regional context Jana Dam is located in a gorge on the Thukela River. The dam wall would be situated at a point some 12km downstream of the Klip and Thukela Rivers. Although the entire dam falls within the uThukela Region the Left (North) Bank of the dam will fall within the Emnambithi sub-region while the Right (South) Bank will fall within the uMtshezi sub-region. Access to Jana dam from the Left Bank is via Ladysmith and the district road ZM 212-2. Access from the Right Bank is via the town of Colenso and the district road via Cingolo Nek to the farm Brakfontein. Land on the Left Bank is largely that demarcated as Ingonyama Trust Land while land on the Right Bank is under freehold tenure (See Map of dam site in Appendix D).

- Jana Dam would consist of the following components:
- An access road for the purposes of construction and then for maintenance and operation.
- A construction camp
- A quarry (or series of quarries) inside the dam basin
- A pumping station
- The dam wall and its basin. At present a Jana Dam with a full supply at about the 860m amsl contour is being mooted as an optimal size at feasibility level.

Each of the components is associated with socio-economic impacts. In order to assess these impacts a fieldwork-based series of investigations was undertaken. An intensive period of fieldwork was undertaken during May 1998, November 1998, and March to May 1999. Fieldwork was largely undertaken in the proposed Jana basin area and followed channels of communication opened by the Public Involvement Consultants. Fieldwork consisted of the following elements:

- A socio economic survey among households occupying communal/tribal land on the Left Bank of the Jana site. The purpose of the survey was to generate a socio-economic profile of the people resident in the area, establish patterns of resource utilisation in the basin area and to garner an impression of magnitude and significance of potential resource losses.
- Focused interviews with key individuals in the communal/tribal area to generate a sense of the losses associated with specialised utilisation of resources.
- Interviews with interested and affected parties on the Right Bank. This was done via a mailed questionnaire and follow up interviews with key individuals.
- Interviews with certain regional government officials and with people who hold specialist knowledge around resource values.

Although the general findings are that there do not appear to be any fatal flaws associated with Jana Dam it will nevertheless require a great deal of sensitive negotiation and management. In terms of the Left Bank Jana Dam was found to be sensitive to increases in dam heights. Above 840m (purchase line about 850m) the Jana Dam has a markedly greater impact, in terms of both magnitude and significance than below this level. The particular concern is with the impact on the villages associated with the Mziyonke settlement. The impact of the dam on the Right Bank (i.e. freehold land) is not, within reason, as sensitive to increases in the height of the FSL. In terms of potentially problematic issues the impacts to the village of Mziyonke are of the greatest concern and are dealt with in more detail in the section below.

3.2 Impacts associated with Jana Dam Left Bank

3.2.1 Mziyonke and Mankandani Settlement: Population Profile

The information presented in this section is based on the findings of a survey that was carried out of households that are likely to be affected by the proposed dam. The survey was undertaken in order to generate a profile of the people likely to be affected and to assess the likely impacts of the dam on their livelihood strategies.

In total, 550 people, residing in 74 households, were included in the interviews. The characteristics of these people are generally typical of rural areas in Kwazulu-Natal. As **Table 3.1** indicates, more than half of the people residing within the proposed dam are female, which reflects the impacts of migrancy upon the structure of rural households in the Thukela River valley. Approximately 84% of the population reside in the dam site on a permanent basis, while the remainder commute and migrate between the valley and places of work further away.

Table 3.1: Gender and Residential Status

	No of People	%
Male	258	47,0
Female	292	53,0
Permanent Residents	460	83,6
Non-Permanent	90	16,4

The age profile shows that the population is generally youthful. **Table 3.2** presents a detailed analysis of the population that indicates that almost one half of the resident population of the dam site is not older than 20 years. The high proportion of young people is fairly typical of rural tribal areas and can be attributed to a combination of factors, notably, the absence of many working age people and a relatively high natural population growth rate.[3] Further analysis shows that the absence of working age people is most evident among males in the 31-40 year and 41-50 year age category.

Table 3.2: Age Profile

Age Category	% Male	% Female	Total
0-10 years	13,1	13,5	26,6
11-20 Years	12,6	10,1	22,7
21-30 Years	8,8	9,6	18,4
31-40 Years	2,9	6,8	9,7
41-50 Years	2,4	5,8	8,2
51-60 Years	2,4	2,4	4,8
61-70 Years	2,9	4,3	7,2
>70 Years	1,9	0,5	2,4
Total	**47,0**	**53,0**	**100,0**

An analysis of the composition of households as provided in **Table 3.3** indicates that pre-school-age and school-going-age children are the largest demographic segment, collectively making up 40,7% of the households. This is followed by a category of unemployed adults made up of people who are actively seeking employment (25,1%) and not seeking employment (3,2%). Only 17,2% of people in the surveyed households are engaged in economic activity, either through self-employment or through wage employment. 13,9% of people are either “retired” or pension-drawers.

Table 3.3 : Household Economic Composition

Category	%
Self-Employed	7,0
Wage-Employed	10,2
Pre-School	4,3
Scholar	36,4
Retired / Pensioner	13,9
Work-Seeker	25,1
Non-Seeker	3,2
Total	**100,0**

Households range in size from two to 17 people, with the average at 7.4 people. This is fairly typical of rural tribal areas where having a large household enables a family to maximise income earning opportunities and minimise potential economic risk.

Given the present socio-economic and demographic profile, there is a high rate of economic dependency within households residing within the proposed dam site. This is indicative of the lack of local employment opportunities within the Thukela valley. Less than half of the average household occupants (48,8%) fall within the economically active age group (18-64 years). Only 17% of the adult

[3] As discussed above, however, this relatively high population growth rate is expected to slow.

resident population are engaged in income earning activities, which implies that there are five dependants for every employed person.

In addition to displaying a high dependency rate, the affected population has a relatively low skills base, which is not uncommon given its rural context. **Table 3.4** shows that one fifth (20,6%) of the population living in the surveyed households has an education level of less than Standard 2, meaning that they have had at the most three years of formal education at a junior primary school level. Over half of the population (54,4%) has an education level of between Standard 2 and 5 at which point they can be regarded as functionally literate. One quarter of the population has an education level exceeding Standard 5.

Table 3.4: Skills Levels

Education	No of People	%
<Std 2	113	20,9
Std 2-5	299	53,7
>Std 5	137	25,3
Total	**240**	**100,0**

10 people = unknown

For those people engaged in wage employment, the wider Ladysmith area offers the greatest employment opportunities. More than half (54,4%) of the employed people commute between their places of residence and Ladysmith on a daily, weekly or monthly basis

Many of the surveyed households are highly vulnerable to conditions of poverty. The average household income stands at R526, 00 per month and is made up of wage income, pension and welfare transfers, migrant remittances and income from agricultural activities. **Table 3.5** presents a detailed analysis of household income levels. It shows that the largest proportion (67.6%) of households fall within the R1-R500 income category. The low level of income into the area is indicative of the reliance of residents upon the resource base and upon subsistence agriculture.

Table 3.5. Distribution of monthly household income categories

Income	No of Households	%
0-500 Rand	50	67.6
501-1000 Rand	17	23.0
1001-1500 Rand	6	8.1
1500-2000 Rand	0	0.0
>2000 Rand	1	1.4
Total	74	100,0

In terms of contribution to income the following categories, as set out in **Table 3.6** are important:

- Migrant Remittances
- Pensions
- Local Wages (mostly based upon circulation of cash income from pensions and migrancy via participation in local agricultural work).

Table 3.6: Income by source

Income Category	Amount R	% of survey income
Pension	17 650	45.3
Migrant Remittances	11 760	30.2
Local Wages (mostly associated with agriculture)	3 860	9.9
Income from local business	2 780	7.1
Sale of crops	1 049	2.7
Sale of livestock	850	2.2
Sale of animal products	300	0.8
Other	680	1.7
Total	38 929	100.0

Critical is that migrant remittances and pension payouts contribute over 75% of the income into the area. Although migrant remittances and pension payouts would not be directly impacted upon by the resource loss associated with the dam, income from agricultural activities, the third largest category would be very extensively impacted upon. This is discussed in more detail in the following section.

3.2.2 Mziyonke and Mankandani: Impact of Dam on Agricultural Activity

Agricultural activity is critical to the Mziyonke and Mankandani community. As with many rural areas in South Africa, particularly those in the former “homeland states”, agricultural activity plays an important economic, subsistence and social role. Of these facets it is the social importance that is often overlooked when considering impacts of the loss of agricultural land. Land is often used as a form of security that enables those made redundant in the formal employment sector a degree of security. It also allows those without access to a fixed income from the formal sector to generate some money by working the lands for those households that are better off. This emerges as an issue of major concern in the Mziyonke and Mankandani area. In particular female headed households found the ability to be able to work the land for wealthier neighbours, and to be paid either in cash or kind, a major source of security. Given the central importance of agricultural activity this section of the report sets out to:

- Offer an assessment of the agricultural resources of the Mziyonke Community that may be flooded by the proposed Jana dam.
- Provide a description of the present pattern of agricultural land use.
- Offer an assessment of the impact of the proposed dam on agriculture in the area at varying Full supply Levels (FSLs) as a final decision has not yet been taken on the FSL.
- Consider, and make a recommendation, regarding possible compensatory measures for the lost resources.

The agricultural potential of any area is determined by its climate, topography, soils, vegetation and water supplies. This section is therefore concerned with these factors and with the physiography and geology of the area which influence its climate and soils.

a) Physiography and geology

The greater Mziyonke and Mankandani area consists mainly of a shelf on the upper slopes of the Thukela Valley scarp at an altitude of 850 - 900 metres. It also includes a narrow band of steeply sloping land next to the river and a ridge of rocky hills to the north and east of the shelf. Slopes on these three physiographic units are as follows:

- 20 - 50% on the Thukela scarp
- 5% on the Mziyonke and Mankandani shelf
- 15 - 30% on the hills above the shelf.
- Not surprisingly the only arable land, apart from one or two small alluvial terraces beside the river, occurs on the shelf.

Physiography thus largely determines the distribution of arable land. It also has an important influence on climate as the shelf lies to the north and west and in the rainshadow of ridges of higher ground at 950 - 1 000 m to the south and east. The geology of the area is dominated by dolerite intrusions into sedimentary rocks (sandstone, shale and coal) of the Vryheid formation. These various rocks give rise to different and distinctive soil types as will be discussed later.

b) Climate

There are no long term climatic data for the area, the nearest stations being Ladysmith (full climatic data) and the farms Holm Lea, some 15 km to the west near Pieters Station, Doornkraal about 10 km to the north and Fitty Park some 10 km to the north east. The mean annual rainfall for these stations is as follows:

Table 3.7: Regional Rainfall Figures

Station	Altitude	Mean Annual Rainfall (mm)
Doornkraal	1 065	797
Fitty Park	1 044	655
Holm Lea	1 036	722
Ladysmith	1 078	735

Although the figures for Doornkraal and Fitty Park seem rather high and rather low respectively the average of about 725 mm is typical of the country around and to the south of Ladysmith. It should, however, be noted that the above stations are about 150 m higher than the Mziyonke shelf so that a lower rainfall should be expected there — probably about 700 mm per annum on the shelf and below 700 mm on the valley floor. The monthly distribution is strongly seasonal with the main rainy season being from November to March.

Temperatures may be expected to be 1 - 2^{0}C warmer than those for Ladysmith as given below in Table 3.8.

Table 3.8: Mean monthly temperatures for Ladysmith

Month	J	F	M	A	M	J	J	A	S	O	N	D
Mean max. temp. °C	29	29	28	26	23	20	21	23	26	27	28	29
Mean min. temp. °C	17	17	15	12	7	3	3	6	10	13	15	16

From an agricultural point of view the important features of this type of climate are:

- the rainfall which, at an estimated average of 700 mm per annum, is substantially below the generally accepted threshold of about 800 mm p.a. for intensive dryland cropping. Crop yields are therefore likely to be rather low with periodic crop failures.
- the temperature range which is one that favours the production of most of the common field crops such as maize, pumpkins, sorghum and most vegetables. Deciduous fruits like peaches, plums and apricots and citrus crops such as oranges should do well, although hail may be a problem.
- a warm sunny climate with an annual average of about 7,8 hours sunshine a day.
- In terms of the Bioclimatic Classification of Natal by Phillips (1969) the area is located in Bioclimatic Group 10a (Sub-arid riverine and lowland) though transitional to Unit 8a (Upland, drier type).

a) Vegetation

The vegetation is described by Acocks (1975) as Valley Bushveld. Most of the bush on the shelf has, however, been cleared so that the shelf now consists either of cultivated land or of *Hyparrhenia* veld. The scarp slope down to the river and the surrounding hills are, however, still bushveld. The carrying capacities of the two veld types are assessed as follows:

- Valley Bushveld : 6,5 ha per Animal Unit* (AU)
- Hyparrhenia veld : 3,5 ha per Animal Unit (AU)

b) Soils

The only existing information on the soils of the area is from the broad reconnaissance soil survey of the Thukela Basin carried out by van der Eyck *et al* (1968). They show the soils on the Mziyonke and Mankandani shelf as consisting of clayey and loamy soils of the Doveton and Msinga series of the Hutton form and the Shortlands series of the Shortlands form. All three of these are red well-drained loamy to clayey soils of high agricultural potential. This was confirmed during a field visit on 26-4-1999 although there was a change to shallower greyish brown plinthic soils near the western edge of the area visited. Practically all of the soils presently being cultivated are of the Hutton and Shortlands forms of good depth which, as already mentioned, are prime agricultural soils.

An animal unit is defined as the grazing equivalent of a 450 kg steer which consumes 10 kg of dry matter a day.

c) Water resources

Water resources, for agricultural use, appeared to be confined to the dam near the store and to flow in the Thukela River and seasonal flow in the Nkehli and Mziyonke/Makhanyana streams. There are several springs feeding the stream above the dam and they were indicated by respondents, as primary sources of domestic water.

There is also scope for water development on the shelf by building farm-sized storage dams on the Nkehli stream and even higher up on the stream which supplies the existing dam. It is not known what potential there is for developing groundwater supplies but deep wells near the drainage lines on the shelf may be worth investigating.

d) Resource degradation

As is usual in such areas the main erosion problems tend to be in the grazing areas, especially close to the homesteads where there is much trampling by livestock e.g. the area to the north of the road where it enters the shelf. The hills above the shelf are also showing signs of heavy grazing pressure, even before the start of winter. The cultivated land and the adjacent grassland in the winter grazing area was, by contrast in generally good condition (See Plate 1).

Plate 1: Grazing camps in Mziyonke showing clear demarcation between summer and winter areas and well-maintained fence.

e) Agricultural infrastructure

This seemed to be confined to:

- the dam near the store (there was no evidence of any irrigation from this source and interviews indicated that it was a source of stock water only)
- a dipping tank near the dam
- a fence separating the cropped area from the summer grazing area around the homesteads and on the hills above them.
- The 1:50 000 map of the area also shows a fence running in a north-easterly direction apparently separating the Mziyonke and Mankandani Communities grazing land from that of the Community now settled on the farm Strasbourg 2391.
- A few internal tracks connecting the various settlements on the shelf and leading to the various blocks of arable land.

The Mziyonke area, though situated in rather dry country for intensive cropping, is a good agricultural area and is considerably better than most parts of the adjacent tribal areas. It has well balanced soil, water and grazing resources though now showing signs of population pressure on the summer grazing.
The loss of both grazing and cropping land as a result of flooding by the Jana dam will obviously aggravate the population pressure on the remaining land as discussed in the following sections.

f) Land use

The Mziyonke and Mankandani Community's land is at present being used for three main purposes: residential land, crop production and grazing, with two broad categories of grazing land:

- summer grazing around the upper homesteads and the hills above them;
- winter grazing in the cropped lands and the adjacent grassland (and presumably the scarp slope down to the Thukela River).
-

The areas of land devoted to these various land uses are approximately as follows:[4]

Residential land	67 ha in 10 residential areas
Cultivated land	244 ha
Summer grazing	1 055 ha
Winter grazing	937 ha

g) The cultivated land

The cultivated land is still nearly all in use unlike many other tribal areas where a high proportion of arable land is now lying fallow. This suggests that the Mziyonke and Mankandani soils still have a reasonable nutrient status and that the fences enclosing the cultivated land are effective in preventing, or at least minimising, damage from livestock. The crops seen (nearly all maize but with a

[4] The figures given for available cultivated land differ from earlier estimates as land classified as cultivated land now excludes that which may be arable but which has not been utilised for these purposes in recent years.

few pumpkins) looked well grown despite the very dry late summer and autumn. The plant populations were, however, very low (about 10 000 plants per ha versus a target population of some 40 000 plants per ha on commercial farms in the prime cropping areas).

h) Livestock and the grazing areas

Only a few livestock were seen. They seemed to be a typical tribal herd of mixed ages and classes, which are left to graze extensively over the hills in summer, and in and around the cropped areas in winter. As already noted the summer grazing is under pressure and is obviously overstocked. The winter grazing, which has a full summer's rest every year, is, however, in very good condition.

i) Impact of proposed dam on existing agricultural land use

In order to assess the impact of the dam on the Mziyonke and Mankandani area table 3.9, overleaf, shows the effects of the 860 m and 880 m Full Supply Levels in terms of the areas that would be lost and those remaining of cultivated and grazing land respectively.[5] It will be seen from table 3.9 that at a FSL of 860 m the following effects will occur:

- ***The total area of cultivated land will be reduced by 20% from 244 ha to 196 ha. This effect is not, however, uniform throughout the area. Some parts of the area will lose all its cultivated land and most of its winter grazing so that although it remains intact as a residential area it is no longer a viable agricultural unit.***
- ***The winter grazing is largely lost throughout the area.***
- ***The summer grazing is mainly unaffected except that, with most of the winter grazing becoming inaccessible, the livestock will have to remain in the summer grazing areas during winter leading to severe over-stocking with serious consequences for both the livestock and the natural resources.***

With a FSL of 880 m the main effects are likely to be:

- The loss of a further 82 ha of cultivated land bringing the total area lost to 130 ha or 53% of the cultivated land.
- The loss of practically all the winter grazing thus posing a major threat of severe overstocking and erosion on the summer grazing land.

In brief at a FSL of 880 m the area would become agriculturally non viable for at least half of the Community.

Table 3.9: The impact of the Jana dams at varying Full Supply Levels on the Mziyonke and Mankandani Community.

[5] Although the 860m contour seems to be a likely Full Supply Level the impact at 880m is retained to demonstrate the sensitivity of the agricultural resource base to increases in the size of the reservoir.

Full Supply Level	Cultivated land		Summer grazing		Winter grazing	
	Area lost (ha)	Area remaining (ha)	Area Lost (ha)	Area remaining (ha)	Area lost (ha)	Area remaining (ha)
860 m	48	196	Little	1055	522	416
880 m	130	114	Little	1055	685	253

3.2.3 Agricultural Compensation and Mitigation Considerations

The loss of agricultural land that provides a relatively secure economic base, particularly for marginal social categories, is a significant impact of grave concern. In order to address this some compensation and mitigation considerations, which are unique to the Mziyonke and Mankandani situation are discussed below. This section should also be read in conjunction with Section 6 of the report which looks at compensation and mitigation options in more detail.

Several types of compensation may need to be considered in the case of agricultural losses for the Mziyonke and Mankandani community. These include the following:

- Payment in cash for some lost assets in the form of developments such as buildings and fruit trees.
- The creation of local job opportunities.
- Improvements to local services such as:
  - A better access road
  - An improved domestic water supply
  - Improved schooling and medical facilities
  - Improved postal and telephone services.
  - Potential for the provision of electricity.
- Improvements aimed at increased agricultural production off the reduced area that remains available for agriculture.
- The provision to the Community of additional land to replace that lost.
- It has been customary in the past to pay compensation for developments such as houses or other assets such as fruit trees which occur on land needed by the State, and to pay for the land where that is free-hold land. In the case of tribal land the tendency has been to compensate for the expropriated land by offering other land elsewhere, or by introducing developmental interventions into the area that remains.

The creation of job opportunities and improvements in services to the area would, no doubt, be much appreciated although improved services alone, even though they may make a substantial difference to the people's way of life, seldom result in major improvements in a community's economic circumstances. They should therefore perhaps be regarded as a sort of "sweetener" rather than a substitute for the lost land.

Improvements aimed at increased agricultural production might include:

- irrigation to increase the productivity of all or some of the remaining crop land.
- the establishment of pastures so as to increase the carrying capacity of the reduced grazing area.

To give some idea of the impact such improvements can make it may be appropriate to note that in 1996, Rural Development Services (in Integrated Planning Services, 1996) found that irrigable land under horticultural crops had a potential of yielding a gross margin** of R5 000 per ha or more, given suitable infrastructure and markets, compared to R500 - R1 000 per ha for common field crops under dryland conditions. In other words good irrigable land has the potential of earning about ten times as much as from dryland production. The provision of water for the irrigation of 5 - 10 ha would therefore go a long way in compensating for the reduction in total arable land.

The use of pastures can also have a fairly dramatic effect on increasing the carrying capacity for livestock. For example Kikuyu grass, in high rainfall areas, may increase the carrying capacity from about 2 ha per AU on the veld to about 0,5 ha per AU on the Kikuyu pastures i.e. a fourfold increase. In slightly drier areas this effect is somewhat less marked as more drought tolerant grasses such as *Digitaria eriantha* or Rhodes grass have to be used. Nevertheless such pastures also have a high carrying capacity and can carry at least twice as much livestock as an equivalent area of veld grass.

There is, however, often a problem with pastures in a tribal area and that is that in order to produce effectively the pastures have to be fertilised at considerable cost. This cost can be offset against increased income from the livestock in the case of commercial livestock enterprises e.g. dairy or weaner production. In a typical tribal herd, where milk is not normally sold and where young stock are not sold but kept for various reasons, there is no income to cover the costs of maintaining the pastures.

It is concluded, therefore, that in this case, the pasture option is not a viable one. The irrigation option, on the other hand, is a valid option and could be implemented in one of two ways:

- by pumping water from the proposed Jana dam.
- by using water from another source (e.g. small dams on stream and tributaries).

The first option though attractive in the short term, carries a long-term commitment in meeting the pumping costs as the Community are unlikely to be able to meet these costs themselves, especially as they have no Eskom power. With power supplied as a result of the TWP initiative this may change. The second option may therefore be the more attractive in the long term.
In this context the potential sources of irrigation most worthy of further investigation are:

- A possible dam on the Nkehli stream.
- Another dam on the stream above the existing dam near the store.

** Gross margin : Gross income less direct production costs.

Both or either should be aimed at providing a total of about 50 000 m^3 of irrigation water per annum. Finally there is the option of providing additional land to compensate for the lost grazing (and arable) land. An area of comparable size could be obtained from one of two possible sources:

- From the State land adjacent to the tribal areas in the Eastern Klip river/Emnambithi district e.g. the farms Opmerksaamheid or Oliphantskop.
- From other commercial farmland in terms of the current land redistribution programme.

By way of summary and in terms of mitigation and compensation for agricultural impacts it is recommended that a combination of the following incentives be considered:

- ***Cash compensation for their individual assets affected by the dam.***
- ***As many local employment opportunities as possible.***
- ***Improved services, especially in terms of an up-graded access road and improved domestic water supplies.***
- ***A limited area of irrigation from a local gravity-fed water source for at least a large community garden and, possibly, some commercial plots.***
- ***A nearby area of additional land where those members of the Community who lose their houses may be relocated.***

3.2.4 Other Impacts Associated With Jana Dam

a) Infrastructure

In addition to the impacts associated with agricultural losses at Mziyonke and Mankandani there are a series of other impacts that need consideration. In Mziyonke and Mankandani these amount to the following:

At a full supply level of 860m the dam would be expected that have a buy out line at 870m[6]. In terms of the policy of the Department of Water Affairs and Forestry no permanent infrastructure, particularly of an accommodation nature, would be permitted within the buy out line. The buy out line acts to demarcate land required for safety purposes. Within this buy out line the following infrastructure would be lost along the Left Bank.

[6] Again it should be emphasised that the likely FSL for the Jana Dam is 860m but that an assessment of 880m is included for the sake of completeness.

- ***57 homesteads would have to be relocated. Of these nine are currently abondoned. Households are generally well constructed and well maintained (See Plate2).***
- ***The majority of these households have at least one grave associated with them, most have more (See Plate 3). From an analysis of the survey results the number of graves expected to be relocated is about 85. The issue of graves was found to be a very emotive one. Belief in the powers of the ancestor spirits appears to be widespread in the community. People believe that ancestor spirits have the power to punish evildoers and reward the faithful. Gravesites are often associated with the ancestors and neglect of the gravesite can incur the wrath of an angered ancestor. Disturbance of grave sites is regarded as problematic and can lead to the ancestors punishing the household by visiting misfortune upon it. Graves need to be relocated with all due sensitivity. This usually means re-burial with provision of goats or cattle to appease the ancestors.***
- ***Makhanyana Store, dipping tank and reservoir would all be lost or very close to the purchase line.***
- ***A formal church building would be lost.***

Plate 2: Typical homestead in Mziyonke and Mankandani area.

Plate 3: Typical gravesite in Mziyonke and Mankandani area.

At a full supply level of 880m the buy out line would be about 890m.

- 85 homestead would have to be relocated. Of these nine are currently abandoned.
- Again the majority of these households have at least one grave associated with them, most have more. The number of graves expected to be relocated is about 125.
- Makhanyana Store, dipping tank, and reservoir would all be lost or very close to the purchase line.
- A formal church building would be lost.
- Two schools would be lost.

b) Other agricultural activity

Although the bulk of the agricultural activity, along the Left Bank, is that associated with Mziyonke and Mankandani and has been described in detail above, a number of commercial crops of a more illegal nature were noted. The production of dagga was firmly denied in interviews, but field observation noted several areas of dagga fields in lowlands along Thukela and its tributaries. The extent of such cropping appears minor, however. There are dagga fields (about 2.5ha) that will be lost on the Makhanyana stream close to the confluence with Thukela (at about the 760m contour).

Furthermore, other pockets of agricultural cultivation (mostly maize) were noted. On the Mpukane Stream about 4 ha of cultivation (between 820-840m) would be affected by the Jana Dam. Upstream of the Klip/Thukela confluence the settlement of Esdakheni and Pietershoek would lose about 12ha of land. Most of the households that would have to relocate have small gardens within the boundaries of the household plot. These provide maize, legumes and assorted other vegetables.

c) Other resource utilisation

Interviews during fieldwork in May 1998 revealed that there are approximately 12 *izinyanga* (traditional healers) active in the Mziyonke and Mankandani area and an additional 1 in training. Local *izinyanga* appear to rely heavily on wild plant resources growing within the river valley. A number of species harvested for their roots and/or bark were mentioned in particular as being unavailable outside the valley.[7] The income generated by healing activities was estimated to vary between R 600 and R 1200 per month. Should these resources be lost due to inundation, local *izinyanga* would be forced to purchase roots and barks at the Zulu chemist in Ladysmith at considerable cost. In all likelihood, such costs would either render healing activities unprofitable or increase the costs of local *izinyanga* services.

In terms of broader categories of resource use in the Thukela Basin, which would be inundated, the following was found to be the case.

- ***poles for construction are utilised from trees growing in the area***
- ***firewood is gathered from the bush and thicket area.***
- ***sand/gravel is taken from the alluvial areas***
- ***thatch is cut from grasses left to grow between the fields.***
- ***wild fruit trees—amagwenya, dolofiya were mentioned as important.***
- ***wild vegetables—ntshungu, amakho, khelengese mentioned.***
- ***fish—caught and eaten by boys only***
- ***reeds —used to make mats to be sold in Ezakheni***
- ***water from local springs/streams and from the Thukela. At Mziyonke there is a hand pump on the school premises and the community in the vicinity of the school gets water from the pump. Furthermore, a pump is located at the store and this would also be lost.***

The impact on access appears to be limited although an important access road between the Mziyonke Primary School and the homestead of the areas Induna would disappear if the dam is built. In addition a series of minor tracks and paths would be lost.

According to the Resource Use Study commissioned as a separate study for the Thukela Water Project the value of these resources to each household from the area to be flooded by the Jana dam is estimated at R16 597 per household per year. This study also finds that current levels of utilisation of firewood, medicinal plants and building materials is believed to be unsustainable as a result of increasing pressures on resources. However depletion of the resources

[7] It appears as if the harvesting of the resource is fast exceeding limits of sustainability.

will not occur in the short to medium term, and significant quantities of these resources would still be available to the community in ten years time. Utilisation of these resources is not only meeting local consumption needs. Sale of the medicinal plants and craft resources in particular is meeting a regional need. The impact of the resource loss would thus be felt wider than merely within the communities adjacent to the dam.

The loss of the resource base would have a number of negative impacts were identified that would significantly affect resource utilisation and the livelihoods of the Mziyonke and Mankandani community (from the TWP Resource Use Study 1999):

- loss of economic opportunities for local harvesting and sale of resources for craft production by flooding the resources
- loss of a substantial percentage of firewood and thus household energy supplies through flooding of the valley.
- loss of medicinal plant resources for both household consumption and income generation by flooding
- increased rates of resource depletion resulting from construction activities as well as increased numbers of people (construction personnel) with access to the resources
- escalating degradation of remaining resources due to increased pressure on these resources following flooding of the valley

d) Loss of Sense of community

Also of concern was the notion of community integration. For many households, particularly those that are economically marginal, survival depends upon the ability to be able to call upon kin and neighbours to help one out in times of difficulty. These survival networks are based both upon ties of neighbourhood reciprocity and of kinship and contribute to people a "sense of place" and belonging. Because such networks depend largely upon many years of integration and mutual trust the potential disruption of these ties is a source of some disquiet for many people in the dam area. Reciprocal ties are often given expression through communal work undertaken in the spirit of ubuntu. Resettlement, as a result of the dam, of portions of the community could potentially lead to a loss of community integration and consequent erosion of the survival ties.

Adding to a sense of loss of community integration and to a sense of loss of community and of place are the various sites of historical, cultural and spiritual significance that would be lost. These are detailed in the TWP report entitled **Jana, Mielietuin Dam Area and Aqueduct Routes Historical and Cultural Sites**. The report indicates that there are a number of sites of importance to the local people that they would be concerned about losing. This sentiment was borne out in the interviews undertaken in the area. Of particular importance are:

- Mtholo tree (used as a resting place and camp site for *amabutho* visiting the local *inkosi*.)
- Nginjani pool (used as sacred ritual site)

- Sites of founding ancestors
- Nsindwane Pool

e) Health Hazards

Concern about the possible spread of water related diseases (bacterial, malaria, schistosomiasis) has been raised. An interview with researchers at Medical Research Council indicated that the dam would be unlikley to be associated with the spread of malaria, but that the danger of schistosomiasis (bilharzia) should not be underestimated. According to the **Specialist study on the ecological impacts relating to the creation of lake environments** (1999) prepared as part of the overall IEM study:

"infection usually takes place near the margin of the water where vector snails may be abundant in fringing vegetation. The spread of bilharzia in dams is therefore closely related to the availability of snail habitat and the drawdown-induced paucity of the riparian zone is therefore important in limiting vector snail habitat. Roodeplaat Dam, near Pretoria has a stable water level and a well-developed fringe of aquatic vegetation. People are frequently infected with schistosomiasis at Roodeplaat Dam, but zero riparian zone has other ecological consequences. Choices may need to be made between the two."

Mitigation measures designed to ameliorate the potential impacts of the spread of bilharzia could include educational programmes designed to educate people about the spread of the disease and a programme that ensures that the nearby clinic is equipped to deal adequately with such outbreaks.

This study also indicated that from their water quality analysis there should be little concern for the occurrence of bacterial diseases such as typhoid, cholera and dysentery for bacterial populations decline rapidly in dams.

Also of concern to many residents of Mziyonke and Mankandani was the potential for the dam to be a hazard in terms of drowning. The nature of the topography means that the dam will probably become very deep, very quickly. This could prove a problem to non-or poor swimmers who venture off from the shoreline. Mitigation measures could include the provision of fencing around the dam, although experience from other parts of the district holds that fencing is a highly sought after commodity and unlikely to remain in place for long periods. Fencing may also prove to be unpopular with stock farmers who will almost certainly wish to access the dam to water livestock. Again a community education programme designed to make people aware of the dangers of the dam must be considered.

3.2.5 Mitigation for Other Impacts Associated with the Left Bank of Jana Dam

Despite the potentially negative impacts the proposed Jana Dam would have a number of positive implications for the quality of life of the local population living near to it.

In the first place, the proximity of a permanent body of water could potentially enhance the viability of implementing rural water reticulation schemes to the communities adjacent to the dam. It could also enhance the viability of small irrigation schemes immediately adjacent to, and downstream of, the dam.

Secondly, the construction of the dam will entail the improvement of existing road infrastructure, the provision of bulk electrification and the construction of site buildings and infrastructure. These infrastructures will potentially have a direct bearing upon people's access to infrastructure and services. For example, the installation of bulk electricity will enhance the viability of reticulating electricity to nearby community facilities and households; an improvement to the road network will enhance the reliability of access roads into the Thukela valley. If the construction camp is located on the Left Bank the vacated site buildings could possibly be made available to local communities for public facilities. **It is recommended that, from a socio-economic impact point to view, serious consideration be given to locating some or all of the construction infrastructure on the Left Bank of the proposed dam.**

Interviews with community leaders in the Mziyonke and Mankandani area indicate that the in terms of community infrastructural needs the priorities would be:

- A clinic
- An adult education centre/community hall
- Additional classrooms

A telephone interview with a regional official with the Department of Health indicated that the recent construction and staffing of a well equipped rural clinic in a neighbouring area (some 9km away) has meant that the Mziyonke and Mankandani area is not considered a priority area and even if clinic infrastructure was provided there could be no guarantee that the department of Health would staff and equip it.[8]

As such the construction infrastructure that might be left behind would probably best be suited to providing a community hall and additional classrooms. Should the construction camp be located on the Left Bank then provision should be made in contractors' tender documents for conversion of this infrastructure for community benefit in the post construction phase.

In addition to basic needs, the proposed dam could also have repercussions for local economic development within the middle reaches of the Thukela valley. Firstly, the construction phase will provide employment opportunities for local labour and small-scale contractors. Secondly, in the case of public works projects, such as the upgrading of roads, employment would be supplemented by basic adult education and training opportunities, which could enhance the skills base of the workforce. Thirdly, the injection of wages and salaries into the valley will have important implications for the regional economy by increasing the disposable income of households. Although some of this income will be spent outside the local economy on goods that are not available within the local economy, money will undoubtedly also circulate within the local economy and create multiplier effects on a significant scale. An attempt to quantify these impacts by means of a social accounting matrix is reported on in the Financial and Economic Viability Study work module documentation.

[8] This is of some concern and again emphasises the importance of an integrated development approach that looks at the most efficient and effective means of service delivery.

In terms of the loss of the resource base, mitigation for the negative impacts could include:

- careful location of construction village and infrastructure to minimise impact on the resources,
- salvage and relocate resources to areas outside of flooded boundaries,
- provide alternative energy resources through electrification of the Mziyonke and Mankandani area,
- establishment of alternative economically viable income generation opportunities,
- promote commercial propagation of high value plants to reduce pressure on remaining populations and assist in meeting regional and national demand,[9]
- populations of standing water species of fish will increase and the riverine fish will be found mainly near the inflows. Opportunities for aquaculture could be explored. According to the **Specialist study on the ecological impacts relating to the creation of lake environments** (1999) prepared as part of the overall IEM study the potential for some fish to do well in the dam is relatively high. In particular the study notes that:

> *"A section of natural riverbed of approximately five kilometres will remain between the headwaters of the dam and the Boiling Pot and Harts Hill falls. This will be the only area where riverine-spawning fish species such as Barbus natalensis, Labeo rubromaculatus and L. molybdinus will be able to breed and from there move into the dam. Since there are many suitable breeding areas for scaly in the river above the impoundment, providing these are kept free of dense algal growth and silt the scaly population of the impoundment will increase, although they will occupy mainly the headwater region of the dam. The larval and juveniles from these species will have abundant food in the impoundment and their populations should increase. The impoundment will probably become populated mainly by carp that will muddy the water in the impoundment and as such reduce water quality. Clarias gariepinus is likely to do well in the impoundment as they can breed in the shallow, flooded marginal vegetation as well as undertake spawning migrations up the incoming river. Oreochromis mossambicus may also flourish around the margins of the impoundment. Labeo molybdinus and Barbus anoplus could become minor components of the population. The minnow, Barbus trimaculatus, may do well in the flooded sheltered bays of the impoundment especially during the early years of impoundment. Bass and bluegill may increase but will be confined to the less turbid parts of the dam (nearer to the wall)."*

[9] This would particularly apply to plants with a medicinal value. In this regard the cultivation programme driven by izinyanga in the Driekoppies Dam Resettlement Programme would provide an interesting model.

However, the primary form of mitigation will probably have to be encapsulated into a comprehensive Resettlement Plan. Resettlement of individuals or communities represents an extreme case of potentially negative developmental impact. Under these circumstances the boundaries between compensation and mitigation often become blurred. In the case of the Thukela Water Project, residents on the Left Bank of the Jana Dam are almost certain to require either resettlement or relocation.

As an example guidelines such as the World Bank documents are of crucial importance.[10]

- **OD 4.30 (involuntary resettlement) and World Bank Technical Paper No. 80,**
- **OD 4.01 (environmental assessment)**
- **OD 4.11 (cultural heritage) and OPN 11.03 (Management of Cultural Property in Bank-Financed Projects)**
- OD 4.20 (indigenous people)
- OD 10.70 (Project Monitoring and Evaluation)
- **GP 14.70, (Involving Non-governmental Organisations).**

Of particular importance is OD4.3 which spells out in a 32 point directive the critical elements for involuntary resettlement planning. The following principles form the cornerstones of the resettlement policy.

- Involuntary resettlement should be avoided or minimised where feasible, exploring all viable alternative project designs. This principal should be followed even during construction. For example, mid-construction opportunities might mean that realignment of roads or reductions in dam height may significantly reduce resettlement needs. Where these opportunities are available they should be pursued after due consultation with the affected parties.
- Where displacement is unavoidable, resettlement plans should be developed. All involuntary resettlement should be conceived and executed as development programs, with re-settlers provided sufficient investment resources and opportunities to share in project benefits.
- Displaced persons should be (i) compensated for their losses at full replacement cost prior to the actual move; (ii) assisted with the move and supported during the transition period in the resettlement site; and (iii) assisted in their efforts to improve their former living standards, income earning capacity, and production levels, or at least to restore them. Particular attention should be paid to the needs of the poorest groups to be resettled.
- Community participation in planning and implementing resettlement should be encouraged. Appropriate patterns of social organisation should be established, and existing social and cultural institutions of re-settlers and their hosts should be supported and used to the greatest extent possible.

[10] World Bank directives are increasingly being seen as the benchmarks for project evaluation. In a scenario where the TWP may require funding from outside agencies, satisfying international criteria becomes critical to acquisition of loans.

- Re-settlers should be integrated socially and economically into host communities so that adverse impacts on host communities are minimised. The best way of achieving this integration is for resettlement to be planned in areas benefiting from the project and through consultation with the future hosts.
- Land, housing, infrastructure and other compensation should be provided to the adversely affected population who may have usufruct or rights to the land or other resources taken for the project. The absence of legal title to land by such groups should not be a bar to compensation.
- Developers should endeavour to ensure that the population displaced by a project receives benefits from it. For example where employment from the project can be reserved for those resettled this should be done.
- Resettlement and mitigation issues are discussed in more specific detail in Section 6 of this report.

3.3 Jana Dam: Impacts Associated with the Right Bank.

Impacts associated with the Right Bank, in the freehold farming area, are in the main less problematic than those associated with the Left Bank. In all five farms are directly affected. All five farms are either given over to game farming or to cattle ranching. A limited amount of maize production is undertaken.

In terms of the farms affected the following will be impacted upon.

• Ramak, Klipberg & Brakfontein	Dr Muller (Mr V. Albers - manager)
• Gannehoek	Mr J Dippenaar
• Schurf de Poort	Mr D. Froneman
• Gannehoek	Mr H. Bosse
• Monte Christo	Mr T Mason (Mr I Milne - manager)

The more specific impacts include the following:

- The Farmhouse at Gannehoek will be lost and 2 Tenant Farmers (Rondavels and improvements) will be inundated.
- The access road through the farm Gannehoek and within the Thukela Valley will be lost.
- The farm Ramak is used as a game farm and some of their important resource area would be inundated. This is a significant commercial loss. The other farms have cattle kept on them (with the exception of Gannehoek, from which cattle have allegedly been removed as a result of poaching). Farmers on this side of the river, with the exception of the owner of Ramak, are positive about the dam and feel that it will add value to their farms.
- Approximately 41ha of commercial land used for cultivation will be lost. For the freehold land compensation for the loss of land and infrastructure is unlikely to be problematic providing that compensation is acceptable, in terms of value.
- Commercial river rafting activities (undertaken from the Right Bank) will be disrupted.
- Considerable other grazing land will be lost.

Of these impacts the most notable are those associated with the farm Ramak and those associated with the white water rafting. These are discussed in more detail below.

3.3.1. Impact on the Farm Ramak (operating as Emaneni Game Park)

This property was purchased by Dr Muller, a surgeon who resides in Germany, in 1996. Prior to that, Mr Conrad Vermaak purchased the property in 1989 and introduced game and established it as a commercial hunting lodge.

According to the farm manager Dr Muller has already invested approximately R3 million into the park and a number of further developments are planned including a camp site near the river and a swimming pool at the main camp site.[11] The main camp site is situated at the top of the hill which overlooks the river and gorges and is quite scenic and unspoilt.

Dr Muller brings German clients with him when on his twice yearly visit to the park. He also sends other clients throughout the year. Mr Vermaak brings his own clients from the USA and Mr Albers (the manager) also organises South African visits. People visit the park to engage in game watching, game hunting and to enjoy the natural beauty and peacefulness.

The lodge has 8 beds en suite and 6 beds with shared facilities. Mr Albers estimated the park to have had 30 visitors over the past year with a turnover of around R 200 000- R 250 000. They expect these numbers to grow substantially once the development is complete.

The price per night for a South African visitor is R600 and R 900 for German clients, including full board and guiding. The park presently has 15 different species and they are planning on introducing another 3-4 species in the near future.

Dr Muller is in the process of arranging a conference to be held on the park next year by high ranking German business people and bankers. If it is successful than he will consider doing more in the future.

The main negative consequences that Dr Muller and Mr Albers believe would result from the building of Jana Dam would include:

- People (mainly German tourists) are looking for unspoilt nature and peace and quiet which the park presently offers. A dam will destroy this.
- The business will not be able to operate during construction.
- The dynamite used during construction will scare the animals and they may escape.
- Loss of employment including their own staff and to local people who make curios to sell to their tourists.
- A decline in local business and other tourist attractions which the park presently supports.
- If the dam is constructed, Dr Muller will remove his investment and either find another place which will not be developed, or take his funds back to Germany.

[11] Dr Muller was aware of the proposed TWP when he bought the property having been made aware of the possible dam by both the PIP consultants and by the previous owner of the farm.

The park presently employs between 4-5 permanent people to 30-50 temporary people throughout the year. There are 4 families and 9 kraals on the property.

Given that the dam will inundate the bulk of the farm and that the construction camp may be located upon the farm the possibility of Emaneni Game Farm continuing to operate as a viable enterprise seem to be remote. Under these circumstances it is recommended that the developer offer to purchase the farm in its entirety. The land not needed for the operation and maintenance of the dam could then be disposed of after construction is complete. Although the means by which the land is disposed of should be considered as part of a development plan for the dam the following possibilities exist at present.

- Land is made over to Department of Land Affairs for the purposes of land restitution. Although possibly the first choice in terms of current state policy this option should be carefully considered in terms of best use land practices.
- Land is sold off to a private developer.
- Land is sold to neighbouring farmers to consolidate into their land holdings and as part of compensation package offered to them for land lost to the dam.

For the most part farmers on the other affected properties are less concerned about the impact of Jana Dam. In the main the reasons forwarded for this were the following:

- A great deal of the land that will be lost is steep and of little agricultural value.
- The presence of the dam could constitute a tourist attraction that will enhance the value of their properties and resonate well with the general move towards game farming and eco-tourism.
- The dam will provide a buffer between themselves and the tribal lands. Stock theft, much of it allegedly arising from raids across the Thukela, will be more difficult to carry out once the dam is in place.

Although generally positive towards the dam some of the landowners expressed concerns with compensation for losses and with potential construction related impacts. These concerns were similar in nature to the concerns expressed by the landowners in the Mielietuin area and are discussed in more detail in Section 4.

3.3.2 White Water Rafting

Mr Mark Calverley has a rafting business in which he takes tourists' rafting on the Thukela. He owns a piece of land in the gorge immediately below the proposed Jana Dam wall. Mr Calverley is also quite opposed to the development as his business will be affected. KwaZulu-Natal is becoming increasingly well known for its whitewater sport. Although the races and activities on the Thukela and Bushman's attract fewer participants than other rivers in the province (the Duzi Marathon on the Msunduzi River is the best known example) numerous river-running enterprises are active in a variety of locations on these two rivers.

According to the TWP Tourism Study the Thukela Gorge (part of which will be inundated by the Jana Dam) is a wild, waterfall-strewn stretch of the river, with road access at very few points. It was on this stretch in 1999 that the South

African wildwater rafting championships were held to select the SA team for the world championships later in the year. According to TWP Tourism Study river rafting activities include:

- CSA affiliated clubs such as the Johannesburg Canoe Club that runs annual down river kayaking trips in theGorge.
- Commercial river rafting by Zingela Safaris and Sunwa Ventures, both commercial tour operators.
- River guide training by X-Treme Equipment and Wildwater Training, both SARA-affiliated training bodies.
- An unknown number of private trippers, usually experienced kayakers rather than leisure groups.

On the whole, it appears as if the Thukela is an under-utilised river-running resource by world standards. Whitewater tourism is a major component of the world adventure travel sector. Similar basins in America, Europe and Australasia provide work for dozens of rafting operators. South Africa's isolation from the world tourist market, until recently, limited the development of this resource. Uncertainty surrounding the future of the Thukela watercourse, and crime, are making further whitewater tourism development and marketing difficult.

The loss of a section of the river will almost certainly be regarded as a major blow to those involved in whitewater rafting and respondents have expressed regret around the possible loss of the "wild and untamed nature of the river". However, indications are that some of the best white water rafting will remain intact in the gorge below the dam. Mitigation options might involve timed release of water from the dam (in accordance with standard operating procedures) that could guarantee good rafting at particular times of the year.

3.4 Impacts Associated with Access Roads

For the most part the two major access roads that may be associated with the Jana Dam appear to have little in the way of associated negative impact. Indeed the impact seems to be almost overwhelmingly positive. Both roads are continuations and upgrades of existing roads. The road into the north bank area would almost certainly be of great benefit to the people of Mziyonke and Mankandani as the current roads is little more than a dirt track which becomes impassable in the wet. Greater access into and out of the area would have major positive benefits for commuters and migrants. It would also allow people quicker access to clinics and hospitals in times of emergencies. For the most part respondents in the Mziyonke and Mankandani area were very positive about the possibility of an upgraded road. They were however, quick to point out that labour drawn from the immediate area should be given priority in working on construction of the road. Increased traffic volumes during the dam construction period could however have some negative impacts. These could include:

- Increased safety hazards to residents as a result of heavy vehicle traffic.
- Stock being killed or injured by road traffic.
- Increased noise and dust pollution.

Mitigation for these impacts could be designed into a local level liaison strategy that would govern incidental compensation payments and organise operational linkages between contractors and the residents of the area.

Similarly the access road along the Right Bank would benefit people in the area. Modifications to the design of the original road route seem to have allayed the fears of both the Gannehoek community and the farmers affected by the road.

3.5 Summary

For the most part the Jana dam appears to have little in the way of social impacts that might be considered fatal flaws. Having said this the impact on the settlements of Mziyonke and Mankandani should not be underestimated. The poverty and consequent vulnerability of the settlement means that particular attention should be paid both to the mitigation of impacts as well as to optimisation of potential positive impacts. Although people in these communities are generally favourable towards the dam this is predicated upon their no being worse off after project implementation than before. In fact, for most the dam represents a developmental opportunity from which they expect to benefit.

The social and subsistence value of land in Mziyonke and Mankandani, was discussed in some detail above and with much of the agricultural land being lost to the dam (particularly with a 880m dam) it is difficult to see how all of the community could continue to survive, even with substantial development input. Under these circumstances (and given the option) the entire village (or sections of the village) may elect to be relocated. Given that the village has a history of resettlement (mostly evictions from neighbouring free hold farms) the notion of another move will probably not be easily accepted and may become a rallying point of opposition to the dam.[12] By resettling people the logistics of ensuring that people benefit form the development become difficult. People resettled out of the dam basin may not be easy to accommodate in terms of employment opportunities and the infrastructural benefits associated with the dam may not accrue to those relocated. In order to make resettlement potentially attractive a suitable resettlement area may have to be identified and purchased and/or an appropriate resettlement programme put in place. In addition, the land will have to be developed to receive people ahead of the construction phase of the project.

An alternative to resettlement might be a development programme that attempts to replace land based economic opportunities with non-land based economic opportunities. These could include the development of entrepreneurial skill. This has met with only limited success in the Lesotho Highlands Water Project. However, a combination of the resettlement programme with a non-land based economic development programme for those who wish to remain in the area may be successful. These will have to be carefully designed during the detailed design phase of the project.

In terms of the Right Bank it appears as if most of the landowners are happy with the concept of the dam. Although they have some concerns with compensation issues these can probably be satisfactorily addressed through negotiation of fair and equitable amounts. The means by which this may be undertaken is discussed in more detail in Section 6 of the report.

[12] This has not yet been the case and relations between the Tribal Authority and the project are, in fact, good. However given that there is bound to be a degree of resistance to the dam there is little to suggest that opposition may not become more vocal.

SECTION 4: MIELIETUIN DAM

4. MIELIETUIN DAM

4.1 Introduction

In terms of its sub-regional context Mielietuin Dam is located on Bushman's River.[13] The dam wall would be situated at a point some 15km downstream of the town of Estcourt and approximately halfway between the northern limit of the TLC boundary and southern limit of the TLC boundary of Weenen. The entire dam falls within the uThukela Region and specifically the uMtshezi sub-region. Access to the dam from the Left Bank is via Estcourt or Weenen from the Main Road 13. Access from the Right Bank is via the town of Estcourt and along the district and farm roads. Land on both the left and the Right Bank is under freehold tenure.

As with Jana Dam, Mielietuin Dam would consist of the following components:

- An access road for the purposes of construction and then for maintenance and operation.
- A construction camp
- A quarry (or series of quarries) inside the dam basin
- A pumping station
- The dam wall and its basin. At present, a Mielietuin Dam with a FSL on the 1025m amsl contour is being mooted but at the time of writing this had not yet been finalised.

Each of the components is associated with a series of socio-economic impacts. In order to assess these impacts a fieldwork-based series of investigations was undertaken. An intensive period of fieldwork was undertaken during May and June 1998, and March to May 1999. Fieldwork followed channels of communication opened by the Public Involvement Consultants. Fieldwork consisted of the following elements:

- Interviews with interested and affected parties and with landowners on both the Right and Left Banks. This was done via one on one interviews held, for the most part, on the affected properties.
- Interviews with certain regional government officials and with people who hold specialist knowledge around resource values.

As with the proposed Jana Dam discussed above the severity of the social impact of the Mielietuin Dam is directly linked to the eventual FSL. For the purposes of generating an overview of the social impacts the dam was examined in terms of a FSL of 1040m amsl and 1020m amsl. With a FSL of 1040m amsl a buy out line of 1050m amsl was assumed. At 1020m amsl a buy out line of 1030m amsl was assumed.

In all nine landowners are affected by both the 1040FSL and the 1020FSL. All nine farms (one is a small holding) would be greatly affected at the 1040FSL (given the impact of a buffer zone) while it appears as if only five properties would be greatly affected by a dam at 1020m amsl (see Plate 4). At a full supply level of 1025m amsl the dam would inundate and area of about 1200ha. With a set back zone at 1035m amsl the dam would require about 1 700ha.

[13] The river is also know as the Mtshezi and gives its name to the sub-region.

In the case of the 1040m amsl dam, and at the time of the interviews, seven of the nine landowners indicated that they would probably would want to be bought out entirely as their farms would no longer be viable enterprises.[14] The degree of uncertainty relates to the long term nature of the planning and lack of finality around potential FSLs. It also relates to lack of clarity as to access that landowners would have to the dam periphery.

In the case of the 1020m amsl dam all nine landowners might be affected (depending on the nature of the setback zone) but under these conditions only two farmers would appear to want to be bought out (one of these would probably want to review the decision when the time comes). The remainder would want to continue operating under certain conditions. At the 1025m amsl it would appear as if all nine landowners would still be affected but again, only two may elect to be bought out entirely.

In general the current state of the majority of the farms appears to be one of slow economic decline symptomatic of the crisis in agriculture besetting much of southern Africa. For the most part farms in the Mielietuin area are given over to beef or dairy farming although some farmers are practising a mixture of agricultural activities and some of the land is under potatoes and vegetables. In addition some of the pastures are irrigated. Farmers indicate that market pressure and the decline in agricultural subsidies have made farming much less profitable. Stock theft was also blamed in some instances for the increasing cost of farming. As such most farmers are looking at alternative land use and farming strategies in order to make the land viable again. Game farming is regarded as the one alternative that appears to be viable.

Critical issues that appear to be uppermost in the minds of the landowners include the following:

1. *How will compensation be calculated?* From meeting with the stakeholders it is evident that they expect that compensation will be based on replacement value and not on market value. Under these circumstances most stakeholders would appear to be satisfied. However estimates of replacement value obtained from some of the stakeholders appear to be based on a set of potentially unrealistic expectations.
2. *When will compensation be paid?* Some stakeholders have argued that compensation should be paid as soon as possible. Although there is an acknowledgement that the state cannot be expected to acquire assets before it needs them some respondents felt strongly that the planning process had negatively impacted upon the value of their property. Some farmers indicated that they would choose to have land acquired as soon as possible and then be given the option to lease it back until the dam made operations problematic.
3. *Where access to portions of properties is rendered difficult or impossible would DWAF expropriate those pieces of land?* Some stakeholders felt that they had pieces of land that would be difficult to service once the dam was in place and they would want these portions of the land expropriated or made more accessible. Some landowners have more than one access to their homes and would want this situation to remain.
4. *Would landowners have access to the dam water?* Some of the landowners indicated that the river and/or streams and springs that provide them with

[14] The two landowners who indicated that they probably would not want to be bought out are Mr MacKay (Selbourne Farm) and Dr Erasmus (Glen Ann).

stock watering and domestic water would be inundated. They would want to be assured that a supply of water would be made available.

5. *Where farmland is expropriated by the state or implementing agent would neighbours have first option to buy remaining portions of the farms*? Farmers were concerned about uncontrolled settlement on land which is contiguous to themselves.
6. *Will the dam be drawn down frequently*? Most landowners were concerned with the aesthetic nature of the dam and indicated that a dam that remained full for most of the time was preferable to one that is frequently drawn down. Under these circumstances the dam would enhance the value of many of the properties and would make the development a great deal more acceptable to many of the stakeholders.

4.2 Concerns Raised By Individual Landowners

Each of the individuals concerned had particular concerns relating to the impact of the dam on their property. Summaries of these concerns are provided in the text below.

4.2.1 Mr MacKay (Selbourne)

Mr Mackay is on the Right Bank of the river with the dam wall to be constructed on his property. His family have held the land for about 120 years. He indicates that his primary farming activity is beef and that the farm is currently viable, but will encounter difficulty if it is significantly reduced in size. At the 1020 level about 300ha would be lost. Losses at 1040 would be more, but have not been calculated at this stage.

Irrespective of the FSL his aim is not to move from the land as he has another vision for utilising the remaining land.[15] He would however want full compensation (at replacement value) for the land lost. He would also want compensation for the nuisance value created by blasting and heavy construction activity. He expressed concerned that blasting might affect his house that is over 120yrs old. He also indicated that he would want to be paid out as soon as possible and then lease the farm back until the dam water made the farm impossible to operate. Leasing the farm during the construction period would make it easier for his transition from beef to game farming.

He has 13 families living on the farm. The dam would inundate two of the homesteads. He has indicated that he would accommodate those labourers elsewhere on the farm.

Mr Mackay said that he wanted local labour to be used as much as possible during the construction period but indicated that they would need to be very strictly controlled as increases in stock theft rates could arise. He was also concerned that access roads would be lost and he would want them replaced. He would be unhappy with the dam being fenced and would want access to the water for his stock/game.

[15] The current game reserve initiative (the Gongolo Conservancy) under way on the land east of the offers a great deal of opportunity for landowners on the Right Bank to link in with property that has a significant frontage.

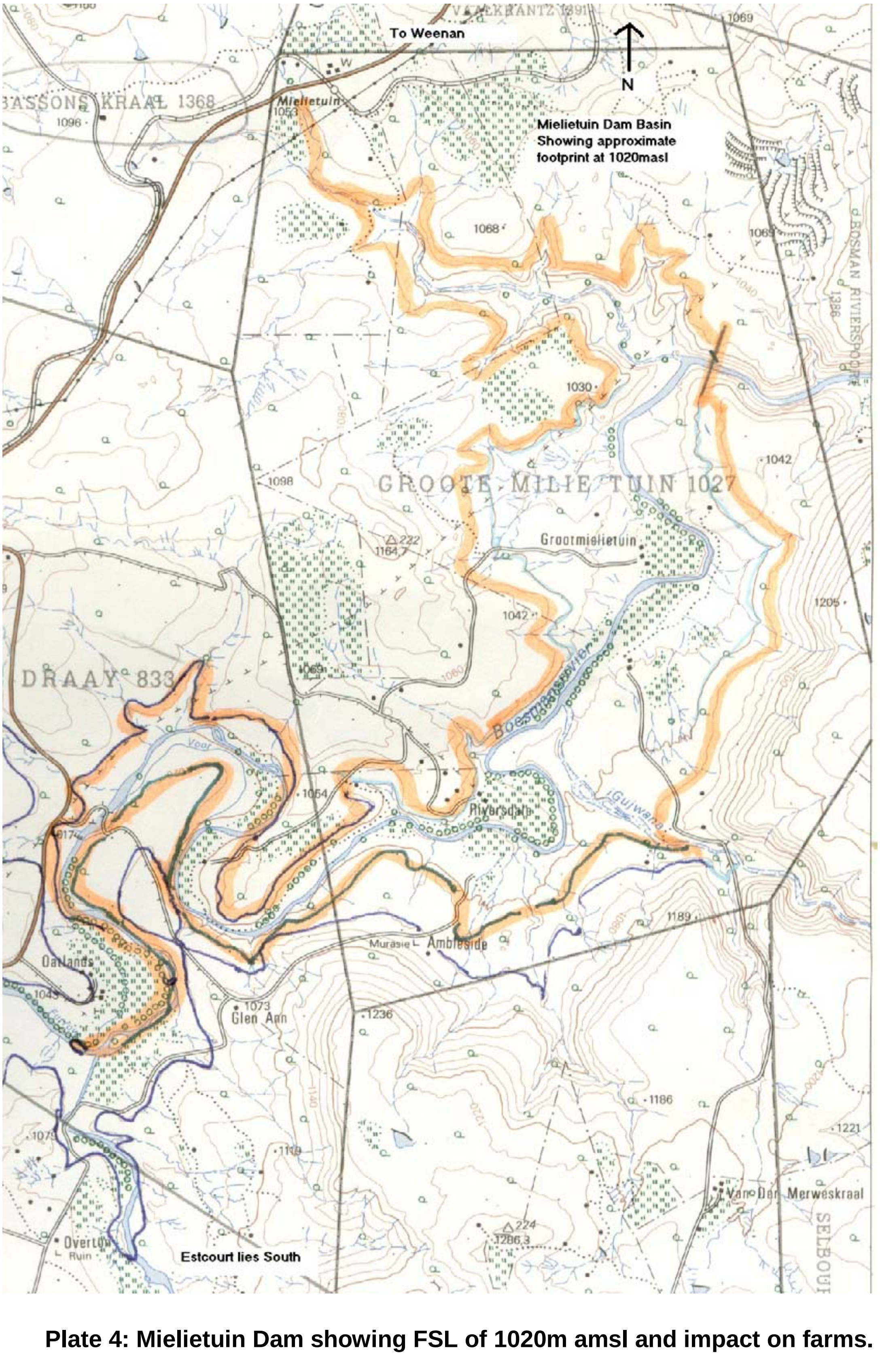


Plate 4: Mielietuin Dam showing FSL of 1020m amsl and impact on farms.

4.2.2 Dr Erasmus (Glen Ann)

Dr Erasmus has the farm upstream of Mr Mackay on the Right Bank. His major concerns are that access to the farm and homestead would be cut off and that a portion of the farm would be isolated altogether. Cattle farming is his main activity and he indicated that two of his nine grazing camps would be lost to the dam. Despite this he would not want to be bought out altogether (at either the 1040m or 1020m flood level) but would want to be paid replacement compensation for land lost or isolated. He would want assurances that DWAF would create access to the homestead, and would allow him domestic and stock water access to the dam. He has no resident labour on the farm.

4.2.3 Mr Green (Overton)

Mr Green has the farm Overton which is upstream of Glenn Ann. He also has Rensburgspruit, which is contiguous to Overton but not affected by the dam. Mr Green lives on Rensburgspruit. His main farming activities are cattle and potatoes.

Overton would lose 60ha of irrigated pasturage at the 1040m amsl level. As such it would not be a viable farm on its own but as it is contiguous to Rensburgspruit Mr Green says he would want the remaining portion of Overton absorbed into the main farm. He estimates that two labourers would probably have to be laid off if the dam was built and the extent of farming was further curtailed. He also indicated that he would want to exercise options to buy out neighbouring land that is acquired by the state, or implementing agent, as part of wholesale expropriation.

4.2.4 Mr Oates (Riversbend)

Mr Oates indicates that his family has been living on the farm for four generations. He currently manages the farm for a Closed Corporation (CC) belonging to the family. He indicated that the CC would probably want to sell the farm but that he and his son would want to lease the farm back and possibly to buy the remainder of the farm not inundated. He stated that current market value is well below the replacement value and would want to be paid out at replacement value rates. He also indicates that an overseas purchaser has shown interest in purchasing the land as part of a game farming operation. He also indicates that there is some potential to diversify into other forms of agriculture but that this would depend on continued access to water.

At the 1040m level the greater percentage of irrigated pasturage (currently 44ha but potentially 120ha) would be lost. At the 1020m level the impact would be much less. In fact according to Mr Oates the impact of a dam at this height might be positive, as the dam would probably enhance the scenic value of the valley.

There are eight labourers living on the property. Control of access and labour during the construction period would be of critical importance according to MrOats.

4.2.5 Mr Schlanders. (Groot Mielietuin)

Mr Schlanders lives in the Winterton area but maintains a beef farm at Groot Mielietuin. He expressed doubt about the viability of the beef farming enterprise and is converting to game. He hopes to have a fully functioning game farm within the next five years. He has been approached by the Department of Land Affairs to sell his farm to them but no final arrangements have been made. At the 1040m contour the farm would not be economically viable (at least as a beef farm) as the irrigated land that lies in the riparian zone would be lost. Mr Schlanders indicated that he needed to discuss the impacts with his sons and they would make a decision as to opt for full expropriation or only partial expropriation when the time comes. He indicated that if the DWAF was to allow access to the water edge for the purposes of game watering and utilisation by tourists then the remainder might be viable even with a 1040m dam. At the moment he estimated replacement value to be in the order of R1300 to R1500 per ha.

4.2.6 Mr Dorfling: (Riversdale)

Mr Dorfling operates two farms as a single farming entity, one in Weenen and the Riversdale farm. He said that his farming operation is only viable by utilising both properties. He said that if the dam is to be constructed, he would need to the bought out in total (both the Riversdale farm as well as his farm in Weenen). Timing is critical and he has expressed concern over the future of his farm for his sons. He would want to be paid out as soon as possible and then lease the farm back until the dam water made the farm impossible to operate. He would wish to be expropriated irrespective of whether the dam was at the 1040m or 1020m contour.

In Weenen Mr Dorfling has 100 ha under irrigation and is growing vegetables as well as a pig farming operation. On the Riversdale farm 18 ha is under irrigation and the main activity is cattle farming.

There is no labour resident on his property, but approximately 60 people are employed on a casual basis. In his opinion, the remainder of Riversdale has potential to link with the game farm initiative (Thukela Biosphere) to the north. He feels strongly about the game fence between Riversdale and Groote Milietuin, which he paid for in entirety.

4.2.7 Mr Diack (Oatlands)

Mr Diack has the farm Oatlands. The size of the dam is of critical importance to Mr Diack. At the 1040m contour he would need to be completely expropriated, as the dam would inundate most of the irrigated land and remove much of his infrastructure. At the 1020m level little would be lost and in fact the enterprise might be enhanced. He would however need clarity on the setback zones as his house is close to the 1:50 year flood line on the Bushman's River.

Mr Diack currently runs the farm as a dedicated dairy operation. He has 40 irrigated ha and plans to irrigate a further 40ha very shortly.

He also has a plan to develop the farm (and to possibly purchase neighbouring farms) to expand his operation into a large labour intensive dairy farm. In all about 300 jobs would be created. He anticipates doing this with a plan to create large numbers of jobs for disabled people. He states that he is about to launch a programme that would gear in an anticipated R25million for the project. Funds would be raised both from overseas (an investor is said to be lined up) and locally.

He does not foresee a major impact with construction but if the main Estcourt-Weenen road becomes very busy a sub-way for cattle crossing to the farm north of the road might be required.

If the 1040 dam was to be built then he feels that compensation should be paid as early as possible so that he can begin his operation in another area.

4.2.8 Mr Seele (Rondedraai)

Mr Seele has an 80ha smallholding. He does not farm it but has his residential property on the farm. He leases the rest of the land to his neighbour. He is concerned that he be paid out replacement value for his house, rather than market value. His house would be affected by the 1040m dam both in terms of his home being within the setback zone and his borehole being lost. His home would probably be unaffected by the 1020m dam.

4.2.9 Mr Schievers (Elmwood)

Mr Schievers's has a dairy farm that supplies Maas. At the 1020m level he would probably not be affected by the dam at all. At the 1040m level some of his prized irrigated land would be lost. Most of the lands are riparian and appear to lie close to or below the 1040m contour.

The Maas that he produces is sold locally and depends on a stable and loyal market. By expropriating the farm, Mr Schievers said, it would be difficult for him to start up elsewhere. He would therefore reluctantly want to be expropriated if his operation did not prove to be viable. He would need to be assured, if the property was viable with the dam in place that his road network and access to water remain as is. Ideally he indicated that he would want to be paid out as soon as possible after the project is initiated and then lease the farm back from DWAF until the dam water made the farm impossible to operate.

He indicated that construction vehicles could affect his operation as the majority of his land lies north of the Estcourt- Weenen road. Access over the road could become more complex.

4.3 Access Roads and quarry sites

As with Jana Dam there appear to be no major negative socio-economic impacts associated with the access roads that would be constructed for the purposes of the Mielietuin Dam. The M13 would, as a matter of necessity, have to be re-aligned as a consequence of inundation. The owner of the land upon whose farm the new alignment would be constructed, and in all likelihood this would be Mr Schievers, would have to be duly compensated. In fact detailed design for re-alignment of the road should be undertaken in consultation with Mr Schievers as the potential problems associated with isolation of the northern grazing camp by the road may be mitigated with careful design and the possible inclusion of an underpass.

For the rest it appears as if roads required for the dam would upgrade and improve existing access. Stakeholders regarded this as a positive impact. In particular improved access roads would probably enhance the value of the valley in terms of the tourist potential associated with proposed game ranching initiatives.

The quarry sites and materials necessary for the dam would be in all likelihood be located within the dam basin and therefore do not present a major impact.

4.4 Historical Issues

These issues are described in detail in the historical and cultural sites report dealing with the Jana and Mielietuin areas and aqueduct routes. However it bears mentioning that most of the respondents were aware of the historical significance of Groot Mielietuin farm and expressed regret that it might be lost.

4.5 Summary

It appears as if little resistance to the building of the Mielietuin Dam can be expected from the landowners. Most see the dam (particularly as close to the 1020m level as possible) as a potentially positive development. This view is probably predicated upon the following:

- Property prices have declined (partially as a result of the uncertainly around the dam but probably more directly as a result of pressures on diary farming and perceptions around crime) and interest in the area, driven by decisions around the dam, might be re-stimulated.
- The drift from diary to game means that many farms may actually aesthetically benefit from the presence of the artificial lake. This will particularly come to pass if the dam remains full for much of the time. Under these circumstances property prices might very well increase with developers and speculators entering the market. The presence of the Thukela Biosphere, the Weenen Nature Reserve and the Estcourt game farming initiative means that impetus for this kind of enterprise is in place.
-

The small number of landowners actually active in the area, the degree of relative good will, and the potential positive impacts of the dam means that the foundations for “win-win” negotiations with stakeholders have been laid. Realising this is however dependant upon the following elements:

- ***The FSL of the dam. The closer the height is to the 1020m contour the happier most stakeholders will be. In this regard the mooted 1025m dam does not appear to be nearly as problematic as the 1040m dam would be.***
- ***Clarity for stakeholders on access to the dam periphery. The National Water Act (1998) makes provision for stakeholder involvement in management of the periphery of dam, as Water User Associations. The guidelines under which this could take place should be part of a development plan generated for the dam. This should be done during the detailed design phase of the TWP.***
- ***Clarity on likely compensation principles. Particular attention will have to be given to the replacement/market value debate and to what appears to be fairly unrealistic expectations on the part of some landowners as to what this entails.***

SECTION 5: AQUEDUCT ROUTE

5. AQUEDUCT ROUTE

5.1 Introduction

The aqueduct is the means by which water is transferred from the proposed storage dams to the existing Kilburn Dam. From Kilburn the water is transferred out of the Thukela River System via the Drakensburg Pumped Storage Scheme. The proposed Jana Dam and aqueduct system is being designed to deliver approximately 11m^3/s, and the proposed Mielietuin Dam and aqueduct system to deliver 4m^3/s. The two aqueduct systems would meet in a confluence and thereafter, allowing for losses (in the case of an open canal), have the capacity to deliver about 15m^3/s. The current costs of constructing the aqueduct are estimated to be upwards of R1.5 billion.

The planning process as it has applied to the aqueduct has included the following steps:

- Pre-and feasibility level design of a technically acceptable canal route. This included the scoping of environmental and social impacts of the route and the incorporation of a series of technical and other amendments. For the purposes of this report this canal route now is referred to as the "optimised canal route".
- In addition to the optimised canal route (which consists of a combination of canals, tunnels and, pipelines) a route that consists only of a buried steel pipeline has also been identified.
- A combination canal and pipeline route has also been evaluated. This would consist of a steel pipeline from the Jana and Mielietuin dams and from their confluence, a canal delivering water to the Kilburn Dam.

All of the routes have been assessed. Assessment methods included the following:

- Personal interviews with the directly affected landowners and/or trustees/managers of lands.
- Telephone interviews with directly affected landowners and/or trustees/managers of lands.
- Mailed questionnaire to directly affected landowners and/or trustees/managers of lands.
- Site visits.
- Examination of aerial photographs, ortho-photos and, topographical maps.
- Interviews with stakeholder representatives and people with an "expert opinion".

For its greatest part the aqueduct (irrespective of which route is selected) will run through freehold lands in the Magisterial Districts of Weenen, Estcourt and Bergville (See Figure 4). Land use types affected by the proposed aqueduct and alternatives include the following:

- Private game farms
- Tourist and leisure resorts
- Mixed dryland farming
- Irrigated pasturage
- Irrigated grain crops

The majority of stakeholders expressed a great deal of concern with the "optimised canal route" and with the concept of open canals in general. Most concerns related to the following.

- ***Canals can be a hazard to people, livestock and game. Falling into a canal can be fatal and if livestock or game cannot get out they either drown or starve to death.***
- ***Canals disrupt farming operations and can be a barrier to access.***
- ***Canals can be an eyesore and detract from the aesthetic quality of certain areas.***
- ***Canals require expropriation that may remove irrigated or arable land from productive use.***
- ***Construction work associated with canals introduces hazards and can make farms accessible to criminal elements.***
- ***Access roads necessary for the maintenance of the canals can create entrance and escape routes for criminal elements (particularly stock-theft).***

Pipelines and tunnels, although disruptive during construction, were generally regarded as a far more acceptable option. The particular issues associated with the routes and alternatives are discussed in more detail below.

5.2 Optimised Canal Route

The amended optimised canal route is approximately 183 km in length and generally split into three sections. These are:

- Section A: storage dams to Colenso;
- Section B: Colenso to Bergville;
- Section C: Bergville to Kilburn.

For the purposes of discussion in this report the route, and alternatives, are split into three more logical impact sections. These are:

- Jana Dam to confluence;
- Mielietuin Dam to confluence
- Confluence to Kilburn

a) Jana/ Dam to confluence

This part of the canal aqueduct is about 39km in length and affects the following land use types:

- Private game farms
- Tourist and leisure resorts
- Mixed dryland farming

In all 17 landowners are affected. They are:

Farm	Owner
• Ramak, Klipberg & Brakfontein	Dr Muller (Vic Albers)
• Schurf de Poort	Mr D Froneman
• Schurf de Poort	Schurf de Poort Labour tenants
• Schurf de Poort	Mr H Bosse
• Rietbult	Mr G Grobler
• Monte Christo	Mr A Mason (I Milne)
• Colenso TLC Lands	Colenso TLC
• Labuschagnes Kraal	Ekuthuleni beneficiaries
• Meadowdale	Mr N Nkabinde

The Emaweni Game Farm (made up of the farms Ramak, Klipberg & Brajkfonntein) is particularly badly affected by the aqueduct. This was discussed in detail in Section 3.3.1 and it is fairly representative of impacts associated with other game farming initiatives along the aqueduct.

For the most part owners expressed concern with the impact of the canal on their cattle and game farming initiatives. In particular game ranching, and the hunting and eco-tourism market that supports it, is highly competitive and landowners expressed a fear that:

- Stock would fall into the canal and drown or starve to death.
- The canal would be a visual eyesore and drive tourists and hunters away.
- The disruption caused by construction would stress animals and lead to losses of game and stock.
- The disruption caused by construction would mean that the market share of hunters and tourists that they currently enjoy would be lost and difficult to re-capture.

Also critical is the impact associated with the Labuschagnes' Kraal (Ekuthuleni) resettlement project, located close to Colenso. The canal would divide the proposed project, and the Department of Land Affairs has registered strong concern with the possible impacts. Their view is that the open canal should be re-routed as it would run very close to the planned residential part of the settlement and would constitute a considerable hazard to the future residents

For all of the affected individuals in this part of the route the mooted pipeline would be seen as by far the better alternative.

b) Mielietuin Dam to confluence

This part of the aqueduct is about 24km in length and runs from the dam at Mielietuin to the confluence with the Jana aqueduct. The critical problems associated with this part of the route are the passage of the aqueduct through the Mtuntwane and Umzulusi portions of the Biosphere. The affected landowners are:

Farm	Owner
• Mielietuin	Mr B Schlanders
• Vaalkrantz	Mr N Ralfe
• Middleplaats	Mr A Mackenzie
• Sterkspruit	Mr M Winter
• Ndanyana	Mr J. Henderson
• Umsuluzi River Game Park	Mr M Mayer
• The Aloes	Mr G Horner
• Meadowdale	Mr N Nkabinde

The owners of the Mtuntwane (made up of Ndanyana, Sterkspruit, Middleplaats, and Vaalkrantz farms) and the Umzulusi portions of the Thukela Biosphere have expressed strongly negative opinions about the proposed canal route. Both portions make up Cell C of the Biosphere. The contiguous alignment of Cell C to the Weenen Nature Reserve makes this a key part of the Biosphere. Negotiations around the partial removal of some of the game fencing between the Reserve and Cell C of the biosphere means that game will be able to move across a larger area and, according to the respondents, makes the Biosphere a great deal more attractive as an enterprise. Respondents argue that the canal very seriously compromises the viability of Cell C, and by extension, the Biosphere project. They also argue that the viability of the Biosphere is critical to the economic development of the relatively depressed sub-region.

Given the nature of these claims a more detailed assessment of the value of the enterprise is under way. The results should be available shortly. However the following general points can be made.

- Given the nature of the soils and terrain and the high stock theft numbers, the current game-farming plan probably constitutes the only commercially viable land use option.
- Both enterprises are being developed on farms utilised previously for commercial, mixed and cattle farming. Power-lines, irrigation canals and alien vegetation detracts from the otherwise “pristine” nature of the area.
- Both enterprises would rely on a mixture of hunting, sale of game, letting of conference venues and eco-tourism in order to survive.
- The fact that the area is Malaria free is a considerable selling point in the overseas hunting market.
- The Umzulusi project is a great deal more developed than Mtuntwane and as a business venture appears to be better grounded.
- The canal has a greater impact on the Mtuntwane project. Most of the aqueduct as it runs through the Umzulusi area would be in the form of a siphon.
- The current value of the Umzulusi project is approximately R10million. The value of the Mtuntwane operation is not yet known but in a developed state would probably also be worth about R10 million.

The canal also bisects a piece of land that belongs to the Tembalihle – Cornfields community and has apparently been earmarked for eventual incorporation into the biosphere as part of a community tourism venture.

According to respondents this venture, should it materialise, would also be rendered non-viable by the canal.

Upon exiting the biosphere the canal runs through mixed farming area before Aqueduct Junctioning the Jana aqueduct.

Some respondents did indicate that the canal aqueduct did have a potential benefit in that it forms a natural barrier between the reserve and biosphere and the Tembalihle and Cornfields communities. Although respondents denied that relations are particularly strained, they did indicate that frequent acts of stock theft and poaching probably emanate from these communities. As such the further south the canal is moved the less problematic and the more beneficial the development become. Furthermore respondents contacted about the proposed pipeline all agreed that it was a far more acceptable alternative to the canal system.

c) Confluence to Kilburn

This portion includes sections B and C of the optimised canal route and is about 120 km in length. The sections are assessed as a single unit as the issues that have arisen along this part of the route are common to both. In all, 55 separate landowners are affected. Details of landowners are included in Appendix A.

For its greatest part the aqueduct would be located in lands used for commercial farming of varying levels of intensity. In terms of contribution to employment, commercial farming is the economic backbone of the area.[16] However, according to some respondents this sector is under pressure. Evidence for this is to be found in land values that have not kept pace with inflation.[17] Declining land values are said to be the result of the following issues:

- Progressive removal of subsidies for agriculture;
- High interest rates;
- Political uncertainties;
- Insecurities created by the perceived wave of “farm killings” and increases in stock theft levels;
- Uncertainties over the National Water Act and its effects on the viability of irrigation.

In terms of the Thukela Water Project the current situation has implications for estimates of the value of farms that are affected.

For the most part farmers who have responded to the questionnaire are negative towards the notion of the aqueduct. The most common concerns are the following:

- Canals can be a hazard to people and livestock. Falling into a canal can be fatal and if livestock cannot get out they either drown or starve to death. Farmers expressed concerns over the safety of their families and labourers.

[16] Although, interestingly, manufacturing contributes more to the Estcourt GGP and “Electricity and Water” in the form of the Drakensberg Pumped Storage Scheme contributes more to the Bergville GGP.
[17] According to Anthony Leiman of the Economics Dept. at UCT land values, expressed in terms of expected return on investment are still high. This is apparently as a result of the premium people place upon farming as a lifestyle.

Fencing of the canals was seen to be only part of the solution as effectively maintaining fences in an area where theft of such is commonplace was regarded as being close to impossible.

- Canals disrupt farming operations and can be a barrier to access; this can lead to increased costs of managing and operating the farm and in decreases in the value of the land.
- Canals require expropriation that may remove irrigated or arable land from productive use. This includes land under centre pivots, the removal of which would make some farms non-viable.
- Concerns around amounts paid for expropriation of land arose in many of the interviews. Canal servitudes would have to be expropriated and current property clause s25 (3) of the Constitution was seen to be a potential hazard. The clause is the basis for arriving at the amount of compensation that is paid to the owner of expropriated property. Concern was expressed that market value is not accorded primacy in determining compensation nor is the principal, that is entrenched in United States law for example, in force. This principal states that the owner of expropriated property, should be in "as good a position pecuniarily as if that property had not been taken". This apparently includes consequential damages including litigation and appraisal expenses The South African clause in the constitution states that: "*The amount, timing, and manner of payment, of compensation must be just and equitable, reflecting an equitable balance between the public interest and the interests of those affected, having regard to all relevant factors, including:*
    - *the current use of the property;*
    - *the history of the acquisition and use of the property;*
    - *the market value of the property;*
    - *the extent of direct state investment and subsidy in the acquisition and beneficial capital improvement of the property; and*
    - *the purpose of the expropriation."*
- Canals can be an eyesore and detract from the aesthetic quality of certain areas.
- Construction work associated with canals introduces hazards and can make farms accessible to criminal elements. Respondents regarded this as an impact of very great concern given current levels of perceived violence directed at farm owners.
- It was pointed out that access roads necessary for the maintenance of the canals can create entrance and escape routes for criminal elements.
- It was also pointed out that although the roads to the pumping stations are not in themselves problematic, they likewise create access opportunities for criminal elements.

In addition the canal would directly consume the following resources and assets:

- The route is made up of 53km of grazing land.[18]
- 67 km of currently utilised arable land.
- Of the currently utilised arable lands the canal runs through seven areas irrigated by centre pivots.

[18] Figures were obtained from measurements from aerial photographs and topographical mapping and are not exact. They are however reasonably accurate.

- Two farm dams and six farmhouse structures or farm buildings are either directly located on the route or so close to the route as to necessitate resettlement.

In terms of the quantified responses from the landowners the following aspects of interest arose.

- 86% of the respondents were owners or trustees that live on and work the farms for their livelihood. Only 7% of the farms are owned by absentee landowners. The other respondents were the DWAF, Conservation Services and the manager of a closed corporation that owns the farm.
- The median length of ownership of the farms is 13 years.
- 71% of the directly affected farmers were either negative or very negative towards the project. 8% were positive and the rest saw it as either necessary for the long-term development of the country but bad for the farmers, or they had no strong opinions.
- 34% of the farming activity along the route is devoted to beef farming. 33% is devoted to wheat or grain, 14% to game farming, 13% to dairy and the rest is made up of sheep farming and “other cash crops”. Income from other (non-farm) sources has not been included in this analysis.
- The 39 responding farmers employ a total of 437 people. By extrapolation it may be inferred that the 53 farms affected along section B and C probably employ about 600 people. This excludes casual and seasonal labour.
- The 39 responding farmers house a total of 222 labourers’ families. By extrapolation it may be inferred that the 53 farms affected along section B and C probably house about 300 families.
- 59% of the farmers currently have some form of water rights and are irrigating.
- 34 of the farmers were prepared to give an estimate of their farm value. Those who did not respond to this tended to be those who did not own the land. The values ranged from R400 000 to R11million. The two farms given the highest value were Drakensville and Sandford Lodge, both of which have been developed as tourist destinations and holiday resorts. The average value was found to be R1.69m. However if Drakensville and Sandford Lodge (which skew the sample) are excluded then the average value drops to R1.33million. The median value was found to be R1m.
- 46% of the farmers indicated that their farms would not be viable economic units if the aqueduct was built.
- 20% of the farmers indicated that the aqueduct would impact upon graves on their property. Three farmers indicated that the aqueduct would threaten Anglo-Boer War graves. Four farmers also indicated that they were aware of archaeological sites on the farms that would be affected by the aqueduct.
- In terms of concerns associated with the canal route the majority of farmers expressed concerns with safety hazards associated with the construction and post construction phases of the canal. The majority also thought that construction activities would lead to increase in soil erosion. However by far the greatest fear appears to be crime. 87% of farmers said that they thought that crime would increase during construction and 64% said that it would continue to increase in the post construction phase.

Other impacts that the farmers associated with the construction of the canal included the following:

- Spread of AIDS to farm workers from construction workers

- Proliferation of weeds in the disturbed areas
- Increases in poaching of game
- Loss of peace of mind

For the most part farmers were extremely sceptical about the DWAFs' ability to successfully manage the impacts of the aqueduct. Farmers pointed to similar experiences with the construction of other canals, roads, pipelines and powerlines. They indicated that other developers had made similar promises and had failed to keep them. In many instances farmers indicated that, should the aqueduct go ahead, they would prefer to be bought out completely rather than to have a portion of the farm expropriated.

In terms of mitigation the survey of affected farmers indicated that the following would be the position that they would adopt in terms of compensation and mitigation.

- Full expropriation of all farms not deemed to be economically viable as a result of the construction of the aqueduct. Where batches of farms are bought up they may be re-planned and re-sold. Although demands in terms of land redistribution may be given a degree of precedence the needs of displaced farmers should not be ignored. In terms of farmers likely to be regarded as so badly affected as to demand full expropriation the following appeared to be the case:

- Table 5.1 No of sub-divisions affected by the optimised canal route

Section	No of Subs Affected	No of Subs "badly" affected
Kilburn to Confluence	55	35
Confluence to Jana	9	6
Confluence to Mielietuin	9	5
Total	73	46

- Sub-divisions are as reflected by the latest records available from the Surveyor General. In some instances (not many) the sub-divisions have been amalgamated into single farms but they all exist as units defined as "viable" farms. "Badly affected" was defined as the farms either cut into two large pieces, or are farms that have the canal running through centre pivots. The bulk of these farmers will argue that the canal renders their farm a "non – viable" unit. In all likelihood some of these claims will prove to be difficult to substantiate but to err on the side of caution these claims are treated as legitimate.

- Access points across the canal that are positioned in negotiation with the landowner. This would in all likelihood have to be some kind of a bridge. If the farms defined as "non-viable" are expropriated then there are only about half of the 27 remaining farms that would need access points. The rest would be happy to have the small portions of land cut off, expropriated. Under these circumstances about 14 crossing points would be needed. If farms are not expropriated wholesale then at least 73 crossing points should be provided for.

- The fencing is to be regularly and effectively maintained by the developer. The cost to be borne is for the original fence plus replacement of fencing either damaged or stolen. Farmers will insist on this being part of the bargain as it represents, for them, a critical issue. The claim that is made is that fencing will be a futile effort as the rate of fencing theft is so great that the DWAF will be continually replacing it. Farmers indicate that with a service road running the length of the canal control of access to the fencing will be difficult to implement. For the farmers failure of the developer to comply with this will result in increases in reports of stock loss and potential lawsuits involving the law of *delict*.
- A canal designed in a manner that allows for the safe escape of people, livestock and, game that fall in.
- Full replacement of all housing and infrastructure that is destroyed or that is difficult/impossible to manage as a result of the construction of the aqueduct route.

5.3 Steel Pipeline alternative

The potential for replacing the pre-feasibility aqueduct, along its entire length, with a steel pipeline has been evaluated. The pipeline route has been slightly modified since it was first proposed. Following a meeting with the community the route has been altered to avoid the closer settlement of Bethany. The steel pipeline route would cover some 121km, of which approximately 25km is along the route from Jana Dam to the confluence, 18km from Mielietuin to the confluence and 78km from the confluence to Kilburn.

The breakdown by section of the route is as follows:

Table 5.2: Impacts along Section of Pipeline route

Section	**No of Landowners**	**Km of Arable Land**[19]	**No of Centre Pivots Affected**	**Km of grazing/game ranch land**	**No of farmhouse structures/ dams affected**
Jana to Confluence	9[20]	1.0	0	23.9	1
Mielietuin to confluence	6	0.0	0	20.0	0
Confluence to Kilburn	42	34.2	5	42.7 (includes section of tunnel)	6

[19] Again, figures have been taken from aerial photographs and are reasonably accurate
[20] A full list of stakeholders is included in Appendix 1.

Affected landowners along the route have been contacted and asked for their opinions. The following main points emerged:

- ***Landowners affected by the pre-feasibility aqueduct route almost universally prefer buried pipelines to the canal system***
- ***Landowners would generally prefer that a servitude be registered and that the land over the pipeline not be expropriated. They understood that they would be paid for the servitude but would not be allowed to construct structures over the servitude or would not be compensated for losses incurred should the developer need access to the pipeline for the purposes of maintenance.***
- ***Landowners not affected by the optimised canal route are generally not very receptive to the idea but they are not as antagonistic as the owners along the original canal based route***

- Concerns about expropriation/registration of servitudes also occur along the pipeline route but again the impact will not be as keenly felt as with the optimised canal route. In particular the following categories of concerns were expressed during interviews.
- Concerns about construction activities and associated impacts over this period were also expressed. The major concerns were with potential for loss of control of movement patterns on the farm and threats escalating stock theft and loss of personal security.
- Concern over possible loss of income during the construction period. In particular the landowners in the Thukela biosphere made the point that they were developing a business and a market share. The construction period would chase off potential clients and it would take them some time to recapture their market share in the post construction period.
- Concern over the possible spread of HIV/AIDS to farm workers from the construction teams
- Concerns around impacts on irrigated land were expressed and farmers wanted to be assured that their land would be restored to a full fertility after construction and that they could continue to irrigate on the land.
- Concern over the fact that an unsightly scar may be left by the pipeline. Landowners wanted to be assured that all practical measures would be taken to rehabilitate the land.

Despite these concerns and from the social impact perspective the pipeline route has far less in the way of associated impacts and is the option most favoured.

5.4 Combined Canal and Pipeline Route

The combined canal and pipeline route would consist of the following elements:

- A steel pipeline from Jana Dam to the confluence (25 km).
- A steel pipeline from Mielietuin Dam to the confluence (18km).

- A steel pipeline to the confluence of the Thukela and Little Thukela (Injasuti) Rivers.
- A largely canal based route from the confluence of the rivers to Kilburn (121km).

Although the combined route could avoid some of the concerns relating to the optimised canal route it is not as socially acceptable as the steel pipeline route.

The combined route would address the following problems:

- Some of the concerns that members of the Biosphere have with the non-viability of the venture following construction of the canal.
- Grave concerns of the Department of Land Affairs with the canal route through the Labuschagne's Kraal.

However, the combined route would not solve the problems that the commercial farmers in the area from the confluence of the Thukela/Little Thukela Rivers to Kilburn Dam have with the canal route.

5.5 Pumping stations

The canal route would require pumping stations at Jana and Mielietuin Dams and then a further three pumping stations. These are:

- Shelly
- Rietfontein
- Woodford.

The pipeline route would require pumping stations at Jana and Mielietuin Dams and then a further two pumping stations. These are:

- Rustenberg
- Bethany

All of the proposed pumping stations are located on freehold commercial farmland. All three of the pumping stations associated with the canal route are located on arable land. The two pumping stations associated with the pipeline are on land not currently cultivated although the Bethany pumpstation is adjacent to land cultivated by the farm Hunters Rest.

Compensation would have to be paid to farmers for expropriation of the land upon which the pumping stations are constructed. Respondents indicate that the construction of the pumping stations carry with them many of the concerns associated with the rest of the construction activity, i.e. fear of increased crime rates, uncontrolled access to the farms, dust, noise, etc.

Under these circumstances the fact that the steel pipeline requires only two pumping stations as opposed to the three required by the canal route means that the pipeline alternative is once again preferred from a social impact point of view.

5.6 Summary and Recommendations

The bulk of the impacts associated with the amended pre-feasibility aqueduct can be mitigated, albeit at cost. Impacts that will be difficult and possibly expensive to mitigate, and therefore deserve special attention, are those associated with the following instances.

- Impacts on parts of the biosphere;
- Impacts on Labuschagnes' Kraal resettlement project;

As such **the pipeline route is the option most favoured.** The costs of the pipeline should be weighed against costs of compensation and mitigation. Where costs of the pipeline (including operation and maintenance costs) are less, equal to or marginally greater than the costs of the optimised canal route plus all associated compensation and mitigation costs, then the pipeline should be preferred.

Furthermore mitigation should include the following:

- The accommodation of the aqueduct based construction crews (including pumping station crews) within the town limits of Colenso, Bergville and Winterton. This would minimise social tensions around the potential security threats that construction crews pose to farmers.
- If the canal is selected then fenced canals but with access points across the canal that are positioned in negotiation with the landowner. The fencing is to be regularly and effectively maintained by the developer.
- A canal designed in a manner that allows for the safe escape of people, livestock and, game that fall in.
- Full replacement of all housing and infrastructure that is destroyed or that is difficult/impossible to manage as a result of the construction of the aqueduct.
- Full expropriation of all farms not economically viable as a result of the construction of the aqueduct. Where batches of farms are bought up they may be re-planned and re-sold. Although demands in terms of land redistribution may be given a degree of precedence the needs of displaced farmers should not be ignored.
- Proper re-internment of any graves disturbed.
- A negotiated arrangement for securing the properties during construction periods and strict controls imposed upon contractors.
- Negotiated arrangements for securing access roads that are constructed for the purposes of servicing the aqueduct.

SECTION 6: COMPENSATION & MITIGATION

6. COMPENSATION AND MITIGATION

6.1 Introduction

Water is a social and economic good. It is essential for life, and economic development is not possible without it. South Africa is relatively water poor and development and management of the water resources should reflect the value placed on them by the users while keeping a balance between what is fair (social equity) and what is economically efficient. Under these circumstances effective management of the water resource is not possible without sound planning and appropriate development. The Department of Water Affairs and Forestry (DWAF) as the body entrusted with the development and management of this resource is keenly aware of its responsibilities in this regard.

DWAF recognises that development projects that require the expropriation or acquisition of assets, or displace people involuntarily, *can* give rise to economic, social, and environmental problems. The Thukela Water Project is no exception in this regard.

In the case of the Thukela Water Project compensation, particularly with regard to the acquisition of land, is complicated by the fact that two land tenure systems co-exist within the project area. Compensation for freehold land (land held by title deed and available to be traded freely within the market system) is relatively straightforward. Compensation for land held under tribal tenure (in this case by the Ingonyama Trust) is more complex.

Historically land under tribal tenure was held communally in terms of customary law. This land was held in trust and administered by traditional authorities on behalf of the community. The community (*umphakati* or those regarded as insiders) were defined as households who had paid *khonza* (fealty or homage) to a chief. In return for agreeing to a relationship of allegiance to the chieftainship households would be granted rights to land. Rights to land were in two sub-sets. The first were rights for the purposes of constructing a home and for the purposes of cultivating plots for crop farming. The homestead plot and residential area came under direct jurisdiction of the homestead head and could be utilised as this individual best saw fit and without interference from any other party. Security of tenure was predicated upon continued allegiance to the chief and upon effective utilisation of the land granted. Failure to cultivate land for a pre-determined period would result in the loss of rights of use. The second sub-set of rights concerned communal land. The most important aspect of this was right of access to graze livestock on community commonages. Gathering of firewood and other resource harvesting was generally also permitted although local rules differed slightly from region to region. Tribal tenure typically prohibited alienation of land rights through sale, particularly to persons from outside the local community.

6.2 Acquisition of land and compensation in Freehold Areas

Irrespective of the form of tenure, rights to land have to be acquired by the Department of Water Affairs and Forestry (or developer) and can take various forms. Privately held land is that owned by freehold. Roman Dutch law recognises the power of the legislature to acquire land or assets through expropriation *(principle of eminent domain).* Expropriation or acquisition through negotiation is however contingent upon compensation. According to the

Expropriation Act, compensation is only paid for the land and for the value of assets on the land that are acquired. Compensation is not paid for land usage, nor is it paid for potential land use. Thus if the land is used for a water works, surrounding property owners do not get compensated for inconveniences such as smell. The procedure for compensation for assets on privately held land usually entails the following steps.

Valuation of land, improvements and assets is generally undertaken by the evaluator and involves a series of steps. Firstly the evaluator compiles his/her guidelines to appropriate compensation in the project area. These could be guidelines for compensation put out by the Department of Agriculture but would almost certainly be influenced by guidelines/local knowledge made available by local sworn appraisers. Compensation is usually based upon the present market value of improvements and crops. It must be remembered that evaluation must be sufficiently well documented to withstand the test of a court case. Therefore the evaluator must be careful to follow the appropriate procedures. Furthermore the facts as to how the price was agreed upon must be presented as logical arguments supported by the relevant documentation.

The value that is accorded must be particularly well documented in the case of structures. The form that the documentation takes may differ from project to project but should follow a consistent format that indicates:

- the condition/age of the construction;
- property locality;
- the quality/durability of the construction;
- finishing, renovation, decoration, painting and general condition.

Acquisition can take two broad forms, i.e. acquisition through ownership, or acquisition through registration of servitude.

6.2.1 Acquisition by Ownership

In this case the affected land is acquired by the State. The National Department of Land Affairs (DLA) is responsible for buying land on behalf of the state. This follows one of the following paths.

a) Acquisition through negotiation

After receiving instruction from the Department of Water Affairs and Forestry to acquire the land DLA will appoint one or more registered valuators to carry out valuations to determine the purchase price of the property.

The criteria used are that of "open market value" based on the principle of "willing buyer and willing seller". Research into comparable sales of properties as well as an inspection of the property itself is inter alia carried out to determine this.

Valuation reports are scrutinised and considered by the Board on Land Matters and if recommended by the Board, PWD will make a written offer to the owner which will set the normal negotiation process in motion. It should be pointed out that this is the preferred route that the Department would want to take.

b) Expropriation

Should negotiations fail or should the Department of Water Affairs and Forestry so instruct, PWD will resort to expropriation.

Section 25 of the Constitution of the RSA and the Expropriation Act 63 of 1975 will apply. The Expropriation Act spells out the procedure to be followed by both the Department of Public Works and the owner. Compensation is determined as laid down in Section 25(3) of the Constitution and section 12 of the Expropriation Act, which use as basis "fair and equitable" and "market value". The Expropriation Act also provides for payment of other financial losses as a result of the expropriation. The Act furthermore provides for the payment of a *solatium* calculated on a sliding scale (Sec. 12(2)) as well as the payment of interest on the outstanding portion of the compensation (Sec. 12(3)).

It is important to note the rules laid down in Section 12(5) concerning determination of the amount of compensation.

Affected owners being expropriated should also specifically take note of Section 19 of the Act regarding discharge of debt secured by mortgage bond and payment of compensation in case of existence of certain unregistered rights.

6.2.2 Acquisition through Servitude

It is the policy of the Department of Water Affairs and Forestry to purchase land affected by dams. In very exceptional circumstances the Department may agree to servitudes of storage. Where this is agreed to the Department will apply a uniform approach of servitudes only and not a patch work approach namely a combination of purchase and servitudes,

The Department of Water Affairs and Forestry undertake the acquisition of servitudes in terms of section 64 of the National Water Act 36 of 1998 read with the Expropriation Act 63 of 1975. Valuations are again carried out by a registered valuator appointed by PWD and the valuation report considered by the Board on Land Matters.

The basis for compensation is laid down in Section 12(1) (b) of the Act, which reads - "an amount to make good any actual financial loss caused by the expropriation or the taking of the right."

As in the case of expropriation of land, solatium is also payable on the same sliding scale and the provisions of section 12(2), 12(3) and 12(5) as well as section 19 of the Act are applicable.

These servitudes will be subject to conditions and include the rights described in sections 128(1) and 128(2) of the National Water Act, 1998 (Act 36 of 1998) which read as follows:

Section 128(1)
A holder of a servitude contemplated in this Chapter has a reasonable right of access to the land which is subject to the servitude for the purpose of constructing, altering, replacing, inspecting, maintaining, repairing or operating the relevant waterwork, or for any other purpose necessary for the effective enjoyment of that servitude.

Section 128(2)
The holder of a servitude contemplated in this Chapter may, in a reasonable manner and subject to any other applicable law:

- take from the land subject to the servitude, any material or substance reasonably required for constructing, altering, replacing, maintaining or repairing any waterwork or part of a waterwork in respect of which the servitude has been acquired;
- remove and use vegetation or any other obstacle which is on the land subject to the servitude and which is detrimental to the reasonable enjoyment of the servitude;
- deposit on the land subject to the servitude any material or substance excavated or removed from the waterwork in the reasonable exercise of the servitude;
- occupy, during the period of construction of the waterwork in respect of which the servitude has been acquired, as much of the land subject to the servitude as may reasonably be required for -
- constructing camps or roads;
- constructing houses, reservoirs or other buildings or structures, or
- installing machinery or equipment, necessary for the construction of the waterwork;
- occupy, for the duration of the servitude, as much of the land subject to the servitude as is reasonably required for -
- accommodating people;
- workshops; or
- storage purposes, to the extent that this is necessary for the control, operation and maintenance of the relevant waterwork.

The Government, its successors-in-title or assigns shall not be liable for the payment of compensation in respect of any loss or damage sustained by the owner or his successors-in-title on the defined area/s of the servitude/s by reason of the acquisition of the servitude/s and the exercise of the rights thereunder.

The State (Department of Water Affairs and Forestry) reserves the right to cede the servitude right/s. The defined areas of the servitude will not necessarily be fenced-off. In certain cases it may be fenced depending on circumstances.

Access to and utilisation of the defined areas of the servitude are reserved exclusively for the Department and the owner. Utilisation of the servitude areas by the owner is for grazing purposes only and will be at the risk of the owner.

No buildings or structures may be erected within the servitude area without the prior written approval of the Department of Water Affairs and Forestry. The Department will not agree to the construction of accommodation facilities within the servitude area.

6.2.3 Compensation for loss of income as a result of construction activities

From time to time landowners are almost certain to make claims with respect to losses experienced during the construction period. In some instances these will be easy to prove and adjudicate (e.g. prize bull killed by out of control construction vehicle), while in other cases they may be more difficult (e.g. reduction in calving rates as a result of stress induced by noise pollution). In order to deal with this a Compensation Forum should be formed. The Forum would be made up of the implementing agent, nominated or elected representatives of the directly affected landowners, and contractor(s). The panel would meet on a regular basis and adjudicate compensation claims.

The following documents must be furnished prior to payment of a compensation claim:

- a copy of the compensation agreement reached by the adjudication forum.
- a copy of the claimant's identification document.
- the claimant's postal address, if available.
- the residential address, or Eskom stand number.
- an indication of whether the claimant has a banking account, including bank name and number.

6.3 Resettlement and Compensation of People in Tribal Areas

Resettlement of individuals or communities represents an extreme case of potentially negative developmental impact. Under these circumstances the boundaries between compensation and mitigation often become blurred. In the case of the Thukela Water Project residents on the Left Bank of the Jana Dam (Mziyonke and Mankandani area) are almost certain to require resettlement. Section 3.2.5 sets out the principles by which resettlement should take place. The remainder of this section makes more specific recommendation.

6.3.1 Negotiation for Land under Tribal Tenure

Within tribal areas (i.e. the former KwaZulu areas) compensation issues are made more complex by uncertainty as to how compensation for land acquisition should take place within a context where market forces, based upon the "willing buyer willing seller" premise, play no role in determining value. As such the following steps are necessary

At a generic level the determination of who is affected has been undertaken as part of the impact assessment. Information has been obtained through a full social impact assessment, supported by stakeholder interviews with directly affected individuals/households/communities. Information on who is affected includes:

- basic information on the individuals, households and communities affected;
- the socio-economic status of affected households pre and post construction, to enable some measurement of whether they are no worse off at the completion of the project;
- an inventory of structures, land area and land use that will be destroyed, temporarily or permanently, including grave sites, per individual/household/community;

At the detailed design level discussions with those affected as to the project details and plans around compensation must be held. These **must** be held at two levels. Firstly community-level briefing sessions should be used, to initially outline the purpose of the project and thereafter to update people of progress and also to spell out the compensation proposals.

Secondly, within communal tenure areas individual households are given usage of land. This usage is for residential purposes and for the purposes of cultivation. Where structures are affected by a project, or where arable land is needed, compensation discussion take place at a household level. Individual meetings would be held with those affected as the project progresses, typically in late detailed design phase or during the initial implementation phase. Tribal Councils do not, under these circumstances, speak for the affected households.

Individuals were interviewed during the course of the SIA and a picture of who is affected, and to what extent, has been generated. During the detailed design phase this information should be used to work out the likely scenarios for compensation and proposed policies. These would be agreed to at a communal level. During the early implementation phase this should be taken a step further. During individual meetings there must be agreement on quantification of the land/improvements that will be affected with the affected households (the information generated by the SIA is used as a base). The nominated representative of the affected household should sign a site note that lists agreed upon quantified impacts. This is done with DWAF's (or developer) appointed representative.

Upon commencement of the project DWAF (or the Developer), in conjunction with the most appropriate stakeholders appoints an independent evaluator/evaluators. Agreement as to the evaluator is important as negotiation is simplified if it is built on trust around the "neutral role" that the evaluator is seen to be playing. As things stand at present a representative of the Department of Agriculture is gene rally regarded as the most appropriate evaluator. The evaluator should work within the context of the following guideline.

a) Replacement g

A starting principle should be that DWAF (or the Developer) should rebuild housing required for the project rather than offer cash compensation.

All actively utilised dwelling units should be replaced irrespective of the condition of the house. The fact that housing will be new, and usually built from materials that are better than those that are lost, means that households are generally better off in terms of the quality of their housing. The following more specific recommendations are made.

Where DWAF (or the Developer) intends to acquire a residential site, they should ask the owners and occupants of the site where they wish to resettle. This preference is influenced by many factors, including the decisions of neighbours and kin, and is likely to change in response to changing circumstances and opinions in the community. DWAF (or the Developer) should therefore allow ample time and provide the necessary information and other assistance to help people to make this choice. The site should be selected in conjunction with the Tribal Authority. People should n be removed from their sites before they can move into the new homestead being built for them.

DWAF (or the Developer) should investigate the availability of residential sites, with land for gardens where this is desired, in the areas chosen by the prospective re-settlers. In the selection of new residential sites due consideration should be given to the views of the host communities. The likely resettlement points will be confirmed in the detailed design phase.

Should an extended family, a village community or any other group of neighbouring households which are to be relocated wish to live close to one another in future, DWAF (or the Developer) should make every effort to assist them to obtain residential holdings, in a single block or acceptably close to one another.

As a general principle households should be relocated within the same Tribal Authority, but may be relocated elsewhere if:

- there are compelling social, economic or political reasons for their resettlement elsewhere;
- there is insufficient residential land available in the area of their choice.

The present policy is geared to the owner-occupier. Where DWAF (or the Developer) acquires residential property on which there are one or more habitable houses, it should do so according to the choice of the owner and:

- build the same number of new houses. Housing should be rebuilt to resemble that which is lost. That is, a rondavel will be replace with a rondavel, a flat with a flat. A range of designs should be generated from which the individuals can choose. In the case of the Mziyonke/Mankandane these designs should fit into a larger development plan which assists the community in creating a sustainable lifestyle.

- or amalgamate the floor area of the old dwellings into a smaller number of new houses, of at least equal quality and floor area to that of the acquired dwelling(s), at the new residential site.

DWAF (or the Developer) should consult with the owner on which among a number of standard designs, appropriate to the given floor area, should be provided. DWAF (or the Developer) should have the right to demolish every building it acquires, after an acceptable period has lapsed, in order to prevent its unauthorised re-occupation.

DWAF (or the Developer) should be responsible for the construction of the new housing and should provide transport for the occupants and their belongings when construction is complete. The owner should be entitled to remove any materials he or she wishes to salvage within one month of vacating the old dwelling. DWAF (or the Developer) should provide transport for these materials, other than masonry[21], to the new residential site. Where the old homestead was fenced DWAF (or the Developer) should erect a fence of at least equivalent standard.

Cash should be paid in the following instances:

- Incomplete dwelling units, or units which have collapsed and are no longer functioning as dwelling space, should be evaluated and the owner paid out cash for them. An official of the Department of Agriculture should undertake valuation.

- Cash should also be paid for the ancestral hut "*iquhugwana*". These are generally structures of grass and reeds. Replacing them is difficult for

[21] Including stones, bricks, and concrete blocks and slabs.

contractors and people prefer to rescue the material and rebuild the hut for themselves.

- Cash should be paid for "*isibiya*" (cattle and goat pens) and for any other miscellaneous improvements on the site. Alternatively the household could be asked to reconstruct *isibiya* etc. at the new site and be paid compensation when this is completed.

Rebuilding structures, rather than paying out cash for structures is advocated for the following reasons.

Firstly the temptation for people to take the cash and use it for other immediate consumption needs is sometimes overwhelming and people subsequently find that they have to settle for an inferior standard of housing to that which they previously enjoyed. If this situation arose it would run counter to DWAF (or the Developer's) stated policy that no one should be worse off after project implementation than before.

Secondly, the sums paid out after valuation according to the official rates tend to be very low. People sometimes accept these rates because they have little idea of what replacement housing could cost them and the sums mentioned to them often seem large.

Third, experience demonstrates that some contractors take the approach that by bargaining people down to as low a figure as possible they are saving the project money. While this may be true the principal is that that money should not necessarily be saved at the expense of the people who bear the costs of having their way of life disturbed.

Lastly, in a situation dominated by migrancy the possibility exists that the household head could abscond to an urban area with the money leaving a destitute rural family behind to cope as best they can.

In this regard we also feel that, in line with government policy, the replacement housing should (where possible) be sub-contracted out to local "emerging contractors". Alternatively there is no reason, if a suitable emerging contractor cannot be identified, why an established contractor should not be appointed. However he should make use of local labour to construct the buildings as far as possible.

b) Absentee Owners

An absentee-owner is assumed to have his/her own "primary residence" in another place, and so should not require a new house on account of the acquisition of the old one in the project area. In this case he/she, after due consideration is given to issue of social integration, should preferably be offered the cash equivalent of the replacement house under the same conditions as above.

c) Non-owning occupant (e.g. renter, borrower, squatter)

Although they may have no legal claim on the dwellings to be acquired by DWAF (or the Developer), and in which they live, such occupants nevertheless have the right, as persons affected by the project, not to be ejected until they are satisfactorily accommodated elsewhere, as this would certainly reduce their standard of living. DWAF (or the Developer) should therefore ensure, by any appropriate means, that their satisfactory resettlement is achieved. DWAF (or the Developer) is required to do so under the provisions of the Extension of Security of Tenure Act discussed in Section 2 above.

d) Toilets

Whether a property acquired by DWAF (or the Developer) includes one or more toilets, or not, for the sake of improving access to sanitation (and to protect water quality in the dam) DWAF (or the Developer) should provide, as a minimum, VIP toilets at the new site. The standard supplied, however, should not be lower than that which the household enjoys.

e) Water supplies

Where the project is the cause of a reduction in the supply of water from an established source, natural or artificial, to a community or an individual household, DWAF (or the Developer) should reinstate that source or replace it with another of at least equal volume, quality and convenience. A number of small springs, used by the community, will be lost to the dam.

f) Commercial properties

Where DWAF (or the Developer) acquires a commercial property the owner should be given the choice between

- receiving the full replacement value of the property in cash;
- or arranging for the design and construction of equivalent new premises, the cost of which would be borne by DWAF (or the Developer).
- DWAF (or the Developer) should provide transport for the stock and equipment, and any other items the owner wishes to move to new business premises.

g) Graves

As was mention in Section 3 above, for many Zulu people graves are seen as the resting-place of ancestors. According to traditional belief ancestral spirits are displeased when their graves are disturbed. Angry ancestors are often regarded as responsible for misfortunes such as illness, drought, cattle dying, crop failure, loss of employment, etc. The disturbance of graves is therefore regarded as a serious matter. When graves are disturbed a sacrifice should be made to the ancestors to appease the spirit.

The nature of the sacrifice depends on the role that the ancestor is seen to play in the lives of living descendants. The disturbance of a grave of great significance would call for the sacrifice of a bull, a less important ancestor would mean the slaughter of a goat. Each case should be judged on its merits and appropriate compensation be paid out.

A professional undertaker should undertake the re-internment of the grave. Most people prefer that remains be reburied in the “Zulu style” i.e. wrapped in blankets rather than in a coffin.

The chief and Land Allocation Committee of the area of which the families are to be relocated should be asked to arrange for reburial sites to be provided.

The superstructure of the new graves, including tombstones, should be provided to a standard at least as high as that of the old graves.

The exhumation and re-interment should be carried out with all due ceremony and ritual as agreed by DWAF (or the Developer) and the surviving relatives and as ratified by the resettlement committee. Each case should be judged on its merits, and the appropriate compensation given.

The steps to be taken are typically as follows:

- the grave is located and identified and the next-of-kin are informed that it needs re-internment.
- the associated household is asked to identify the deceased person and a preferred site and preferences around blanket/coffin (most people in rural areas prefer that remains be reburied as per custom, that is wrapped in a blanket rather than placed in a coffin)
- the representative of the household must formerly request re-internment.
- a professional undertaker is commissioned to relocate the grave. Quotes should be obtained as per government regulations. The undertaker must comply with all legal requirements including publication of notice of intentions to move graves, etc.
- the undertaker is briefed, and introduced to the family
- the first goat is made available
- reburial takes place
- the second goat is delivered

The costs of the above provisions should be fully met by DWAF (or the Developer).

h) Crops in the Field

Where land with crops is acquired, or crops are destroyed, compensation should be negotiated between the homestead owner and the extension officer from the KZN Department of Agriculture. The procedure for doing this is well defined and has been followed during the course of many development projects in KwaZulu-Natal. A cash payment is made to the household, preferably to the senior woman in the household.

i) General principles around land acquired

The acquisition of land is by far the most difficult impact to mitigate. Cash cannot be paid for land, as it is tribal and not freehold. However fair compensation must be made available. A number of options are outlined below. Each needs to be carefully negotiated between DWAF (or the Developer), the affected individual and the Tribal Authority.

Land will be acquired by DWAF (or the Developer) for the purposes of its construction. Land will be acquired via the established legal channels as outlined above. However, given the historically marginal position that people in the “black” rural areas of South Africa have occupied, notification of intent to occupy land is likely to need to be carefully negotiated at the local level. While the principals around this will have been worked through during the SIA and refined during the detailed design phase the timing will still remain critical. As such DWAF (or the Developer) has the duty to inform any persons whose rights or property will be affected by DWAF (or the Developer) operations before it commences its works which may affect those rights or property. In the case of property upon which there is an occupied dwelling the notice period should be six months and in the case of other property or right to the land, the notice period should be one month. Formal notification should be given in writing and the method of sending these notices is specified as follows:

- It may be served on the owner of the property or land right, who should sign for the receipt of the notice;

- if there is an occupant of the land or property who is not the owner of the property or land right, both the owner and the occupant should be served with a formal notice of DWAF (or the Developer)’s intention to acquire the property or land right;

- If the owner cannot be traced DWAF (or the Developer), in collaboration with the local authorities (*amakhosi*), kin and neighbours, should try to locate his authentic representative, who should be served with the notice and may, at DWAF’s (or developers) discretion, receive the due compensation on behalf of the owner.

Land which has been acquired by DWAF (or the Developer), for example in the vicinity of the reservoir and on vacated construction sites, may not be needed for permanent or exclusive use by DWAF (or the Developer). Such land may be opened for access to its previous users under conditions established by DWAF (or the Developer) or made over to some other public use. The management of this land for the benefit of its previous occupants and users is a form of compensation.

A further issue concerns land acquired by DWAF (or the Developer) for permanent occupation, but where access, subject to specified conditions, may be granted to the public. For example:

- land occupied by a dam basin where DWAF (or the Developer) may permit and even encourage certain people to fish, operate boats, etc.

- land under powerlines where ESKOM has a wayleave which permits it to exclude or allow various forms of land use;

- land on the periphery of a dam basin where DWAF (or the Developer) proclaims a “safety zone” within which human settlement is excluded in order to reduce hazards to local residents;

Access to this category of land may be allowed by ESKOM/DWAF (or the Developer) subject to an agreement under leasehold or any other arrangement agreed by DWAF (or the Developer) with prospective users. It should be noted that the National Water Act 1998 makes provision for the establishment of

Water User Associations for these kinds of purposes. Leases may not be renewed and other agreements may be suspended by DWAF (or the Developer) if the land or water is being used irresponsibly or unproductively, or if DWAF (or the Developer) wishes to resume occupancy.

j) Temporary and Exclusive Occupation

Land acquired for temporary and exclusive occupation and use by DWAF (or the Developer) e.g. land on which contractors' camps and temporary access roads are built. This will later be returned to the previous occupants or made over for some other public use.

In either case the land so occupied should be reinstated by the contractor, and returned to the previous occupants or to DWAF (or the Developer) in the condition specified in the contract.

The tender documents should be highly specific in their requirements for reinstatement, giving the contractor and the supervising engineer clear instructions for reinstatement. These actions should also appear in the bill of Quantities.

The supervising engineer should authorise payment for these items only after a thorough inspection of the site by his own technical and environmental staff, and following formal clearance by the Environmental Division of DWAF (or the Developer).

k) Temporary and non-exclusive Occupation

DWAF (or the Developer) or its Contractors may overestimate the area of land they require for their operations, and should this become apparent they may allow public access for limited purposes, such as grazing or ploughing, until the contract is ended, when the land will be returned to its previous uses, or made over for some other public use, in a condition at lease equivalent to that in which it was acquired.

l) Special issues regarding acquisition of arable land

DWAF (or the Developer) may acquire land for a variety of purposes associated with the project. These could include land acquisition for purposes directly related to the construction of e.g. a dam, including access roads, contractors' camps, and for the inundated area; and also land which may be required for the purposes of resettlement and compensation of affected communities and households. Adequate compensation is difficult under these circumstances and a number of possibilities are outlined below.

Where arable land is acquired by the project, and the affected household wishes to be compensated with land for land, DWAF (or the Developer) should endeavour to provide alternative land of at least equivalent productive potential in a place acceptable to the affected family.

The provision of replacement arable land will normally entail a move of residence for the affected family and its livestock. The acceptability of a resettlement destination therefore requires a combination of suitable arable land, access to winter and summer grazing, and a residential site with provision for a garden, all within convenient reach of one another.

The land rights granted to a family compensated with land for land should provide security of tenure at least equivalent to that which the family held over its previous fields. This may require negotiation, on behalf of the resettled family, with local authorities.

DWAF (or the Developer) should investigate the feasibility and cost of reclaiming land for agriculture through any long-term cost-effective means. Where, for example, it is found to be economically and technically feasible to reinstate a spoil dump for agricultural purposes or to move soil from a reservoir basin to a higher terrace, this should be incorporated into the contractor's contract and bill of quantities. The land so reclaimed should be distributed by the tribal council to applicants selected from among those losing land to the project.

A further possibility is the identification of remaining land close to the dam that can be irrigated, or the installation of irrigation systems for land that remains, to increase the output and value of that land. Land so developed is then divided amongst those losing land.

Where arable land is required by the project, DWAF (or the Developer) should investigate with the local chief and land allocation committee the availability of land which is not being used by its present holders and which could, with the consent of its present holder, become available for re-allocation.

Such arrangements should not be made by DWAF (or the Developer) until it is entirely satisfied that the family relinquishing its land rights will not be impoverished or in any way disadvantaged by the loss of rights over that portion of land. DWAF (or the Developer) should inform persons from whom it is compulsory to acquire arable land that they may, if they wish, investigate the availability of fields belonging to others. If they are successful in finding such land, DWAF (or the Developer) should assist them by all legal and appropriate means to effect the transfer of land rights through the normal channels.

DWAF's (or developers) objective is to ensure that in addition to receiving direct compensation for their losses, affected households should be enabled to recover their own independent earning capacity through enhanced agricultural production from the remaining land and through the development of alternative sources of income.

To offset the loss of land, creative policies need to be identified which accentuate the local development nature of the project. This includes the optimisation of the positive impacts of the project. In addition, the project needs to be based in a broader integrated regional development plan, to support programmes which would lessen the impact and provide opportunities for growth and an improvement in the standard of living and quality of life of those affected.

Where no replacement land is available and none of the developmental opportunities are viable, an extended grain payment, with sufficient added protein to make the package nutritious could be considered. It should be pointed out that this model (although tried in the Lesotho Highland Water

Project) is difficult to implement, with associated logistical and administrative problems and should probably be avoided unless absolutely necessary.

m) Acquisition of grazing land

Grazing land is a communal asset. Compensation for its loss therefore needs to be considered as a loss to the community and also as a loss to individual livestock keepers, both present and future.

DWAF (or the Developer) should compensate the communal loss by planning and implementing range management and fodder production programmes in collaboration with the local communities affected by the loss. The objective should be to improve the productivity of the remaining range resources by an amount at least equivalent to the annual loss in biomass caused by the project. This should take place as part of a rural development programme developed during the detailed design phase.

n) Host Communities

When families or communities who are to be relocated have decided where they want to go, site investigations should be carried out jointly by the people who are to move, the host communities, their chiefs and other representatives, and DWAF (or the Developer).

In the case of families opting for land-for-land it is essential that the required area and quality of arable and grazing land are available in the receiving area, and that the hosts are fully aware of, and are willing and able to provide, the arable and grazing requirements of the future community.

o) Trees and Natural Sources of Fuel

Wherever it is necessary for DWAF (or the Developer) to acquire individually owned trees, it should provide compensation in the form of a negotiated amount of seedlings of the same or another acceptable species for each tree acquired. DWAF (or the Developer) should ensure that the recipients of these seedlings receive any necessary advice and support in their cultivation and care.

Many households depend heavily on natural vegetation for their fuel. Large areas of this communal resource will be lost to inundation, and individual families will thus be deprived. DWAF (or the Developer) should investigate woodlot programmes as a mitigatory measure. This should take place as part of a rural development programme generated during the detailed design phase.

p) Access

Where a family or a community will suffer significantly impeded access and loss of communications on account of the project, and wishes to move to a new site, DWAF (or the Developer) should provide them full entitlement to resettlement and compensation, as if that family or community were to be involuntarily resettled and compensated for its losses.

The definition of ‘significantly impeded access” cannot be formulated precisely, and DWAF (or the Developer) should accept that any family or community that clearly wishes to move has good reason for doing so, and for not wishing to remain. DWAF (or the Developer) should replace roads that it floods or otherwise closes with access of least the same standard.

Where access across river valleys is interrupted by flooding, DWAF (or the Developer) should provide an alternative means of access by ferry, bridge or other means acceptable to the affected communities at former major crossing points, to ensure that communications are maintained.

The provision of alternative means of access would, of course, become unnecessary if all those using the crossing in question had been resettled to a place where they no longer needed to use that crossing.

q) Infrastructure and Amenities

DWAF (or the Developer) should replace any local infrastructure and public amenities it acquires, such as dips, village water supplies, clinics, schools, etc. Environmental and physical planning considerations should be taken into account in the replacement and siting of such infrastructure.

Where DWAF (or the Developer) acquires public amenities and land belonging to a group or section of the public, such as a church or an association, its replacement should proceed along the same lines as the replacement of commercial premises.

r) Optimisation of Development Inputs

A flip side to the development of a compensation policy is accentuation of the potential positive impacts inherent in the project. In the past these have been seen as incidental but with careful thought and a process of local consultation they can be designed to meet a range of local agendas *without necessarily becoming a project expense*. The following items are particularly important:

- reservation of appropriate sub-contracting jobs for local entrepreneurs/ emerging contractors or a preference system in terms of the tendering procedures. Business organisations and training institutions should be encouraged to actively participate in development fora that are intent on actively empowering the local people during the course of the TWP, so that in the longer term “emerging” business have a better chance of remaining sustainable.
- encouraging contractors to optimise the numbers of jobs that they can make available i.e. substitution of plant for labour where possible
- structuring a local employment policy that spreads jobs as widely within the area as possible.
- initiation of a public works allied adult basic education programme for locally recruited workers
- design of construction access roads so that they meet both project and local development agendas
- design of the construction camp so that infrastructure can be used by the community in the post construction phase.

Ideally an integrated regional development plan should be devised, with input from government bodies, prior to construction and in consultation with local people, to ensure that future development plans are incorporated into project plans. This should be contextualised within the ambit of a Resettlement Action Plan (RAP) which should be generated during the detailed design phases of the project cycle and implemented in parallel with compensation. Various committees take on functions at different levels to ensure that the RAP is effectively implemented to the satisfaction of those involved.

6.3.2 Institutional Arrangements

Critical to a successful resettlement process would be a Co-ordinating Committee which would be established to plan, co-ordinate and manage the RAP, negotiate with the affected population and other interested parties, and integrate the RAP with regional agricultural and related development initiatives. It would also, in liaison with a Project Committee, ensure adherence to resettlement policy guidelines, and harmonise construction and resettlement schedules.

On the community level, a Resettlement Action Committee/Committees (RAC) should set up with elected representation from the directly affected settlements, including that from various categories such as resource user groups (agriculture/livestock farmers) and households to be resettled. The main functions of the RAC would be to consult and negotiate with project officials, disseminate information to/from constituencies and the implementing body and its representatives, provide a channel for grievance resolution, monitor resettlement actions, and indicate corrective actions required. Regular meetings with provincial government departments, and representatives of the Contractor and Consulting Engineer, would ensured that appropriate mechanisms are implemented and used for (1) consultation and collaboration between affected resource user groups and the Contractor/Engineer, and (2) conflict resolution. Training would probably have to be given to members of the RAC to enhance their capacity.

One of the key responsibilities of the RAC would be monitoring local employment on the project. The issue of job opportunities relating to construction usually becomes a sensitive issue among the local population, particularly as expectations are raised as to the benefits. A Labour Desk (LD) could be established (as a subset to the RAC but with additional co-opted members) to ensure that the issues are addressed and that employment opportunities for local job seekers are maximised.

The LD should consist of representatives from:

- any local committees that have been formed with representation of affected households, and in response to the project
- the Consulting Engineer
- the Contractor(s)

The establishment of an information/advice office, controlled by the RAC, would probably be an essential component for the collaboration of the affected population in the RAP, and the successful implementation of resettlement actions. Apart from serving as the meeting place of the RAC, the office could fulfil a number of other key functions:

- information dissemination: housing of all important documentation; distribution of information; education on issues
- advice giving, grievance channel: requests/problems of affected people, and responses/actions, to be recorded

In addition to the RAC:

- Opportunities should be created for the affected population to establish informal channels for information dissemination, such as local reference groups organising around a specific issue, which would be linked to the RAC, and
- Management committees, consisting of elected representatives of the affected population and officials from local government, should control and monitor each mitigation option.

Given the recognition of the importance of the social components of a project, project resource and budget allocations should provide the necessary financial security, and in particular resettlement and related actions must be funded effectively.

The Resettlement Action Plan (RAP) should follow an integrated resource development approach, with the implementation of the resettlement actions a collaborative effort between officials and affected individuals. Thus the final RAP should be negotiated extensively with those affected.

6.3.3 Outline of a Resettlement Programme

In terms of a programme for the establishment of the Resettlement Programme the following is suggested:

During the pre-implementation and detailed design phase of the project the RAP is written up. Part of the process of writing up the RAP involves the establishment of a steering committee. Key participants on the Steering Committee will be the developer, key I&APs, the community nucleus from which the RAC would be developed, regional and local authorities and relevant government departments.

The RAP will culminate in the plan being signed off by the Steering Committee and having been approved by the developer and through the necessary legal channels. If external funding is to be acquired for the project then the RAP will probably need International review and approval. Developing the RAP and acquiring the necessary levels of approval process will probably take 18 month to 2years. The RAP must be developed to the same level of detail as is required for other aspects of the technical detailed design programme.

The steps to the RAP would probably be something much like the following:
The RAP might be envisaged as consisting of eight tasks. The tasks are as follows:

- Start-up and establishment of RAC
- Data Generation and analysis
- Compensation Strategy and Compensation workshop
- Host Community Impact Assessment
- Draft Resettlement Procedures

- Review
- Finalise Resettlement and Compensation Plan
- Community Sign-off

Most of the tasks are sub-divided into a set of sub-tasks. Tasks and their sub-tasks are described in more detail below.

Task 1: Start up and establishment of RAC.

This task consists of the following sub–tasks:

Sub task	Description and Aim of sub-task
1.1 Review RAP Docs.	This task will examine all documents generated to date. In particular the SIA would be scrutinised. Interviews with key study members from other components of the project will be undertaken.
1.2 Establish RAC	An ad-hoc RAC will be established. This will be made up of relevant other study team members (e.g. PIP task leader), relevant regional officials, representatives of the directly affected landowners (as identified during the SIA), traditional authorities, relevant NGO's etc. It is important to integrate local level participation into the study at as early a stage as possible. This is so as very often critical project decisions are made in the early phases and by only bringing local level input in at a later stage the opportunity to make meaningful input is reduced. The RAC will also be used to determine the appropriate strategy needed for obtaining permission to undertake the questionnaire fieldwork.
1.3 Develop Survey instrument	Development of the survey instrument is a critical phase of the project. The survey instrument will determine the nature of the database and this will become the baseline data for awarding compensation and for monitoring the socio-economic status of the affected population. Project personnel who have experience in social science research would design the questionnaire. The RAC would also be asked to nominate suitable locally qualified people for training as enumerators.

Task 2: Data Generation

Sub task	Description and Aim of sub-task
2.1 Pilot survey and training	The questionnaire would be pilot tested. The task leader and field manager would take direct responsibility for all interviews undertaken during the pilot study. The pilot study would also be used to train the enumerators in undertaking interviews. Experience shows that this kind of field-work based training is the only reliable way of ensuring that enumerators are adequately trained for the task at hand.
2.2 Refine questionnaire and design template	Lessons learned during the pilot study will be used to refine the questionnaire and a final copy will only be printed after the pilot study has been undertaken. A data entry template will be designed.

2.3 RAP Fieldwork (Data Survey)	Fieldwork data collection, probably by means of questionnaires.
2.4 Land Register	The land register would, as far as possible, be completed at the same time as the interviews. Respondents would be asked to indicate the precise location of their fields. This would be logged on suitable scale maps and/or aerial photographs. Experience shows that this is sometimes the most difficult aspect of the project as land disputes arise and these need to be mediated.
2.5 RAP fieldwork: Data input	Data would, as far as possible be entered onto computers as the questionnaires are completed.
2.6 RAP Data analysis	This will be a first cut analysis exercise and will help to identify major trends and to identify what, if any, gaps are missing. Data analysis will also be undertaken for the purposes of reporting
2.7 Sweep Exercise.	It is anticipated that minor gaps, including missed households and/or problematic data, will arise after a preliminary analysis of the data during sub-task 2.3. A secondary sweep operation is prescribed to fill the gaps identified during quality control and data analysis.
2.8 Report presentation	This will be a report back to the client on the progress of the survey and land register and on major findings.

Task 3: Compensation strategy and workshop

Sub task	Description and Aim of sub-task
3.1 Internal Compensation Workshop	An internal (client and study team) workshop will be held. All relevant study members will be invited and the broad suite of compensation options that might be feasible will be discussed.
3.2 Generate Compensation Options	This sub-task consists of formalising the compensation ideas into a suite of strategies. Formalisation will be based on ideas generated during the fieldwork and during both the internal workshop as well as during the community workshop.
3.3 Advertise community workshop	Arrangements will be made for a community workshop. In order to ensure that attendance is as good as possible it will be well advertised in the local area, among the directly affected landowners and the sub-region. Relevant government officials from provincial, and possibly national level, will also be invited. The Public Involvement Team will be heavily involved in this aspect as will the RAC.
3.4 Community Workshop	The community workshop will review RAP progress but will also be presented with the compensation strategies generated to date. Input will be requested form the workshop.
3.5 Confirm re-establish RAC	The workshop will be asked to either confirm that they are happy with the RAC established under task 1 or to nominate/elect new members.

Task 4: Resettlement site investigation and assessment of impact on host community

Sub task	Description and Aim of sub-task
4.1 Examine potential relocation site	One of the options that may be identified is that of resettlement into another area for the directly affected landowners. Suitable (or identified) sites will be examined.
4.2 Asses impact on host communities	The plan should address and mitigate resettlement's impact on host populations. Host communities and local government departments should be informed and consulted. Conflicts between hosts and resettlers may develop as increased demands are placed on land, water, forests, services, etc., or if the resettlers are provided services and housing superior to that of the hosts. These issues need to be examined and assessed.

Task 5: Draft resettlement procedures

Sub task	Description and Aim of sub-task
651 Legal opinion	Formal opinion will be obtained as to the legalities of compensation and resettlement issues raised. Although informal opinion will have been scoped throughout the project this task will ask a suitably qualified lawyer to give a formal legal opinion.
5.2 Draft resettlement procedures	This document is effectively the draft RAP. It sets out the when who and what of the resettlement and makes concrete compensation recommendations. It describes the process followed during the study and summarises the major issues generated and worked through.
5.3 Advertise workshop	As with the first workshop and in order to ensure that attendance is as good as possible it will be well advertised in the local area, among the directly affected landowners and the sub-region. Relevant government officials from provincial and possible national level will be invited. The Public Involvement Team will be heavily involved in this aspect as will the RAC.
5.4 Community workshop	The community workshop will review RAP progress and will be presented with the draft resettlement strategies. Input will be requested form the workshop.

Task 6 Review

The reviewer will be required to read and thoroughly critique the draft RAP document. The reviewer may wish to visit the study area and speak to those directly involved or involved with the RAP to ascertain that statements contained in the document reflect the position on the ground. The review consultant may also wish to attend the community workshop.

Task 7: Finalise RAP document

The draft resettlement procedures are translated into a comprehensive Resettlement Plan. The document will have taken heed of input from the review consultant and from the community workshop. The document will be commensurate with World Bank standards and with the relevant legal requirements.

Task 8: Community sign-off

At this point the community take ownership of the finalised document and those scheduled for resettlement/compensation will sign off that they are satisfied with the process and with the compensation due to them.

The RAP will identify key actions that need to be followed for resettlement to be successfully undertaken. These will be programmed in detail but these will almost certainly need to begin as soon as final approval for the project to go ahead has been given.

SECTION 7: SUMMARY & CONCLUSIONS

7. SUMMARY AND CONCLUSIONS

The TWP has a socio-economic impact at a number of levels. At the national level the scheme will assist in assuring a water supply for the Vaal River System. As the industrial heartland of South Africa, and indeed the African continent, securing this supply is of critical economic importance. At a regional level the TWP appears to have the potential to provide a much-needed economic boost for the area. As such the regional attitude towards the project appears to be a very favourable one. Although, as pointed out in the report some uncertainties appear to cloud the national and regional planning horizon e.g. HIV/AIDS and the issue of Land Reform, these need not prove to be critical threats. While the project does appear to have both implicit and explicit national and regional benefits there are some threats, certainly at a regional level.

Firstly the potential of the canal system to disrupt the established agricultural base and the emerging eco-tourism, game-farming initiatives in the Biosphere must be considered. Secondly, the potential impacts of reduced flows downstream of the dam need to be closely monitored in order to ensure that those people who have at least a part of their subsistence livelihood dependant on riparian resources are not adversely affected.

At the local level the negative impacts of the TWP, if not properly mitigated, will be more acutely felt. The most critical of these impacts are those potentially felt by the communities of Mziyonke and Mankandani and the landowners along the proposed canal route. The communities of Mziyonke and Mankandani is particularly vulnerable and the report demonstrates that:

- The land that will be lost to a Jana Dam at the 860m amsl Full Supply Level is important to the people of Mziyonke and Mankandani both for subsistence farming and for cattle grazing. Agricultural activity also provides a social security safety net that allows marginal households to survive. At the 880m amsl Full supply Level the impact is even more marked.
- The land that will be lost provides a base for additional resources that are important for the community and for people of the sub-region. Medicinal plants that will be lost as well as materials for handicrafts are important resources.
- Homesteads will have to be relocated. If the area proves not to be agriculturally or otherwise sustainable, given the amount of land that will be lost, then the entire community may have to be resettled. This could lead to the severe disruption of intricately woven social networks.
- A resettlement action plan that is acceptable to the residents of Mziyonke and Mankandani will have to be generated. This could incorporate plans for resettlement of all of the community or some of it. It would also have to consider options for the development of the remaining resource base in the Mziyonke and Mankandani area and/or in the new resettlement area.

The Resettlement Action Plan (RAP) should form an integral part of the Environmental Management Plan drawn up during detailed design. The RAP is a standard planning and management tool for practically all large projects that need a degree of environmental management. The RAP is generally regarded as critical to projects that require a degree of resettlement. In terms of the TWP the RAP should include the following features:

- Detailed situation report of socio-economic status prior to project implementation. This culminates in a database that includes details for each household impacted upon. This SIA provides the core of this database.
- Organogram of consultative and negotiating structures at local, sub-regional and regional level.
- Detailed description of the magnitude and significance of impacts. This is also done at a household level.
- Detailed design of mitigation strategies and compensation measure. This usually culminates in a suite of options.
- Detailed description of the mitigation measures (by household) that will be undertaken to ensure that the impacts are managed.
- Detailed description of compensation packages available and agreed upon by each impacted household.
- Step by step plan for resettlement and the handing over of compensation. This should detail individual responsibilities for when, what and who, and should be precise.
- Detailed plan for monitoring and evaluating the socio-economic status of impacted households over the duration of the project.
- Detailed plan for the mitigation of negative sub-regional impacts (e.g. containment of spread of social pathologies).
- Detailed plan for the optimisation of potential sub-regional impacts.
- Detailed plan for monitoring and evaluation of sub-regional impacts.
- The RAP needs to start as part of the pre-implementation/detailed design phase.

The freehold farmers on the Right Bank of Jana Dam are not as vulnerable to the impacts as the people of Mziyonke and Mankandani. Nevertheless the possibility that the Emaneni Game Farm will have to be expropriated in its entirety exits. Furthermore, the farmers on remaining farms will expect to be compensated fully and fairly.

In terms of Mielietuin Dam it appears as if little resistance to construction can be expected from the landowners. Most see the Dam (particularly as close to the 1020m level as possible) as a potentially positive development. This view appears to be predicated upon the following:

- Property prices have declined (partially as a result of the uncertainly around the dam but probably more directly as a result of pressures on diary farming and perceptions of crime) and interest in the area, driven by decisions around the dam, might be re-stimulated.
- The move from diary to game means that many farms may actually aesthetically benefit from the presence of the artificial lake. This will particularly come to pass if the dam remains full for much of the time (as might be the case). Under these circumstances property prices might very well increase with developers and speculators entering the market. The presence of the Thukela Biosphere, the Weenen Nature Reserve and the Gongolo Game Farming initiative means that impetus for this kind of enterprise is in place.

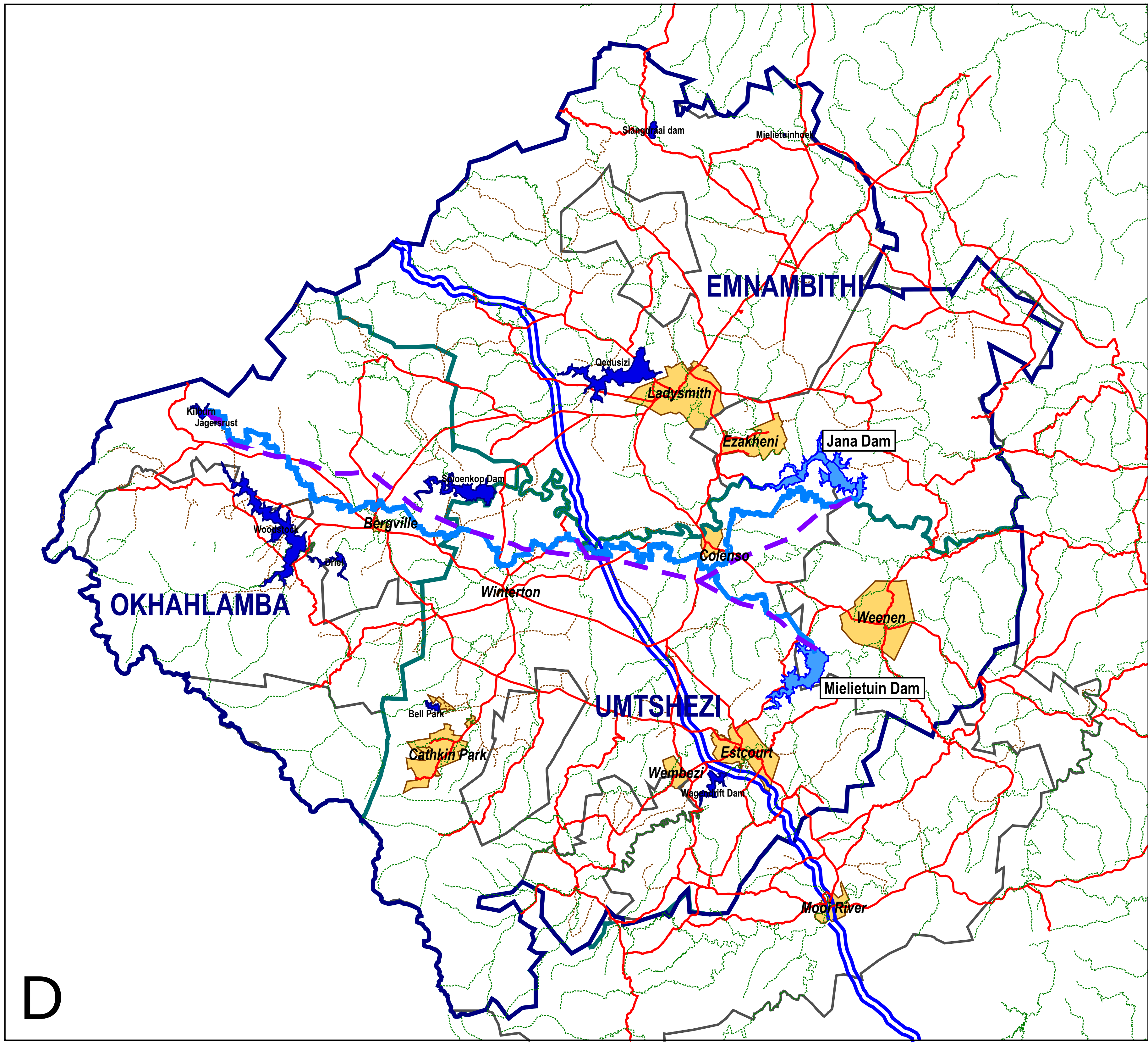
The report indicates that the small number of landowners actually active in the area, the degree of relative good will, and the potential positive impacts of the dam means that the foundations for "win-win" negotiations with stakeholders have been laid.

The aqueduct is however more problematic. Vigorous opposition to the optimised canal route can be expected from a number of quarters. These would be:

- Farmers in the Thukela Biosphere who maintain that the canal route will threaten the viability of their entire enterprise.
- The Department of Land Affairs and the people of Labuschagnes' Kraal (Ekhuthuleni) who consider the canal route to be a threat to their safety.
- Farmers and landowners affected by the canal route who consider it disruptive to farming and a threat to humans and livestock.

In this regard the steel pipeline is considered to be a much better alternative than an open canal, and from a social impact perspective is strongly recommended as the more favoured option. In terms of the steel pipeline the landowners' concerns are largely with impacts associated with the construction period and with the terms of compensation for servitudes registered.

Although no fatal flaws appear to be associated with the TWP, in terms of the socio-economic impacts the impacts of potential resettlement at Mziyonke and Mankandani will almost certainly be difficult to manage, while a canal aqueduct will almost certainly give rise to a great deal of opposition to this section of the project.



Tugela Water Project

Social Impact Scoping Report

Figure 1 : Regional Overview

Legend

- TLCs
- Census District Boundaries 1991
- Sub-Regions
- Uthukela Regional Council
- National Roads
- Provincial Main Roads
- District Roads
- Rivers
- Existing Dams
- Proposed Dams
- Canal Route
- New Pipeline Route

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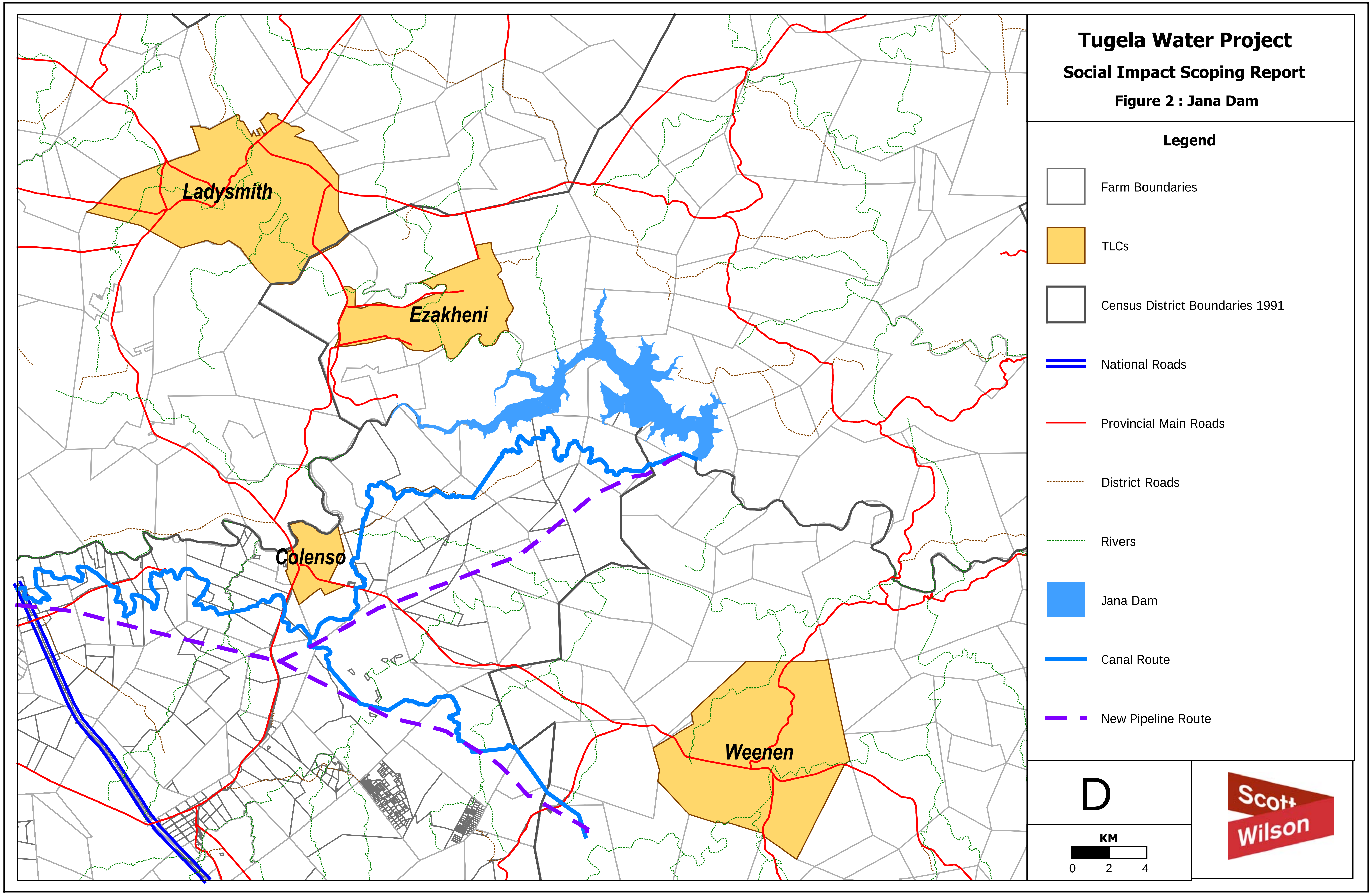
Tugela Water Project
Social Impact Scoping Report
Figure 2 : Jana Dam
Legend
Farm Boundaries
TLCs
Census District Boundaries 1991
National Roads
Provincial Main Roads
District Roads
Rivers
Jana Dam
Canal Route
New Pipeline Route
Ladysmith
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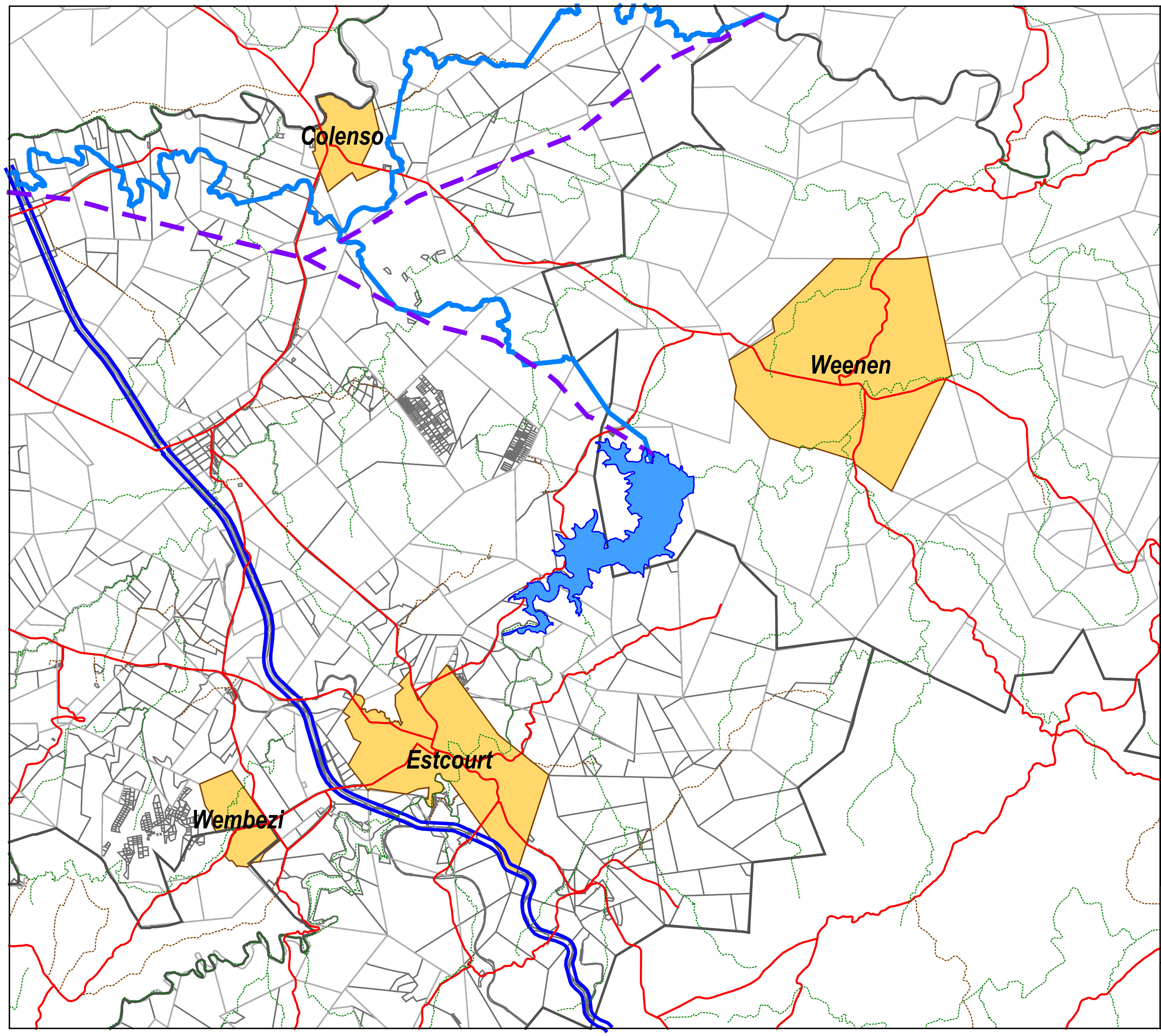

Tugela Water Project

Social Impact Scoping Report

Figure 3 : Mielietuin Dam

Legend

- Farm Boundaries
- TLCs
- Census District Boundaries 1991
- National Roads
- Provincial Main Roads
- District Roads
- Rivers
- Canal Route
- New Pipeline Route
- Mielietuin Dam

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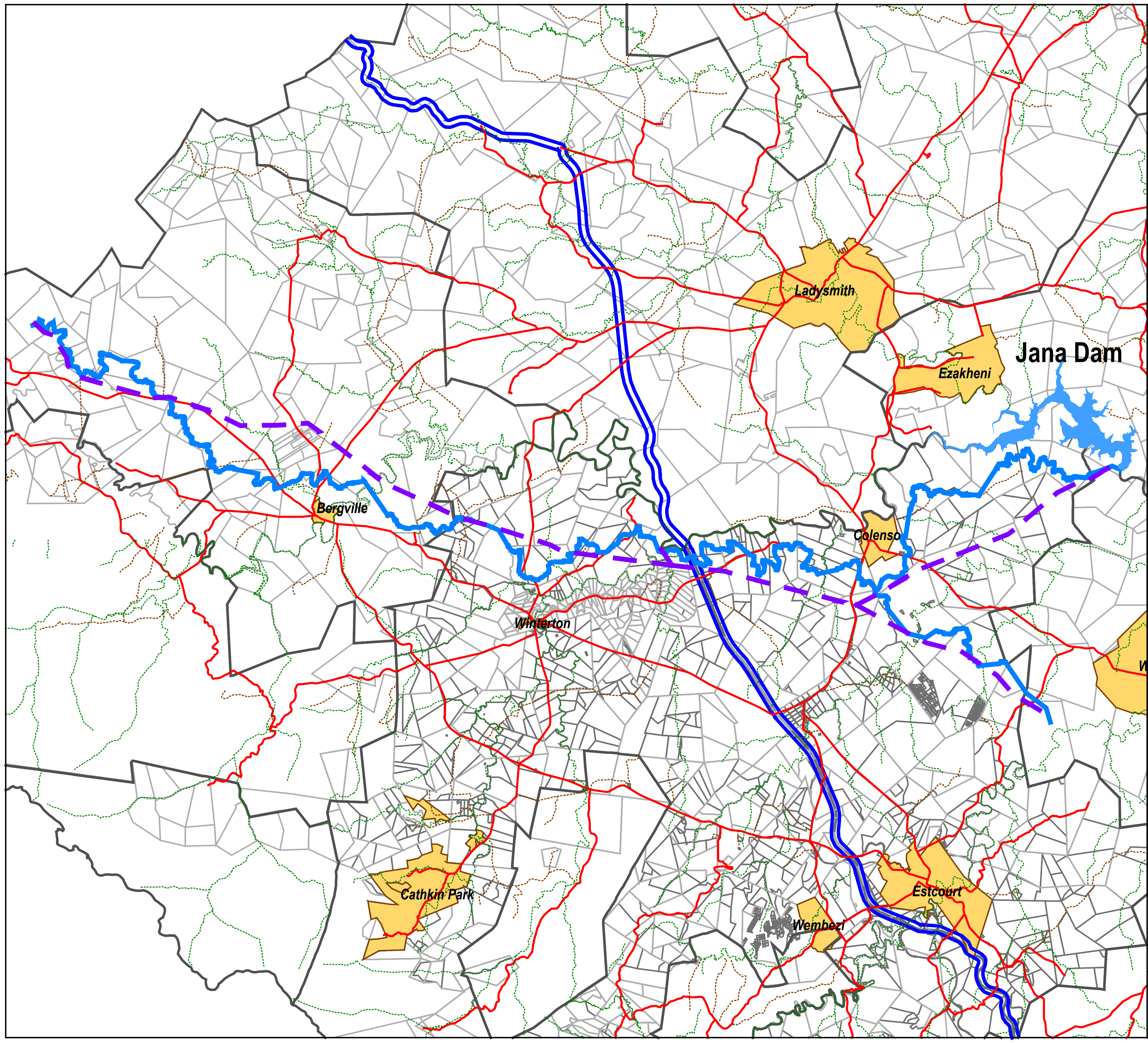

Tugela Water Project

Social Impact Scoping Report

Figure 4 : Conveyance Routes

Legend

Farm Boundaries

TLCs

Census District Boundaries 1991

National Roads

Provincial Main Roads

District Roads

Rivers

Canal Route

New Pipeline Route

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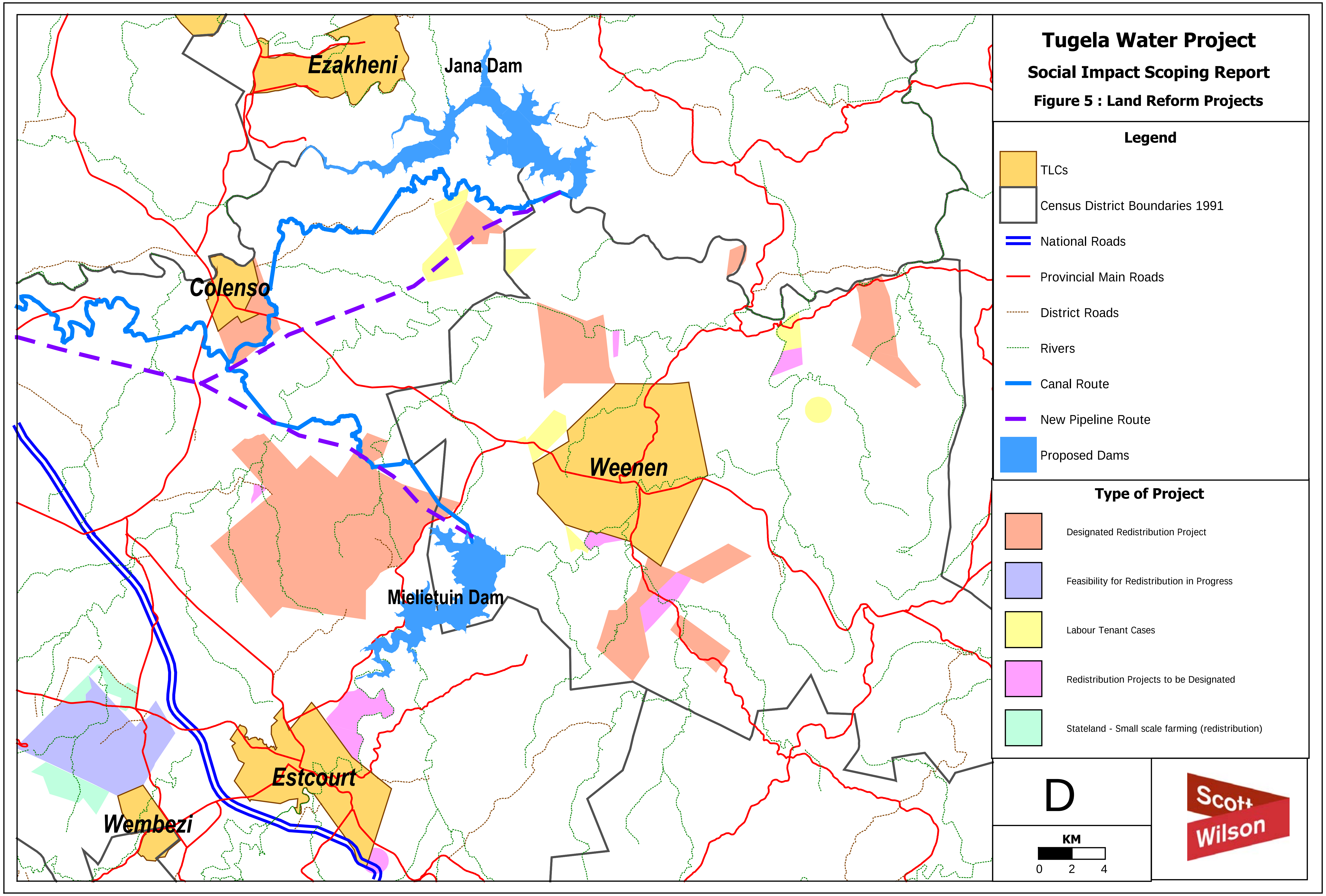
Scott Wilson


Tugela Water Project
Social Impact Scoping Report
Figure 5 : Land Reform Projects
Legend
TLCs
Census District Boundaries 1991
National Roads
Provincial Main Roads
District Roads
Rivers
Canal Route
New Pipeline Route
Proposed Dams
Type of Project
Designated Redistribution Project
Feasibility for Redistribution in Progress
Labour Tenant Cases
Redistribution Projects to be Designated
Stateland - Small scale farming (redistribution)
D
KM
0
2
4
Scott Wilson
Ezakheni
Jana Dam
Colenso
Weenen
Mielietuin Dam
Estcourt
Wembezi

APPENDIX A: List of Stakeholders

Jana Dam Stakeholders Farm Name	Owner
Ramak, Klipberg & Brakfontein	Dr Muller (Vic Albers - manager)
Gannehoek	Jan Dippenaar
Schurf de Poort	Deodat Froneman
Gannehoek	Hugo Bosse
Monte Christo	Tony Mason (Ian Milne - manager)

Mielietuin Dam stakeholders Farm name	Owner
Selbourne	Bruce Mackay
Mielietuin	**1.1 B Schlanders**
Riversdale	Nico Dorfling
Glen Ann	Dr W Erasmus
Oatlands	C Diack
Riversbend	M Oats
Overton (Rensburgspruit)	D Green
Rondedraai	R Seele
Elmwood	Melton Schiever

Optimized Canal route stakeholders From Mielietuin to Aqueduct Junction

Mielietuin	B Schlanders
Weenen Nature Reserve	KZNNCS
Vaalkrantz	N Ralfe
Middleplaats	A Mckensie
Sterkspruit	M Winter
Ndanyana	J Henderson
Umsuluzi River Game Park	Mike Mayer
The Aloes	G Horner
Meadowdale	N R Nkabinde

Jana to Aqueduct Junction

Ramak, Klipberg & Brakfontein	Dr Muller (Vic Albers)
Schurf de Poort	D Froneman
Schurf de Poort Labour tennants	Schurf de Poort Labour tennants
Schurf de Poort	H Bosse
Rietbult	GP Grobler
Monte Christo	A Mason (I Milne)
	Colenso TLC
Labuschagnes Kraal	Ekuthuleni beneficiaries
Meadowdale	N R Nkabinde

Aqueduct Junction to Kilburn

Meadowdale	N R Nkabinde
Navel Hill	Alf Watling
Broadview	AH Furniss
Clouston	D Clouston
Dawn	OT Mabaso
Woodgrove	Dave Wood
Corrylynn	A Khan
Doornspruit	J Mann
Aveleda	Eric Sanders
Riverside	F Vickers
Brumana	MM Labuschagne
Nondilane	A Stockhill
Kopleegte	D Cowley
Kopleegte	ID Warden
Avondrus	CB Schiever
Shelly	J Olivier
Alpine View	Paul Kern

Rustenberg	Boet Jordaan
Glenare	Manfred Hillerman
Vermaaks Kraal	Tiens van Vuren
Poortie	Henry Honiball
Poortie	Ruben Goosen
Rietfontein	Pieter Riddle
Rietfontein	Steve Nel
Eversholt	Boet Jordaan
Sunnybraes	Mrs ME Smuts
Weltevrede	Boet Jordaan
Viclands	Honiball family
Papboom	Tony Braithwaith
Woodlands	Honiball family
Kia Ora	Trevor Wood
Laughing Waters	Hennie van der Merwe
Krommedraai	B Trodd
Hillside	WR Daughtery
Fairview	D Potgieter
Uitsig	D Fick
Al's Auto Repairs (should just miss)	Alan Jung
Devon-Barton	DC Gace
Sandford Park Lodge	P Scott
Needwood	JJ Joubert
Shamrock Langham	J Jackson
Lytton	J Nel
Woodford	Woodford Land Owners - A Mntungwa
Killarney	J Coventry
Valencia	L Vickers
Hartebeesfontein	G de Bruyn
Zanddrift	Mrs F de Jager
Loskop	JP Badenhorst
Cameeldraai	P van Reenen
Bergspruit	Greyling family
Bethel	Mr JJ de Jager
Gransmoor	JJ van Reenen
Scralhoek	JJ van Reenen
Jagersrust - Natal Heim	JP Badenhorst
Jagersrust Dairy - Langkloof	H Grabie

Steel Pipeline Route Jana Dam to Aqueduct Junction Farm	Updated - 29 April 1999 Owner
Ramak, Klipberg & Brakfontein	Dr Muller (Vic Albers)
Gannehoek Land Reform	Gannehoek Trust
Hugo Boss' Labour Tennant	Hugo Bosse
Vaalkrantz (Stoney Ridge)	John Rich
Moordkraal	R Tratschler
Vaalkrantz	Chris Hatting (should miss)
Moordkraal	Waldo Bosse
Umzulusi River Game Park	Mike Mayer
Labuschgnes Kraal (should just miss)	Labusschgnes Kraal
The Aloes	GP Horner
Mielietuin Dam to Aqueduct Junction	
Mielietuin	B Schlanders
Thembalihe Land	Deptment of Land Affairs
Vaal krantz	N Ralfe
Thembalihe Land	Deptment of Land Affairs
Ndanyana	Joe Henderson
Umzulusi River Game Park	Mike Mayer
The Aloes	GP Horner
Aqueduct Junction to Kilburn	
The Aloes	GP Horner
Haasfontein (a portion of it)	Barry Thompson
Corrylynn	Azam Khan
Woodgrove (may miss)	Dave Wood
Doornspruit	J Mann
Nondilane	Arthur Stockhill
Kopleegte	IE Warden
Avondrus	Craig Schiever
Longridge	John Brooke-leggatt
Swinburne	Dirk Herholt
Alpine View (may just miss)	Paul Kern
Rustenberg	Boet Jordaan
Glenare	Manfred Hillerman
Vermaaks Kraal	Tiens van Vuren
Poortie	Henry Honiball
Mount Alice	Gary Green
Rietfontein	Steve Nel
Eversholt	Boet Jordaan
Weltevrede	Boet Jordaan

Sunnybraes	Mrs ME Smuts
Schoongezicht	Honiball Family
Papboom	Tony Braithwaith
Tregenna	J Fyvie
Zuurlager	J Fyvie
Woodlands (may just hit)	Honiball Family
Kia Ora	Trevor Wood
Laughing Waters	Hennie van de Merwe
Krommedraai	B Trodd
Hunters Rest	B Trodd
Valencia	D Fick
Nineveh	Mrs F de Jager
Roode bult	G Dicks
Horton	Mrs F de Jager
Horton	C J Steyn
Horton Radford (Buffels Hoek)	C J Steyn
Zanddrift	Mrs F de Jager
Loskop 21 83	JH Greyling
Loskop 21 83	JP Badenhorst
Cameeldraai	P van Reenen
Gransmoor	JJ van Reenen
Scraalhoek	JJ van Reenen
Jagersrust - Natal Heim	JP Badenhorst
Jagersrust – Langkloof	Mr Grabe

Appendix B: Impact Matrix

SUMMARY OF NEGATIVE SOCIAL IMPACTS

Issues	Type of Impact	Description of Impact	Cause	Management & Mitigation Measures	Implications of Measures
(A) Loss of agricultural resources to support income earning and subsistence activities.	Negative	(A1) Loss of cultivated and land.	Flooding of crop fields and arable land by the dam. Loss of cultivated land to aqueduct Stripping of arable land by extractive activities related to borrow pits and quarries.	(A1a) Introduce development projects to utilise remaining arable land more productively, e.g. irrigation. Purchase of freehold land	Will enhance productivity of arable land and improve income-earning opportunities through sale of surplus produce.
				(A1b) Identify development projects to encourage alternative income-earning opportunities., e.g. entrepreneurial development.	Could replace the reliance upon agriculture-based subsistence and income-earning activities.
		(A2) Loss of grazing land.	Flooding of communal grazing land by the dam. Stripping of grazing land by extractive activities related to borrow pits and quarries.	(A2a) Introduce development projects to add value to remaining land e.g. feed lots and pasturage.	Will enhance the productivity of animal husbandry activities.
		(A3) Loss of fuel wood and medicinal resources.	Flooding of wood land by the dam. Stripping of wooded areas by extractive activities related to borrow pits and quarries.	(A3a) Identify development programmes to replace lost wood land resources, e.g. wood lots.	Could retain a sustainable supply of woodland resources, and create possible income-earning opportunities.

(CONT) : SUMMARY OF NEGATIVE SOCIAL IMPACTS

Issues	Type of Impact	1.2 Description of Impact	Cause	Management & Mitigation Measures	Implications of Measures
(B) Impede local movement of people and vehicles.	Negative	(B1) The dam will inhibit movement of people on foot between the northern and southern sides of the river. The aqueduct route (canal) will do the same	River crossing will be submerged by rising water levels. Canal will cut farming units into parts	(B1a) Construct roadway on the dam wall to link both sides of the dam. Build bridges across canals	Will retain pedestrian link between both sides of the river, and improve vehicular links. Will restore linkages across farms
				(B1b) Identify development programmes to retain linkages between both sides of the dam, e.g. ferry system.	Will enable pedestrian link between both sides of the river.
(C) Loss of housing	Negative	(C1 Households will be affected by the dam and need to be relocated.	Flooding of houses by the rising water level.	(C1a) Employ appropriate compensation measures, e.g. relocate households to land nearby and replace lost structures .	Should more than adequately compensate affected households. In many cases will improve the quality of household structures.
		(C2) Additional homesteads could be affected by the need for extracting quarry material and borrow pits.	Extractive activities related to borrow pits and quarries.	(C2a) Employ appropriate compensation measures, e.g. relocate households to land nearby and replace lost structures .	Should more than adequately compensate affected households. In many cases will improve the quality of household structures.

(CONT) : SUMMARY OF NEGATIVE SOCIAL IMPACTS

Issues	Type of Impact	Description of Impact	Cause	Management & Mitigation Measures	Implications of Measures
(D) Loss of social facilities and important cultural sites.	Negative	(D1Schools will be submerged.	Flooded by rising water level.	(D1a) Replace the school by relocating to higher ground.	Should not affect people's access to educational services.
		(D2) Grave sites will be submerged.	Flooded by rising water level.	(D2a) Employ appropriate compensation measures, e.g. relocation of graves and sacrifices to appease spirits.	Should not have negative repercussions as long as measures are sensitive to the needs of affected households.
		(D3) Small shop near the Jana clinic will be submerged.	Flooded by rising water level.	(D3a) Employ appropriate compensation measures, e.g. replace and relocate shop to higher ground.	Should not adversely affect people's access to shopping.
(E) Loss of community and disruption of community integration	Negative	(E1) Resettlement of people from Mziyonke will result in social dislocation and disruption of survival networks	Resettlement caused by loss of resources to Jana Dam	(E1) Well conceptualised Resettlement Action Plan	Vulnerable social categories not always easy to accommodate within resettlement plans. Calls for well structured monitoring programme.
(F) Safety of human and animal life.	Negative	(F1) Risk of drowning in dam.	Proximity of a deep water body.	(F1a) Public awareness programme of the potential dangers associated with the dam.	Should greatly reduce the possibility of human and livestock drowning.

SUMMARY OF POSITIVE SOCIAL IMPACTS

Issues	Type of Impact	Description of Impact	Cause	Management and Optimisation Measures	Implications of Measures
(A) Provision of basic needs.	Positive	(A1) Enhance access to a secured water supply for local domestic and agricultural consumption.	Proximity of dam will reduce cost.	(A1a) Employ measures to reduce water collection burdens, e.g. rural water reticulation, and irrigation schemes.	Could improve the quality of life and health of local people. Could also increase agricultural productivity and income-earning activities.
		(A2) Enhance access to improved physical and social infrastructure.	Upgrading of infrastructure to support dam construction.	(A2a) Upgrading of existing public roads and construction new roads would improve access into and out of the valley.	For duration of construction, public traffic will share roads with construction vehicles.
				(A2b) Installation of bulk electrification for the dam construction subsidises possible reticulation to local community facilities and households.	Reticulation to households will depend upon affordability.
				(A2c) Re-use buildings and structures built for the dam construction for social and community activities.	
(B) Local economic development opportunities	Positive	(B1) Employment	Construction of dam and infrastructure.	(B1a) Utilise local labour to meet labour needs of the dam construction.	Generate employment and income-earning opportunities for local people.
				(B1b) Utilise local contractors, as far as practically possible, to meet needs of the dam construction.	
		(B2) Training	Construction of dam and infrastructure.	(B2a) Employ public works programmes which incorporate skills development opportunities.	
		(B3) Stimulate local markets for goods and services.	Injection of income into the local economy.	(B3a) Employment opportunities will inject income into the local economy, and stimulate markets for goods and services.	

Issues	Type of Impact	Description of Impact	Cause	Management and Optimisation Measures	Implications of Measures
(C) Public safety	Positive	(C1) Control and attenuation of flooding conditions.	Regulation of water released from the dam.	(C1a) Presence of dam can delay and control the effects of flash floods which would greatly reduce damage to property and loss of life.	
		(C2) Improved river crossing.	Construction of bridge along dam wall.	(C2a) The nearest vehicular river crossing linking the north and south sides of the river is downstream of the proposed dam.	

APPENDIX C: Estimated Compensation Cost

The following cost estimates have been made at a feasibility level to assist in the overall financial economic viability of the TWP. They are rough guidelines and in no way bind the implementing agent/developer to pay compensation at these rates. Negotiations with regard to compensation will take place during further phases of the TWP, should the project go ahead, and will be conducted within the ambit of specially formed committees, who will be tasked to deal with these matters.

Estimated Compensation Costs

Item	Units	Estimated Cost per unit	Total
Jana Dam 860 masl 870 masl buy out			
Expropriation of Emaneni Game Farm	1	R 5,000,000.00	R 5,000,000.00
Expropriation in Freehold Area	ha		
Expropriation of irrigable land	5	R 11,000.00	R 55,000.00
Expropriation of dryland arable land	60	R 2,000.00	R 120,000.00
Expropriation of dryland pasture	380	R 1,200.00	R 456,000.00
Expropriation of veld and vlei	700	R 1,000.00	R 700,000.00
Expropriation of plantation	15	R 10,000.00	R 150,000.00
Expropriation of vegetable lands	5	R 5,000.00	R 25,000.00
Compensation for housing on freehold farming	1	R 250,000.00	R 250,000.00
Labourers housing on Freehold Farming	5	R 100,000.00	R 500,000.00
Compensation in Tribal Area			
Replacement of Housing	57	R 125,000.00	R 7,125,000.00
Compensation for Graves	85	R 3,000.00	R 255,000.00
Compensation for School Buildings	1	R 250,000.00	R 250,000.00
Compensation for Churches	1	R 200,000.00	R 200,000.00
Compensation for Store, Dip Tank, Etc,	1	R 500,000.00	R 500,000.00
Acquisition of replacement land and development of land	1	R 6,000,000.00	R 6,000,000.00
Rural Development Programme for remaining community	1	R 7,500,000.00	R 7,500,000.00
Total Compensation			**R 29,086,000.00**

Mielietuin Dam 1025 masl 1035 masl buy out			
Expropriation of Entire Farms	2	2,500,000.00	5,000,000.00
	Ha		
Expropriation of irrigable land	160	11,000.00	1,760,000.00
Expropriation of dryland arable land	120	4,000.00	480,000.00
Expropriation of dryland pasture	970	1,200.00	1,164,000.00
Expropriation of veld and vlei	300	1,000.00	300,000.00
Expropriation of plantation	1	10,000.00	10,000.00
Expropriation of vegetable lands	5.	5,000.00	25,000.00
Replacement of Infrastructure		1,000,000.00	1,000,000.00
Total Compensation			**9,739,000.00**

AQUEDUCT

Canal Based Route

		Units	Estimated Cost per unit	Total
Expropriation of entire farms		41	R 1,000,000.00	R 41,000,000.00
Expropriation of arable lands[22]	km	24	R 12,000.00	R 288,000.00
Expropriation of grazing land	km	20	R 3,600.00	R 72,000.00
Replacement Bridges		27	R 200,000.00	R 5,400,000.00
Replacement of farm and residential infrastructure		8	R 300,000.00	R 2,400,000.00
Fencing included in construction costs				
Total Compensation				**R 49,160,000.00**

Pipeline based route

		Units	Estimated Cost per unit	Total
Registration of servitude (arable land)	km	35	R 6,000.00	R 210,000.00
Registration of servitude (grazing land)	km	87	R 1,800.00	R 156,600.00
Replacement of farm and residential infrastructure		7	R 300,000.00	R 2,100,000.00
Total Compensation				**R 2,466,600.00**

[22] Assumes expropriation of canal land and servitude area of 30m.

PBV000-00-7599

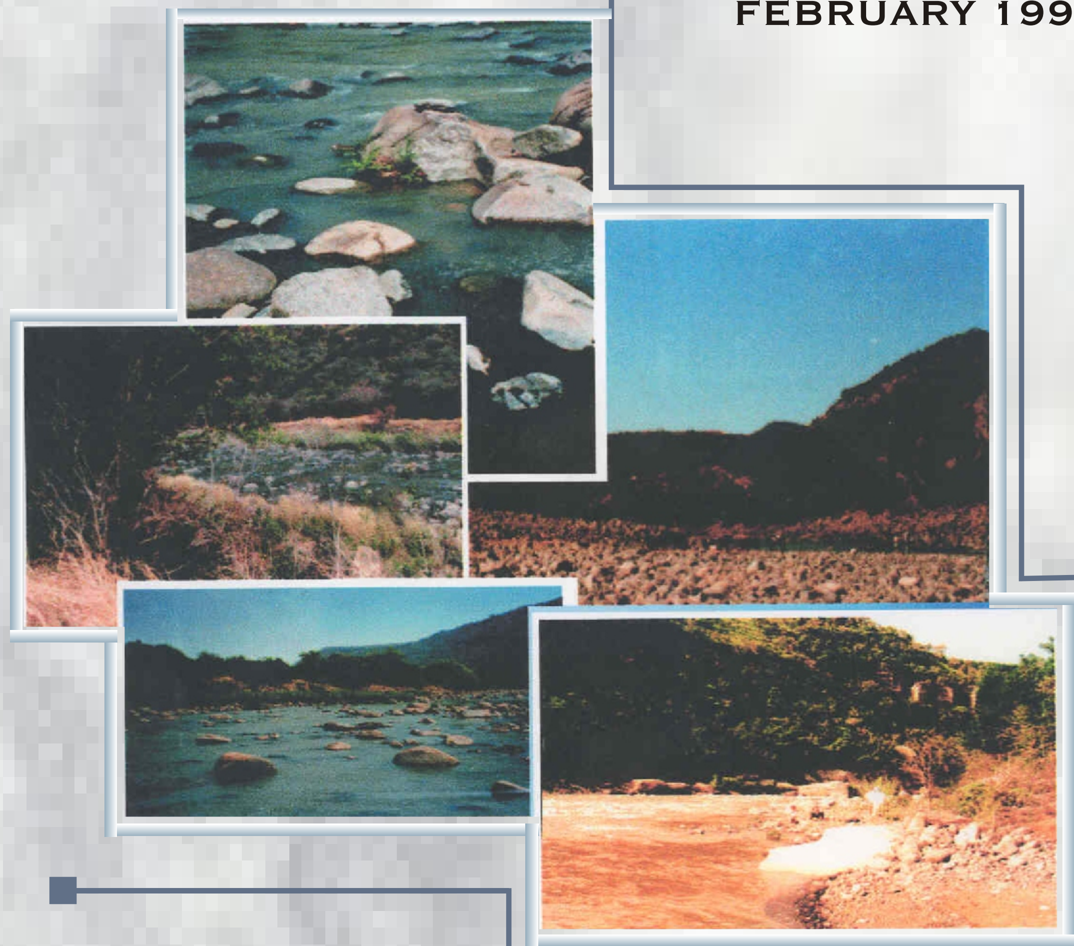
Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

INSTREAM FLOW REQUIREMENTS:

SPIOENKOP DAM

FEBRUARY 1999



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EXECUTIVE SUMMARY

1. Background

An initial assessment of the Instream Flow Requirements (IFR) of the Thukela River was carried out in 1995 during the pre-feasibility Study of the Thukela Vaal Transfer Scheme (TVTS). This study is now in the Feasibility Phase and is called the Thukela Water Project. The further phases and refinement of the IFR study have continued during the Feasibility Phase and the following tasks have been undertaken during 1998.

• ***High flow calibration***
During the 1997 IFR Refinement Specialist meeting, a flood was experienced at both IFR site 2 and 3B. During the flood the water levels in the rivers were measured from the bridges, which were subsequently (September 1998) surveyed so that the flow rates would be calculated. Water levels were also recorded at the IFR sites. These new stage-discharge points were added to the existing hydraulic rating curve to add confidence to the determination of high flow IFRs.

• ***Extension of study area : IFR A (Skietdrift)***
The study area for the 1997 Refinement IFR was extended upstream to include the Thukela River downstream of Spioenkop Dam. An IFR site (Fig 1.1) was selected on this stretch of river in order to assist in evaluating the possible impact of future water demand growth in the Ladysmith area on the TWP and to incorporate this IFR flow data in the overall system analysis.

• ***IFR input into system analysis***
The IFR results for the Thukela River downstream of IFR A (Skietdrift) to and including IFR site 5 (Thukela Ferry) need to be included in the system analysis to determine the effect on the yield of the system. During a scenario meeting the results of the system analysis were presented to the IFR specialists. This includes a range of different scenarios, which might hold significant advantages or disadvantages to the yield of the system. The advantages and disadvantages from an ecological viewpoint were determined.

This report presents the results of the
– the extension of the IFR study area; and
– the input into the yield study.

This report presents the results of the
– the extensions of the IFR study area; and
– the input into the yield study.

Methodology
Approximate 20 IFR studies have been undertaken in South Africa using the Building Block Methodology (BBM), since 1991.

In the methodology the following assumptions are made.

C The biota associated with a river can cope with those low-flow conditions that naturally occur in it often, and may be reliant on higher-flow conditions that naturally occur in at it at certain times. This assumption reflects the thinking that the flows that are a normal characteristic of a specific river, no matter how extreme, variable or unpredictable they may be, are ones to which the riverine species characteristic of that river are adapted and on which they may be reliant. On the other hand, flows that are not characteristic of that river will constitute an atypical disturbance to the riverine ecosystem and could fundamentally change its character.

- Identification of what are felt to be the most important components of the natural flow regime and their incorporation as part of the modified flow regime will facilitate maintenance of the natural biota and natural functioning of the river
- Certain kinds of flow influence channel geomorphology more than others. Identifications of such flows and their incorporation into the modified flow regime will aid maintenance of the natural channel structure and diversity of physical biotopes. (King & Louw)

The flows incorporated into the modified flow regime will constitute the IFR for the river. The IFR describes, in space and time, the minimum amount of water that it is felt will facilitate maintenance of the river at some pre-defined desired state.

As a BBM study has been undertaken for the Thukela River downstream of the Little Thukela Confluence, the extension of the study area by 35 km did not warrant all the required BBM investigations as the additional IFR results could be checked against the existing IFR results. Only the required BBM steps to warrant reasonable confident answers were undertaken.

Environmental Management Class

Chapter 2 of the National Water Act provides, in Parts 1 and 2 respectively for the establishment and application of a system by which water resources will be classified. These provisions, read together with section 6.3.3 of the National Water Policy, make it quite clear that resource classification is designed to afford the degree of protection necessary to prevent unacceptable damage to water resource (that is, to maintain it in a healthy state) or, in cases where a resource is already unacceptably degraded, to restore it to a healthy state.

The process of determining an appropriate level of protection - the management class - comprises a number of steps. The ***present status*** of the resource is assessed by considering the degree of change from the ***reference conditions***, which describe the probable condition of the resource before it was impacted by human activity. The present status, together with an assessment of the ecological and social/cultural ***importance*** of the resource, enables the ***ecological management class*** to be determined. The ***resource quality objectives***, of which the IFR is one, define and quantify the specific characteristics of the resource which are necessary to achieve the management class.

The process as it is currently defined *[by the ongoing work of the PAPITT]* and as it is has been applied to the Thukela River, is as follows:

- A ***present state*** class (PSC) must be allocated to the river reach for which a management class is required. The present state is described by allocating a class (see Table 2.1) to the river reach. The present state is described in six classes with A being near pristine and F irreversibly changed.). These classes are based on the Habitat Integrity system (Kleynhans). The PSC is described for each component which are used to set the IFRs.
- The ***river importance*** (social/cultural and ecological) is then established and considered when determining the protection class. The ecological importance is determined by utilising the Ecological Importance Model (Kleynhans) and the social/cultural Decision Support System (O'Keeffe).
- After a process of consultation, a protection class, i.e the ***EMC*** is allocated to the river reach. The protection class is described in classes ranging from A (near pristine) to D (largely modified) (see Table 2.2). Unlike the PSC, the EMC range does not extend to E and F. Rivers which are currently in classes E and F are not considered to represent sustainable systems, and must therefore be protected and managed for improvement. A high protection class relates to a flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low protection class will ensure marginal maintenance of sustainability and a high risk of ecosystem failure. The EMC is provided for each

component, with specific reference to the differences between instream and riparian components. These EMCs are then further defined into ***Resource Quality Objectives*** which defines the specific objectives requires to achieve the EMC.

The Present State, Importance and realistic EMC are described in the following table.

River reach	PSC		Importance		EMC	
	Instream	Riparian	Ecological	Social	Instream	Riparian
Spioenkop Dam to the Klein Thukela confluence	C/B	C	High	Moderate	B	C

IFR results

The results of the IFR site A, Skietdrift, (the site presenting this reach of river) are summarised as follows:

	IFR A	
	X 10^6 m^3	% OF MAR
MAINT LOW FLOWS	166	18.2
MAINT HIGH	86	9.5
TOTAL	***252***	***27.7***
DROUGHT LOW	64	7.1
DROUGHT HIGH	17	2.7
TOTAL	***81***	***9.8***

Confidence in IFR results
The confidence in the IFR results was motivated by each specialist and the combined results indicated that the confidence in the results was in the *medium - high* range.

3. Scenario modelling

The IFR results for IFR A, 2, 5, 3a & 3b were modelled using the Water Resources Yield Model (WRYM). The water available after supplying the IFRs served as the available yield for the users. The IFRs had a significant effect on the available yield.

IFR scenarios were then formulated and these were evaluated from an ecological viewpoint and the possible impacts on the river of these scenarios described.

The scenarios were the following:

Scenario 1 : Extended Drought
Maintenance flows and the assurances of maintenance flows stayed the same in this scenario. However, the occurrence of drought flows increased by 50%. Therefore, if the drought flows at IFR A occurred 7% of the time (as was determined by the IFR model), it will now occur at 14% of the time.

This scenario would result in a lowering of the EMC class of the river.

Scenario 2 : 10% reduction of all flows
All flows were reduced by 10%. The impacts were evaluated by converting the recommended flows (IFR) to depths and the other relevant hydraulic parameters. The decrease in habitat were then evaluated.

This scenario would result in a lowering of the EMC class by half in the longterm.

Scenario 3 : Dry season decrease of assurance
The scenario consists of
- the summer flows (December to March) to be maintained at the assurance set during the IFR determination
- winter flows with a decreased assurance compared to the assurance set during the IFR determination. The month of Aug therefore were specified to have an assurance of 60 % and will not have an assurance of 30 %. The other months will proportionately decrease
- High flows stay the same.

The impact on the riverine ecosystem if of the resolution that is difficult to quantify. No short term change in EMC is expected.

Ranking of scenarios
The scenarios in the order of least to most damage to the riverine ecosystem are as follows:

- Scenario 3
- Scenario 2
- Scenario 1

It must be noted that Scenario 3 is by far the least deleterious of the three scenarios.

TABLE OF CONTENTS

APPENDIXES

LIST OF FIGURES & TABLES

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CHAPTER 1 : INTRODUCTION & BACKGROUND

An initial assessment of the Instream Flow Requirements (IFR) of the Thukela River took place during the Pre-feasibility Study of the Thukela Vaal Transfer Scheme (TVTS). This study is now in the Feasibility Phase called the Thukela Water Project. The further phases and refinement of the IFR study has continued during the feasibility phase and the detail of work undertaken during the phases are provided below:

PRE-FEASIBILITY STUDY : 1995 IFR

As part of the Pre-feasibility study during 1995, an IFR study for the Tugela River and the Northern and Southern Tributaries based on 8 IFR sites was undertaken. The results of the workshop were analysed and the following actions were specified for the Feasibility phase of the study:

- Cross-sectional re-surveys of all sites.
- Repeat of hydraulic calculations.
- Additional IFR sites in the tributaries.
- Relocate IFR site 2.
- Model IFRs to determine available yield.
- Design a monitoring protocol

FEASIBILITY STUDY : 1997 IFR REFINEMENT

Although the formal Feasibility Study was initiated only in 1997, the IFR refinement study started during June 1996 so as to ensure that the low flow season form part of the study period. This IFR refinement study focussed on

S the main Thukela River downstream of Upper Jana Dam; and

S the Bushmens River downstream of Mielietuin Dam (i.e. the Southern Tributaries).

The Northern Tributaries will be investigated as a next phase. (Fig 1.1)

The IFR actions that were undertaken during the Refinement study for the Southern Tributaries were the following:

- Resurvey of sites on the Thukela and Bushmens River.
- Selection of an additional site on the Bushmens River.
- Cross-sectional surveys of the above sites.
- Hydraulic calculations with four calibrations.
- Riparian vegetation and fluvial geomorphological investigations.
- Photo-point monitoring of all the sites at known flows.
- Hydrological analysis.
- Modelling of the IFR results with the IFR release model to determine the transition between maintenance and drought flows.

FEASIBILITY PHASE : IFR REFINEMENT - 1998

During this period, the following IFR tasks have been undertaken:

- ***High flow calibration***

During the 1997 IFR Refinement Specialist meeting, a flood occurred at both IFR 2 and 3B. During the flood the water levels in the rivers were measured from the bridges, which were subsequently (September 1998) surveyed so that the flow rates would be calculated. Water levels were also recorded at the IFR sites. These new stage-discharge points were added to the existing hydraulic rating curve to add confidence to the determination of high flow IFRs (Appendix A)

- ***Extension of study area : IFR A (Skietdrift)***

The study area for the 1997 Refinement IFR has been extended upstream to include the Thukela River downstream of Spioenkop Dam. An additional IFR site (Fig 1.1) was selected on this stretch of river in order to assist in evaluating the possible impact of future water demand growth in the Ladysmith area on the TWP and to incorporate this IFR flow data in the overall system analysis.

A less detailed methodology was adopted in this determination since existing medium to high confidence IFR results are available for the downstream area which may be used for matching. The methodology to be followed will be consistent with the method proposed for the Preliminary Ecological Reserve (Quantity). (See chapter 2)

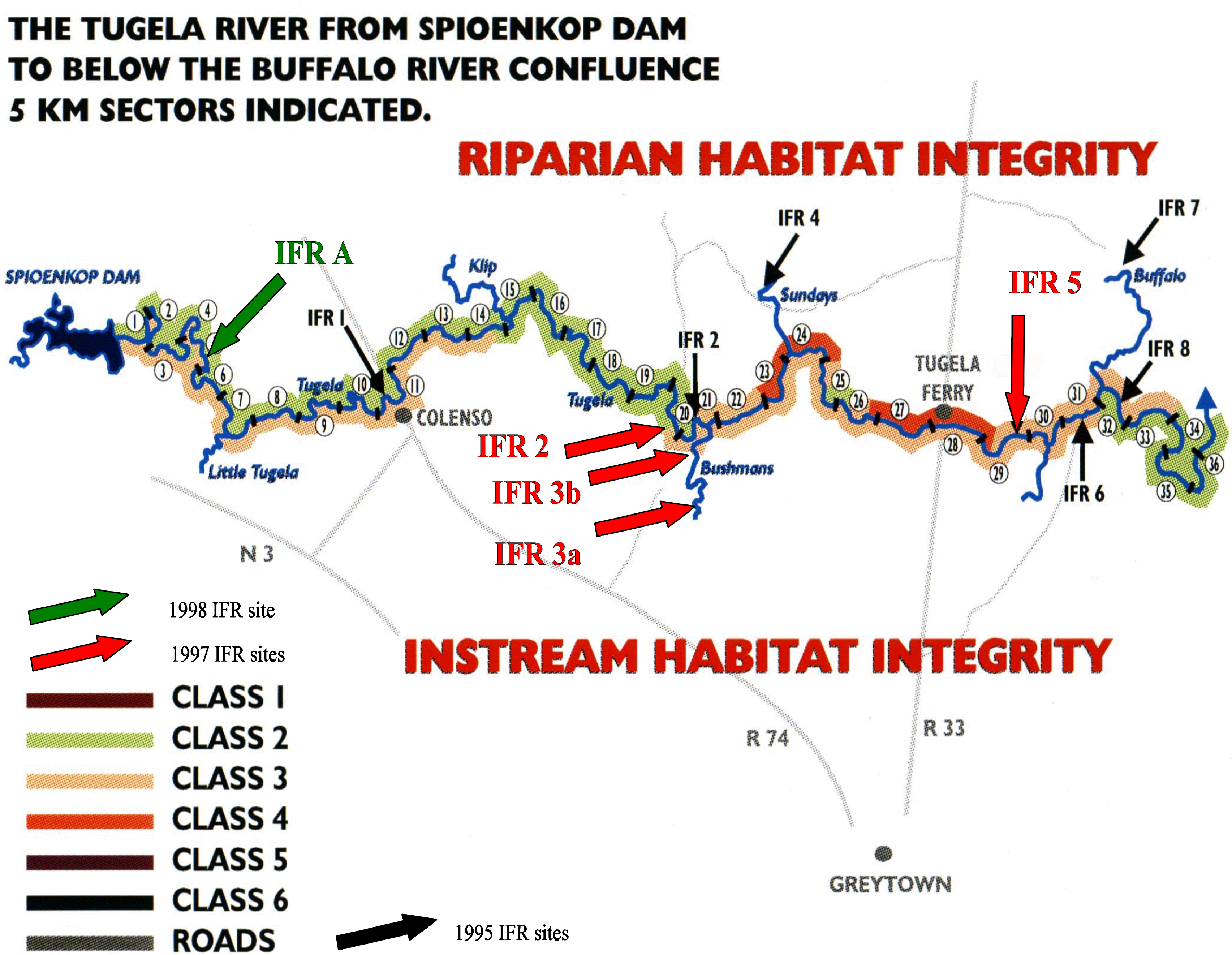
- ***IFR input into system analysis***

The IFR results for the Thukela River downstream of IFR A (Skietdrift) to and including IFR site 5 (Thukela Ferry) need to be included in the system analysis to determine the effect on the yield of the system. During a scenario meeting the results of the system analysis were presented to the IFR specialists. This includes a range of different scenarios, which might hold significant advantages or disadvantages to the yield of the system. The advantages and disadvantages from an ecological viewpoint were determined.

This report presents the results of the

! the extension of the IFR study area; and
! the input into the yield study.

Figure 1.1 : Map illustrating all IFR sites, Habitat Integrity and 5 km segments



CHAPTER 2 : ECOLOGICAL RESERVE and IFR

2.1 THE RESERVE

The supreme law of the Republic is the Constitution of the Republic of South Africa (Act No. 108 of 1996). This includes the Bill of Rights, which is human-centred. The two rights most directly relevant to water are:

- Section 27: the right of access to sufficient food and water; and
- Section 24: the right to an environment not harmful to health and well being, and to have the environment protected for the benefit of present and future generations.

The White Paper on a National Water Policy for South Africa was approved by Cabinet in April 1997, and incorporates the constitutional requirements described above, as "the Reserve".

"The Reserve" has subsequently been codified as a legal requirement in the National Water Act (No 36 of 1998) which was signed into law by the President on 20th August 1998.

The fundamental principles of the National Water Act can be described as follows:
National Government, as Public Trustee of the nation's water resources, is to ensure that water is *protected, used, developed, conserved, managed and controlled* in a sustainable and equitable manner for the benefit of all persons.

- Equity of access: to water services; to the use of water; and to the benefits of water use.
- Sustainable use of water: through measures to protect water resources so as to ensure their indefinite availability for human use.
- Optimal use of water: to foster wise and efficient use of water by, among other things, conservation measures and an economic pricing system.

The basic premise is that water resources must be protected if they are to be used sustainable.

The priorities in the use of water are the following:

- The Reserve, i.e. basic human needs and ecosystem protection. These are the only two rights to water, and the Reserve may not be allocated to other users.
- International obligations
- All other uses require authorisations

It is therefore necessary to quantify the Reserve before allocating water to other new users. In some areas it is possible that allocations of water to existing users may need to be adjusted to meet the requirements of the Reserve.

Definition of the Reserve:
[s(1)(xviii)]:
(xviii) "Reserve" means that quantity and quality of water required-

(a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act (Act. No. 108 of 1997), for people who are now or who will, in the reasonably near future, be-
  (i) relying upon,
  (ii) taking water from; or

(iii) being supplied from,

the relevant water resource; and

(b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource.

Resource Protection

The intention of the new law is to protect all water resources which, from the definitions in S. 1, include rivers, springs, natural channels, wetlands, lakes, dams, surface water, estuaries, aquifers or other underground water and includes the bed and banks where relevant. The aim is to protect all components of the whole ecosystem, i.e. water, biota, riparian zones and sediments.

Chapter 3 of the National Water Act - Protection of Water Resources - describes how resource protection will be achieved by:

- the establishment of a system for classifying water resources (resource classification);
- the determination of:
  * the class of significant water resources
  * resource quality objectives (water quantity, water quality, habitat and biotic integrity)
  * the Reserve.

Resource classification is required because human use causes damage to ecosystems. However, ecosystems are resilient and can tolerate use before they cease to function. The issue is how much use they can tolerate. The class of a resource is an expression of the extent of use which should be permitted, and the level of risk of damage or deterioration to which it should be exposed, to retain its capacity for sustainable utilisation. This is illustrated by the following:

High class	-	low risk of damage	-	low use
Low class	-	high risk of damage	-	high use

The Reserve reflects the level of risk.

In summary the Reserve is about resource protection for sustainable use. The Reserve is not about conservation for conservation's sake, nor does it mean that all resources must be pristine.

This study is specifically aimed at determining the Ecological Reserve (Quantity) only, i.e. not the Ecological Reserve (Quality) and not the Basic Human Needs Reserve.

2.2 THE LINK BETWEEN THE ECOLOGICAL RESERVE (QUANTITY) AND IFR

In the relatively brief history of the determination of the Instream Flow Requirements (IFR) of South African rivers, the most commonly used method has been the Building Block Methodology (BBM). To date the BBM has been applied to more than 20 rivers countrywide, and it was the demonstrable fact that such a scientifically-based methodology existed, and was being successfully used to make estimates of instream flow requirements, that was a key factor in the inclusion, in the Water Law Principles, the National Water Policy for South Africa and the National Water Act, of the requirement for a statutory allocation of water to the resource itself so as to maintain ecological functioning.

Although the BBM has come to be regarded by some as a comprehensive assessment of IFR, it is important to remember that it has hitherto been used almost exclusively in respect of proposed water - related developments - usually dams - by the Department of Water Affairs and Forestry (DWAF). In this context the BBM has developed as a relatively coarse assessment of IFR, its application usually being constrained by time and budgetary limitations, so that great reliance had to be placed on existing available information and general river-related knowledge and expertise, supplemented by minimal additional field data. There are other, more detailed ways to assess IFR, which necessitate an extensive time period to apply, but under certain circumstances might be required.

The ecological maintenance flows of the river - IFR - forms part of the Ecological Reserve of the National Water Act, the other component being the quality aspects of the Ecological Reserve.

The National Water Act specifies two possible levels of determination of the Reserve: a determination under Section 16 in accordance with the class of a water resourse (which may conveniently be referred to as a "full" determination, although it should be noted that the determination is subject to review of the water resource management strategies of which it is a part); and a preliminary determination under Section 17 ahead of the determination of the class (currently referred to as the Preliminary Ecological Reserve (Quantity & Quality)).

DWAF appointed a Protection and Assessment Policy Implementation Task Team (PAPITT) to determine methodologies to determine the Preliminary Reserve. The Task Team also had to recommend methods for the "full" determination of the Reserve, and when and under what circumstances a "full" Reserve is warranted instead of a Preliminary Reserve. PAPITT recommended that the full Reserve methodology for the Ecological Reserve (Quantity) will at present be the Building Block Methodology. Methods for the determination of the Preliminary Ecological Reserve (Quantity) will be a scaled down version of the BBM (called the Preliminary Ecological Reserve Methodology (PERM) (Quantity). It is important to note that this study was undertaken concurrently with the development of methods by the PAPITT. This is why the Ecological Reserve (Quality) did not form part of this study as the methods to determine this had not been developed when this study was initiated. However, as the BBM was in place and has been accepted by the PAPITT as the full methodology, there was no problem with determining the Ecological Reserve (Quantity) at the same time as PAPITT was developing quality-related methods.

The National Water Act also specifies that a Resource Classification System must be developed and applied to determine the Ecological Management Class (EMC). Once the management class of the river has been determined, the IFR has to be determined in accordance with this class.

The results of an IFR following the BBM methodology will therefore represent a comprehensive determination of the Ecological Reserve (Quantity). However, the results will only be accepted if the method which was used to determine the EMC (which does not form part of the BBM) complies with the DWAF requirements.

The process followed for the Thukela IFR is unique in the sense that it is the first time that the IFR study area for which a detailed ('full') IFR is available, has been extended to include an additional 35 km. As this 35 km represents a physically different section of the river, extrapolation from the downstream IFR site 2 would not suffice. However, it would not be cost-effective to undertake the full process for only one additional site and aspects of the Preliminary Reserve method (or the scaled down version of the BBM) have therefore been followed to address this site. As it will be matched to more detailed IFRs, the results generated at this site should be of the same quality as for the BBM.

2.3 IFR METHODOLOGY : BBM

The demand for water from South Africa's growing population is creating an ever-increasing pressure on the country's water resources, especially its rivers. The urgent need to provide more water services often conflicts with the desire to maintain or improve the ecological condition of the rivers. To provide guidance on the sustainable use of a river's water-resources, the Building Block Methodology (BBM) has been developed for assessing the instream flow requirement for any river. (King & Louw). Development has been carried out jointly over the last nine years by the Department of Water Affairs and Forestry and river scientists, and the accent is on identifying a complex of different magnitude flows for maintenance of entire river ecosystems. The BBM caters for the almost universal reality in South Africa of having rapidly to provide scientific guidance on such flows for a river in cases where biological data and understanding of the functioning of the river are limited. However, the methodology works equally well in data-rich situations.

The BBM depends on available knowledge and expert opinion, gleaned from experienced river scientists in a structured 4-day meeting. Limited new data of a specific nature are gathered to facilitate the process. Relevant data on the river are prepared in a way that specialist workshop participants can easily understand and quickly begin to use. Scientists typically involved in the specialist meeting, all with specific roles, are those with specialist knowledge of the river or similar rivers in terms of the fish, aquatic invertebrates, riparian vegetation, river importance, habitat integrity, fluvial geomorphology, local hydraulics, water chemistry and social dependence on the riverine ecosystem. Hydrological and hydraulic modellers provide data inputs and facilitate the workshop process by answering questions and producing additional data as requested. The specialist meeting output, reached by consensus, is a quantitative description in space and time of a flow regime that should facilitate maintenance of the river ecosystem in some predetermined desired future state.

In the methodology the following assumptions are made.

- The biota associated with a river can cope with those low-flow conditions that naturally occur in it often, and may be reliant on higher-flow conditions that naturally occur in at it at certain times. This assumption reflects the thinking that the flows that are a normal characteristic of a specific river, no matter how extreme, variable or unpredictable they may be, are ones to which the riverine species characteristic of that river are adapted and on which they may be reliant. On the other hand, flows that are not characteristic of that river will constitute an atypical disturbance to the riverine ecosystem and could fundamentally change its character.
- Identification of what are felt to be the most important components of the natural flow regime and their incorporation as part of the modified flow regime will facilitate maintenance of the natural biota and natural functioning of the river
- Certain kinds of flow influence channel geomorphology more than others. Identification of such flows and their incorporation into the modified flow regime will aid maintenance of the natural channel structure and diversity of physical biotopes. (King & Louw)

The flows incorporated into the modified flow regime will constitute the instream flow requirement (IFR) for the river. The IFR describes, in space and time, the minimum amount of water that it is felt will facilitate maintenance of the river at some pre-defined desired state.

The recommended flows are identified and their magnitudes, timing and duration decided upon in the BBM specialist meeting. Initially, thought is focussed on the characteristic features of the natural flow regime of the river. The most important of these are usually; degree of perenniality; magnitude of base flows in the dry and wet season; magnitude, timing and duration of floods in the wet season; and small pulses of higher flow, or freshes, that occur in the drier months. Attention is then given to which flow features are considered most important for maintaining or achieving the desired state of the river, and thus should not be eradicated during development of the river's water resources. The described parts of each flow component are considered the building blocks which create the IFR, each being included because it is understood to perform a required ecological or geomorphological function. The first building block, or low-flow component, defines the required perenniality or non-perenniality of the river, as well as the timing of wet and dry seasons. Subsequent building blocks add essential higher flows.

Flows are determined for both maintenance flows (those flows that will maintain the system in the management class agreed on during years other than drought years) and drought periods (flows that will only allow for survival of the most critical components of the ecosystem). The same approach is utilised for both maintenance and drought years, starting off with drought years.

The approach during this specialist meeting follows the following steps:

- The assurances of maintenance and drought flows are determined based on the hydrological characteristics of the system.
- The highest low flow (base flow) month and lowest low flow month are selected utilising the hydrological record to make this decision. In the case of the Thukela River the months were February and August.
- These months are used to set the low flows, and the range of low flows that occur during the year was therefore fixed between the highest and lowest values.
- The low flows for the rest of the months are interpolated from the August and February flows following the natural shape of the annual hydrograph. This extrapolation is undertaken by the hydrologists and checked by the ecologists.
- Each specialist provides motivations describing the physical parameters of the required flows (eg water level, velocity, depth) and the reasons for requiring these flows. Some of the disciplines provided primary and some secondary motivations. Primary motivations refer to motivations provided by the disciplines that require a certain type of flow which is critical. Secondary motivations refer to motivations provided by disciplines that could maintain the component with less flows, but for which higher flows to satisfy the other components requirements will not be harmful.
- After each flow is agreed on, the flows specified are checked for realism in similar years. Normal or average hydrological years are utilised to check maintenance flows and the dryest years to check drought flows.
- During the wet season high flow events are determined and motivated for. High flows refer to freshes, small, medium and large floods. A fresh refers to a small increase in base flow. The high flows are given in cubic metres per second (m^3/s) where the flow specified refers to an instantaneous peak. As the hydrology is provided in mean daily averages, the peaks recommended are converted to slightly lower flows to reflect the mean daily average.
  * In all cases the duration of the floods are specified in days.
  * The shape of the floods is based on the shape of the natural hydrograph.
  * The specified peaks include the low (base) flows
  * When the total volume of each flood is calculated, it excludes the low flow volume which is already included in the total low flow volume
- A hydrological check of each flood is repeated.
- The IFR model, described in Chapter 10, is run with the IFR results and the associated assurances as established in the beginning of the procedure.

2.4 CLASSIFICATION OF THE RESOURCE

2.4.1 Ecological Management Class

Chapter 2 of the National Water Act provides, in Parts 1 & 2 respectively, for the establishment and application of a system by which water resources will be classified. These provisions, read together with section 6.3.3 of the National Water Policy, make it quite clear that resource classification is designed to afford the degree of protection necessary to prevent unacceptable damage to a water resource (that is, to maintain it in a healthy state) or, in cases where a resource is already unacceptably degraded, to restore it to a health state.

The process of determining an appropriate level of protection - the management class - comprises a number of steps (discussed in more detail in 2.4.2 following, and illustrated in Figure 2.3). The ***present status*** of the resource is assessed by considering the degree of change from the ***reference conditions,*** which describe the probable condition of the resource before it was impacted by human activity. The present status, together with an assessment of the ecological and social/cultural ***importance*** of the resource, enables the ***ecological management class*** to be determined. The ***resource quality objectives***, of which the IFR is one, define and quantify the specific characteristics of the resource which are necessary to achieve the management class.

2.4.2 Approach to determination of the Ecological Management Class

The process as it is currently defined *[by the ongoing work of PAPITT]*, and as it is has been applied to the Thukela River as follows:

- A ***present state*** class (PSC) must be allocated to the river reach for which a management class is required. The present state is described by allocating a class (see Table 2.1) to the river reach. The present state is described in six classes with A being near pristine and F irreversibly changed. These classes are based on the Habitat Integrity classes (Kleynhans). The PSC is described for each component which are used to set the IFRs.
- The ***river importance*** (social/cultural and ecological) is then established and considered when determining the protection class. The ecological importance is determined by utilising the Ecological Importance Model (Kleynhans) and the social/cultural Decision Support System (O'Keeffe).
- After a process of consultation, a protection class, the ***EMC*** is allocated to the river reach. The protection class is described in classes ranging from A (near pristine) to D (largely modified) (see Table 2.2). Unlike the PSC, the EMC range does not extend to classes E and F. Rivers which are currently in classes E and F are not considered to represent sustainable systems, and must therefore be protected and managed for improvement. A high protection class relates to a flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low protection class will ensure marginal maintenance of sustainability and a high risk of ecosystem failure. The EMC is provided for each component, with specific reference to the differences between instream and riparian components. These EMCs are then further defined into ***Resource Quality Objectives*** which defines the specific objectives requires to achieve the EMC.

Table 2. 1 : Present state classes

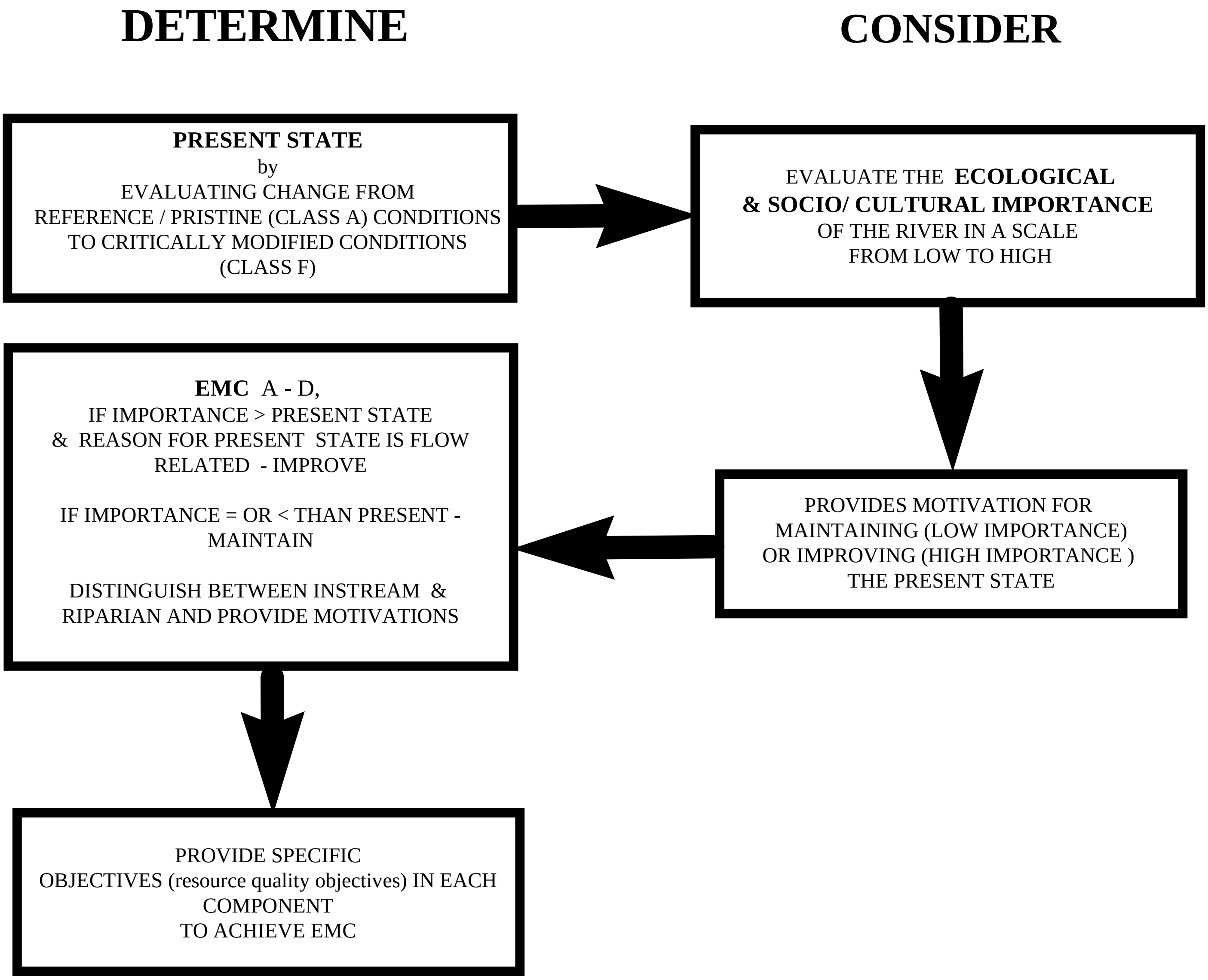
CLASS	DESCRIPTION
A	• Unmodified, natural; • The resource base reserve has not been decreased; • The resource capability has not been exploited
B	• Largely natural with few modification; • The resource base reserve has been decreased to a small extent; • A small change in natural habitats and biota have occurred, but the basic ecosystem functions are essentially unchanged.
C	• Moderately modified; • The resource base reserve has been decreased to a moderate extent. • A change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	• Largely modified; • The resource base reserve has been decreased to a large extent. • Large changes in natural habitat, biota and basic ecosystem functions have occurred.
E	• Seriously modified; • The resource base reserve has been seriously decreased and regularly exceeds the resource base; • The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	• Critically modified; • The resource base reserve has been critically decreased and permanently exceeds the resource base; • Modifications have reached a critical level and the resource has been modified completely with an almost total loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 2.2 : Ecological Management Classes

CLASS	DESCRIPTION
A	• Unmodified, natural - the natural abiotic template should not be modified; • The characteristics of the resource should be completely determined by unmodified natural disturbance regimes; • There should be no human induced risks to the abiotic and biotic maintenance of the resource. • The supply capability of the resource will not be utilised.
B	• Largely natural with few modification - only a small risk of modifying the natural abiotic template and exceeding the resource base should be allowed. • Although the risk to the well-being and survival of especially intolerant biota (depending on the nature of the disturbance) at a very limited number of localities may be slightly higher than expected under natural conditions, the resilience and adaptability of biota must not be compromised. • The impact of acute disturbances must be totally mitigated by the presence of sufficient refuge areas.
C	• Moderately modified - a moderate risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the well-being and survival of intolerant biota (depending on the nature of the disturbance) may generally be increased with some reduction of resilience and adaptability at a small number of localities. However, the impact of local and acute disturbances must at least partly be mitigated by the presence of sufficient refuge areas.
D	• Largely modified - a large risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the well-being and survival of intolerant biota (depending on the nature of the disturbance) may be allowed to generally increase substantially with resulting low abundances and frequency of occurrence, and a reduction of resilience and adaptability at a large number of localities. However, the associated increase in the abundance of tolerant species must not be allowed to assume pest proportions. The impact of local and acute disturbances must at least to some extent be mitigated by the presence of adequate refuge areas.;

The relationship between the PSC, Importance and EMC is described in the following figure:

Figure 2.3 : EMC PROCESS



2.5 EMC PROCESS AS APPLIED TO THE THUKELA RIVER (EXTENSION OF THE STUDY AREA)

2.5.1. Approach to determination of the EMC (downstream of Spioenkop Dam)

The concepts as described under 2.4 have not been applied often in practice and the methods have not been finalised. The results of the Thukela IFR study is not the Ecological Reserve, but will most likely later become the Ecological Reserve (Quantity). It is therefore important that the approach followed to determine an EMC for which to set the IFR is compatible with the methods in their current stage of development The EMC for this section of the river must also link with the Desired Future State (as the EMC was previously called) set for the more downstream stretch. The approach followed in 1997 is compatible with the approach that was followed for this study (see steps below).

- *Determine the present ecological environmental state.*
  A habitat integrity analysis was undertaken to determine the present state categories of the river during 1995. This was revisited and each specialist from the relevant disciplines was required, using the same Habitat Integrity classes, to provide and motivate the present state of the different component/aspect of habitat dealt with by their discipline.
- *Determine the ecological and 'social utilisation / cultural importance*'
  Prof J O'Keeffe defined the ecological importance of a river as "a measure of the value of a river for conservation, including natural, socio-economic and cultural aspects". Criteria for evaluating natural aspects included rarity, special features, resilience/fragility and the degree of modification. The ecological importance and sensitivity of the river will be determined using the DWAF (CJ Kleynhans) model designed for the Reserve. The model will be run during the specialist meeting. Although a social scientist will not be present, the social importance model will be run with the input of the persons present to establish some basis of the social importance.
- *Determine the EMC which would ensure a healthy ecosystem.*
  Based on the present state and the importance and sensitivity analysis, a realistic EMC for each discipline will be derived and motivated for. The class decided on was then defined by describing specific resource quality objectives (flow related) which should achieve the EMC.

2.5.2 Present state

A Habitat Integrity analysis (Fig 1.1) undertaken during 1995 indicated a C class for the instream section. The criteria which were largely responsible for the C Class evaluation were water abstraction, flow modification, bed modification and water quality. This resulted in a high class C (72 % with C being between 60 and 80 %).

The Riparian Integrity analysis resulted in a B Class. Criteria contributing to the changes in the system were removal of indigenous vegetation and exotic vegetation encroachment. This resulted in a high B classification.

2.5.3 EMC

1995

During 1995 the EMC for the downstream section of the river was set as follows:

- To determine a flow regime which will promote/facilitate
  - the natural ecological state (at least maintain as is, no further degradation)
  - aesthetic quality (wild and scenic character of the Thukela River)
  - conservation of the natural heritage including species biodiversity and landscapes.
- To maintain perennial flow.

- To determine a flow regime that will promote the sustainability of the riverine resources for those depending on the presence of a healthy riverine ecosystem.

1997

During 1997, a process was followed which is compatible to the approach followed presently. The table below provides the present state (PS), the EMC and the motivation for the EMC for the river stretch downstream of Upper Jana Dam to IFR 5 (upstream of the Mooi Confluence). This information was used as guidance for setting the EMC for the area downstream of Spioenkop Dam to ensure continuity.

Table 2.3: Present State Classes and EMC for the 1997 Thukela River study area

COMPONENT	PS	EMC	EMC MOTIVATION
FISH	B	B	A decline in water quality or in habitat availability, especially the riffle habitats, must be avoided.
AQUATIC INVERTEBRATES	E-B	B	E present state refers to areas such as Colenso and where over-exploitation of the riparian zone has taken place. There are no known instream biota of special conservation concern restricted to the reaches for which IFRs are to be determined. A moderately increasing allocation of flow will allow recovery of the ecosystem, provided that steps are taken to manage water quality, to manage the catchment to reduce erosion and to properly protect the riparian zone and river banks. Re-establishment of the fringing vegetation would make this EMC achievable.
RIPARIAN VEGETATION	D-E	C	PS due to impacts of floods, grazing, and vegetation removal. The riparian zone has a variety of structural and ecological functions which are important for the stability and integrity of the river. The EMC is therefore one which has a more intact riparian zone which can achieve the structural and ecological functions which are currently in a state of disrepair.
FLUVIAL GEOMORPHOLOGY	C-B	B	The gorge section graded B and the lower gradient sections graded C. The gorge has high geomorphological resilience and the high diversity of habitat should be maintained. The alluvial sections have been subjected to increased siltation and large scale rehabilitation is unlikely to be feasible as a result of high population densities in the catchment. The present diversity of habitats should be maintained by preventing excessive siltation and channel narrowing.
WATER QUALITY	C	B	-
AESTHETIC, ECOTOURISM	C	B	-
HABITAT INTEGRITY	C	B	-

OVERALL RIVER	E-B	C/B	The OBJECTIVE for the Thukela River is to manage the river for the present macro channel (large river). The motivation for doing this is that the uniqueness of the river is due to its size, intermediate floods construct the channel and subsequently the flow regime should be manage for this. The resilience of the river may be lost during floods if the river is maintained in the micro channel. Furthermore, improvement of biodiversity if possible if the macro channel is maintained; if the micro channel is maintained, the morphology of the channel may change dramatically during a flood event and leave a large river with reduced habitat availability. The length of the river is characterised by a range of EMCs and this is reflected in the range of categories selected. Some areas will be susceptible to morphological changes as a result of changes in flow regime, e.g. alluvial areas, while other areas will be less prone to changes due to their inherent stability, e.g. gorge areas. Therefore, a B could be for the EMC for the average river and C would be the EMC for the particularly susceptible, as well alluvial, areas.

2.6 IFR PROCESS AS APPLIED TO THE THUKELA RIVER (EXTENSION OF THE STUDY AREA)

Aspects of the scaled down version of the BBM or the Preliminary Ecological Reserve Method (PERM) (Quantity) will be followed for the additional study area. The PERM (Quantity) will consist, just as for the BBM, of a range of sequential actions. More rapid methods are being designed for most of these actions as part of the development of the PERM (Quantity).

The Ecological Reserve, whether a comprehensive of a preliminary process, consists of six generic steps as follows:

- Delineate geographical boundaries of resource
- Eco-regional and geo-regional type
- Determine reference conditions
- Determine present status
- Select ecological management class
- Set the Reserve.

Each of the steps is discussed in the following table, indicating the differences between PERM , the Quantity Reserve (BBM) and providing the information of the steps undertaken for the additional Thukela study.

Table 2.4: Comparison of detail required for the PERM, BBM and the actions undertaken

for this study

6 STEPS	PERM	BBM	THUKELA (IFR A)
Geographical boundaries of resource	Study area	Study area	Spioenkop Dam to Little Thukela Confluence.
Eco-regional type Geomorphological zoning	Follow to Level II (Kleynhans)*[1] Follow to zone level	ditto Follow to segment level	Map not yet available Zones determined
Determine reference conditions	Virgin hydrology (WR 90) on monthly basis	Virgin hydrology modeled on daily basis	Virgin hydrology modeled on daily basis
Determine present status	Preliminary Habitat Integrity SASS*[2] Possible fish index	Habitat Integrity 2 surveys of fish, invertebrates, vegetation, geomorphology	Habitat Integrity Existing fish information SASS Vegetation (one survey) Geomorphology (one survey)
Select management class	Detail of process still to be defined. Ecological & socio-cultural importance. Default process. DWAF decides	Stake holder process Ecological & socio-cultural importance. DWAF decides	Not Reserve study. Ecological & socio-cultural importance. Most realistic class determined and used.
Quantity Reserve: IFR planning meeting Site selection Hydraulics Social utilisation Starter document Specialist meeting	2 months No Undertaken by aquatic scientific & hydraulician ½ calibrations Standard paragraph No - some E-mailed documents Small group, one day, next to site (1 site)	6 - 8 months over wet and dry season Yes Undertaken by full team 4/5 calibrations Social survey Yes Larger group, 4 days (4 sites) site visit, conference facility	2 months No (extension of existing project) Undertaken by aquatic scientist & hydraulician 3 calibrations (timing problem) Extrapolation from previous study Yes, but in summary and only available at meeting Medium group, 1½ days (1 site), next to site & conference facility

*[1] : Level II refers to the different detail (coarseness) of ecotyping assessment.
*[2] : SASS - South African scoring System : A process utilising aquatic invertebrates to assess the health of the river

Due to the size and importance of the Thukela River, some actions required the same detail as for a BBM to ensure a higher level of confidence (see last column above). A 1,5 day technical group meeting addressed the Spioenkop area once all relevant information has been gathered. One day of this group meeting was spent on the Skietdrift site (see chapter 3) and the remaining half a day will be dedicated to the hydrological check and running of the IFR model so that the results can be incorporated in the system analysis. The additional IFR results will also be checked and linked to the
downstream available IFR results.

The following actions have been undertaken for the study (the relevant specialist studies are attached as appendices):

Pre-specialist meeting actions:
- Select study area
- Geomorphological zoning
- Select IFR sites
- Cross-sectional survey of IFR sites

- Marking and surveying of trees on IFR sites
- Inform all specialist regarding locality of sites and provide with site description.
- Collect available fish information
- Riparian conservation status assessment
- Two hydraulic data collections
- Hydrological modeling and preparation
- Hydraulic modeling and preparation

Specialist meeting actions:

- Determine suitability of site
- On site investigations and surveys such as SASS
- Present state
- Ecological and socio-cultural importance
- Environmental management class
- Assurances of maintenance flows
- Determine IFRs
- Match to previous results
- Attach confidence to results
- Run IFR model.

The following actions are required to follow the specialist meeting.

- Report
- System modeling
- Scenario meeting

The program for the specialist meeting and the participant list is attached as appendix B.

CHAPTER 3 : IFR SITES
(MD Louw & AL Birkhead)

3.1 PURPOSE OF IFR SITES

In order to determine the IFR, it is necessary to determine the flow requirements at a number of points within the system.

More than one IFR site is usually selected within the system for a number of reasons:
- Flow from tributaries entering the system may result in different channel, bank and or habitat conditions which may to be considered seperately.
- The Environmental Management Class (EMC) of particular reaches of the river may differ from the rest and may therefore require a specific Reserve.
- A river system displays biological diversity along its length, and a single IFR point is unlikely to adequately reflect this range of diversity.
- Various hydrological stage points are required within the system to cater for the inflows from tributaries and losses down the length of the system.

A range of hydrological, hydraulic, geomorphological and ecological data is collected at each IFR site. This information is then utilised during the IFR specialist meeting to determine the (Ecological Reserve (Quantity)) for the system.

3.2 SELECTION OF IFR SITES

The selection of IFR sites is guided by a number of considerations such as (Louw *et al*):
- The locality of gauging weirs with good quality hydrological data.
- The locality of proposed & existing developments.
- The locality and characteristics of tributaries.
- The present status defined by the Preliminary Habitat Integrity of the different river reaches.
- The Level II ecotypes present in the study area.
- The reaches where social communities depend on a healthy river ecosystem.
- The suitability of the sites for follow-up monitoring.
- The habitat diversity for aquatic organisms, marginal and riparian vegetation.
- The suitability of the sites for accurate hydraulic modeling throughout the range of possible flows, especially low flows.
- Accessibility of the sites.
- An area or site that could be critical for ecosystem functioning. This is often a riffle which will stop flowing during periods of low or no flow. Cessation of flow constitutes a break in the functioning of the river. Those biota dependant on this habitat and/or on continuity of flow will be adversely affected. Pools are not considered as critical since they are still able to function as an ecosystem or at least maintain life during periods of no flow.
- The locality of geomorphological reaches using stream classification.

The above is valid for the selection of the Preliminary Ecological Reserve Methodology (PERM)(Quantity) sites.

When selecting IFR sites following the PERM (Quantity)methodology as was undertaken for this study a decision making-process is followed which consists of the following steps (Fig 3.1):

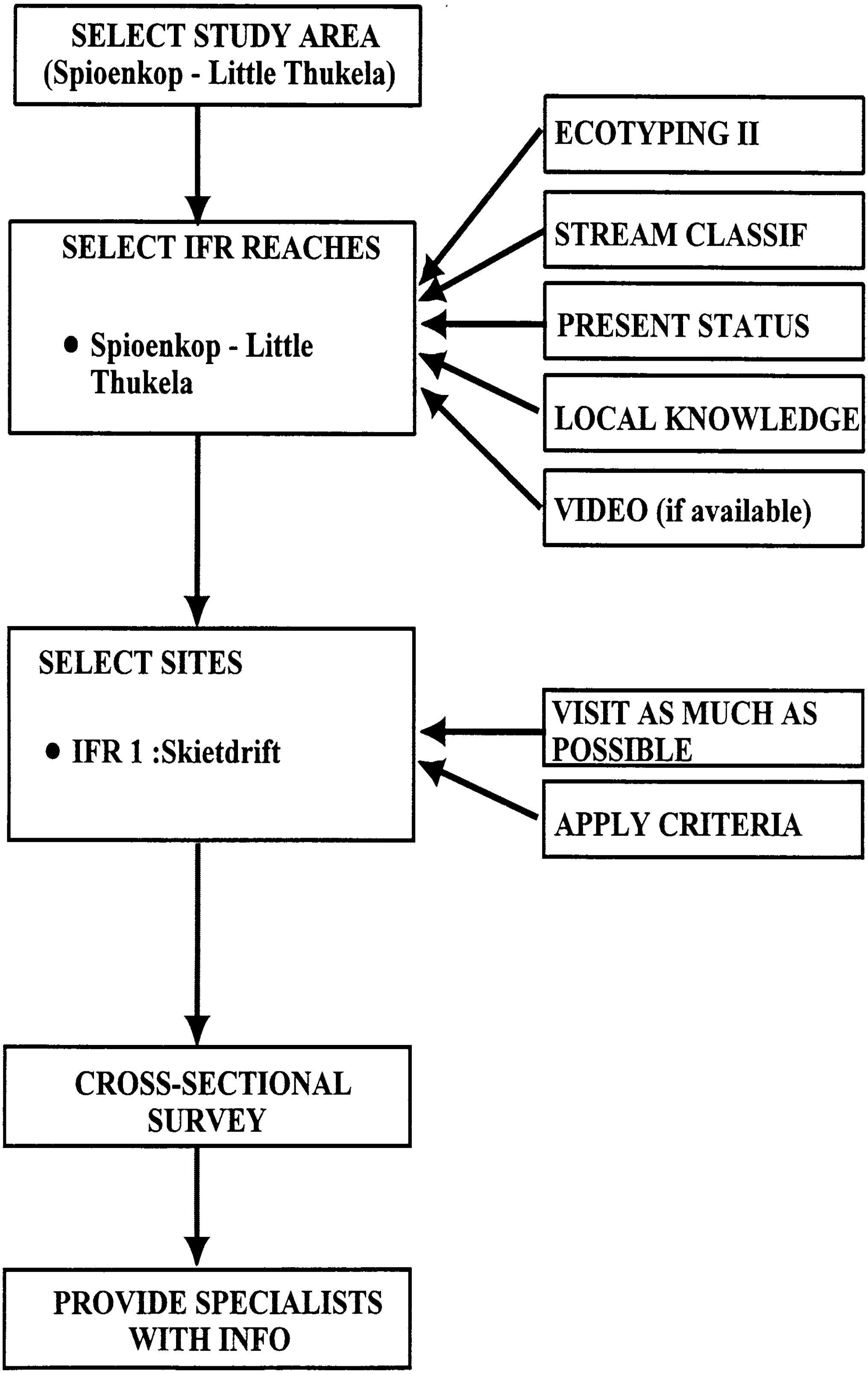


FIGURE 3.1 :
SITE SELECTION STEPS

3.
2.
1

IFR Study area

The first step in selecting the IFR sites is to define the study area. This is also necessary due to the inherent complexity of river systems, and the need to confine the setting of the IFR to specific stretches (each representing a significant resource or forming part of a significant resource of the river).

The study area is the Thukela River downstream of Spioenkop Dam to the Little Thukela River confluence. (Fig 1.1 & 3.2)

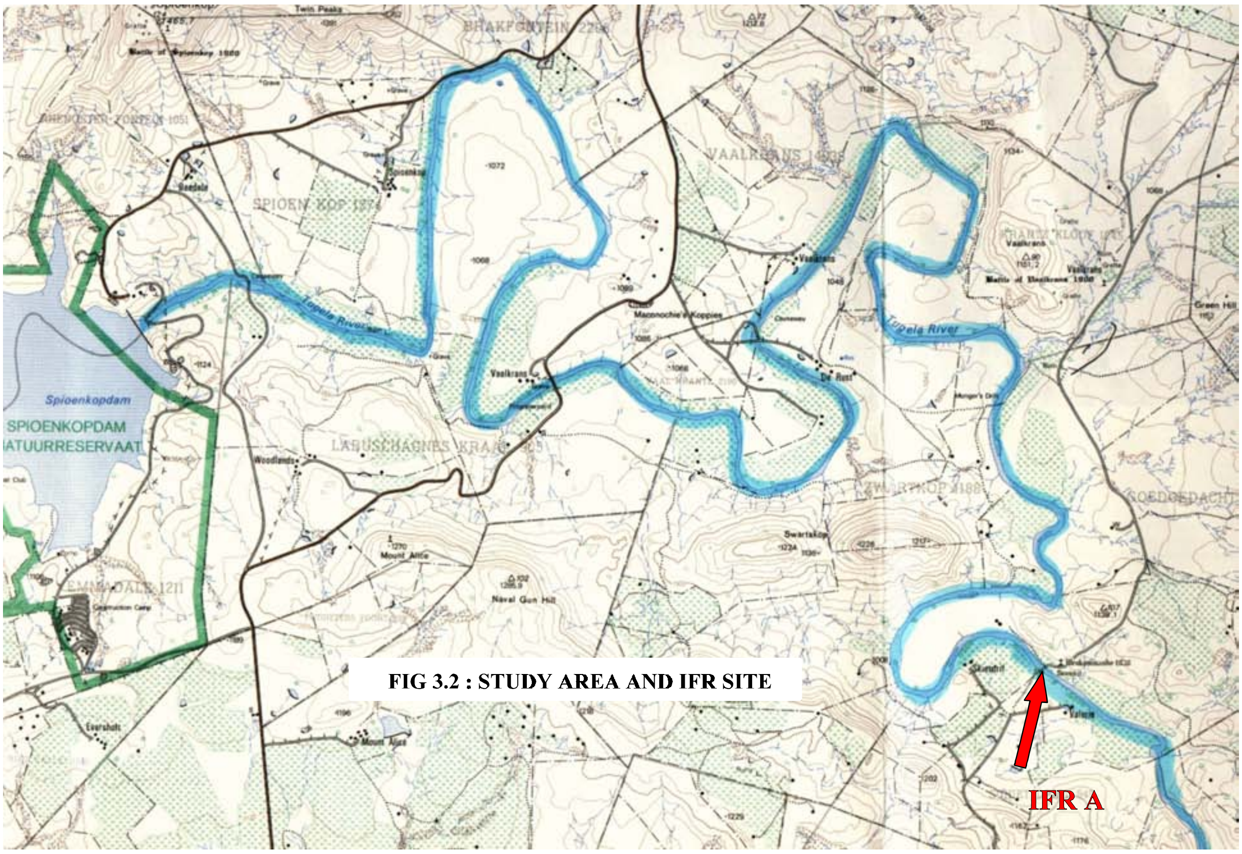


FIG 3.2 : STUDY AREA AND IFR SITE

3.2.2 Selecting river stretches in which IFR sites should be situated

Prior to selecting the IFR sites, river stretches in which the IFR sites must be situated must be identified. (Note that the term stretches are used here as these river stretches are different from the geomorphological reach). The same considerations as described under 2 are applicable when selecting the river stretches.

- ***Ecotype***

Ecotyping to a Level II (Louw) has to be undertaken to determine the different ecoregion types within the study area. The ecoregion typing are based on the premise that ecosystems and their components display regional patterns that are reflected in spatially variable combinations of causal factors such as climate, mineral availability (soils and geology), vegetation and physiography (Omernik, 1987). In South Africa, physiography, climate, geology and soils, and potential natural vegetation have been used as the preliminary delineators of Level 1 ecotyping. Level II typing considers the same characteristics as for Level 1 typing, but in more detail. Level II typing will produce regional or subcatchment scale ecotypes (Kleynhans *et al*).

Only the Level 1 ecotyping was available for the KwaZulu-Natal Region and this illustrated that the study area falls within one region. Based on the stream classification (see below) it is likely that the Level II Ecotyping, when available, will also indicate that the study area falls within one

Ecotype II region.

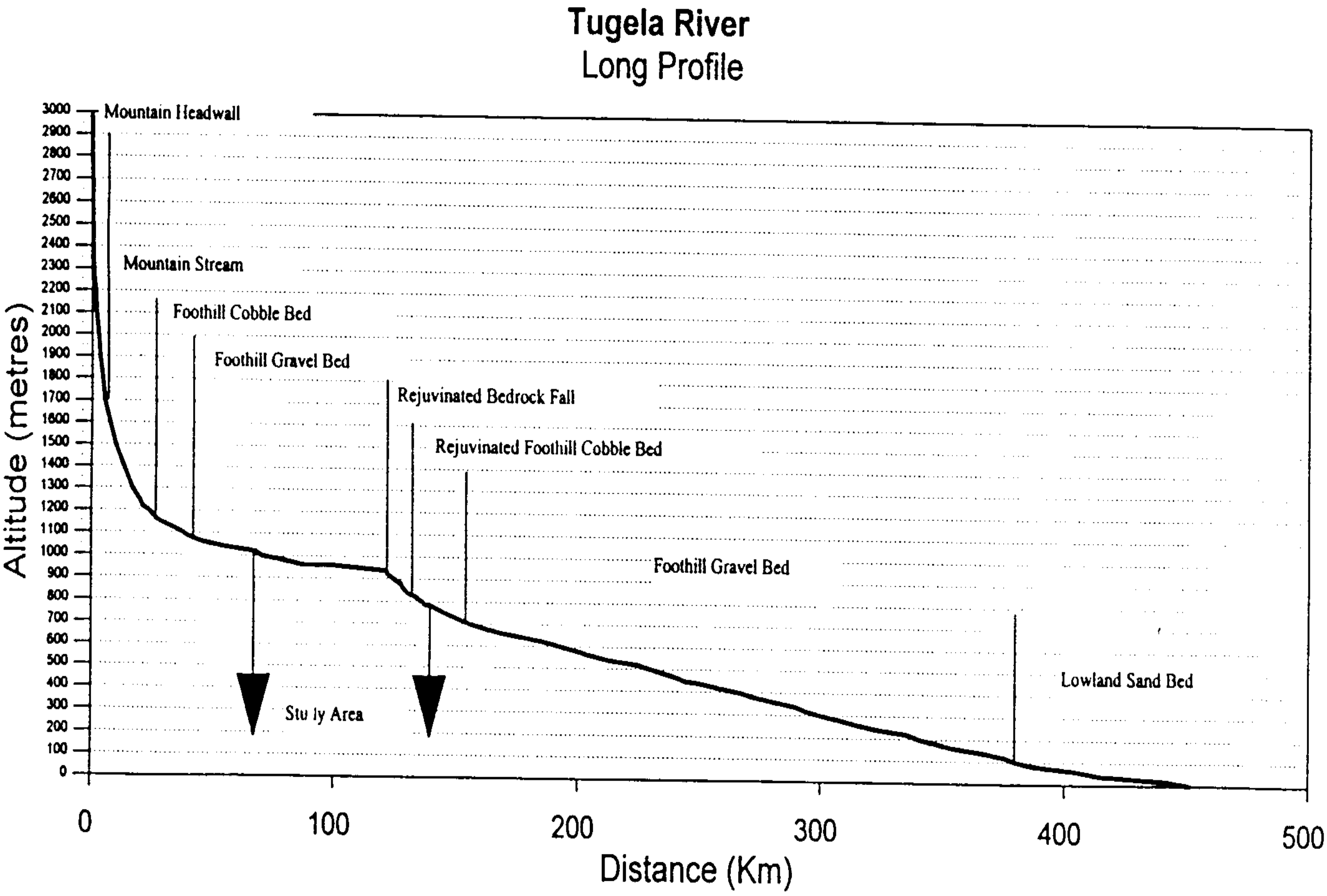
- ***Stream classification***

The stream classification indicated that the study area fell within one zone, i.e. the Foothill Gravel Bed. (Fig 3.3)

Figure 3.3: Geomorphological zonation

- ***Present status***

The Habitat Integrity undertaken during 1995 indicated that the Instream Integrity was a Class C



and the Riparian Integrity a Class B for the study area.

All the above information indicated that only one IFR stretch exists in the study area which would only warrant one IFR site.

3.2.3 Selection of IFR sites

The criteria described in section 2 above were used to select the IFR sites. A video of the river was available from the 1995 aerial survey of the habitat integrity analysis and possible sites were initially identified from the video. These sites, as well as any available access points, were visited so as to select the most suitable IFR site.
As only two calibrations of the hydraulic stage discharge curve would be undertaken, the hydraulic suitability of the IFR site had to be the most important criteria during selection. However, the site still has to provide sufficient biophysical indicators for the setting of the IFR.

The site selection team consists of a hydraulician and an aquatic scientist with sufficient knowledge of the requirements of the different disciplines of sites for IFR determination. This differs from the selection process of a BBM study or full quantity Reserve where all disciplines are represented during the site selection

3.2. 4. Characteristics, advantages and disadvantages of IFR A

The section of river contains mostly pool - riffle/rapid sequences with patches of indigenous riparian vegetation and patches of exotics (poplars and others). Access was problematic, mostly due to farms being inaccessible. Most of areas seen were not suitable due to exotic vegetation and narrow deep channels which were hydraulically problematic.

The IFR A site consisted of bedrock dykes which had a variety of cobbles and gravels within the dyke area. Indigenous vegetation occurs on some well defined terraces.

Placing of cross-sections

The exact placing of the cross-section(s) is derived primarily by the need for accuracy, in the hydraulic data, but they must still provide the ecological clues necessary for determining the IFR. Cross-sections were required over both dykes for hydraulic reasons and also suited the requirements for fish and invertebrates. A more downstream cross-section was selected that transverse a deeper area - run/pool - which was placed for vegetation purposes and ran through patches of good indicator vegetation species.

IFR A : Skietdrift

	Advantages	Disadvantages
General	Access with normal vehicle.	No gauge nearby, flow measurement required. Flow measurement during high flows might be problematic due to absence of large pools.
Aquatic invertebrates	Good diversity of habitats Range of flow velocities Abundant marginal habitat	Limited loose cobbles, mostly bedrock.
Riparian vegetation	A number of indicators species present	Some exotics present. Some disturbance by grazing, crossing, and clearing of indigenous acacias to act as barrier for cattle.
Fish	Good habitat diversity. Marginal vegetation well represented. Movement of large fish observed crossing rapid during low flows.	Riffle-like habitat covering only a small area.
Geomorphology	Site representative of that reach of river.	
Hydraulics		
Photopoint monitoring	Good visibility for fixed point photograph	

3.3 SURVEYING OF THE IFR SITES

Once the sites have been selected, the survey is undertaken by the hydraulician and the ecologist. Riparian trees are marked or identified and also surveyed on the cross-section. Important geomorphological characteristics are also identified and surveyed.

The purpose of the cross-sections is:

- To indicate where various zones and species of riparian vegetation occur.(Appendix __)
- To indicate where specific geomorphological features occur in order to establish required flows for various purposes e.g. bankfull discharge.
- To establish a stage discharge relationship.

This information is then presented to the workshop for identification of the IFR at the sites.

3.4 EVALUATION OF IFR SITES

The site visit during the specialist meeting was the first opportunity for most of the specialists to investigate the selected sites. Table 3.1 reflects the evaluation by the different specialists of the adequacy of the sites to provide sufficient clues to determine high confidence**.**

Table 3.1 : Evaluation of IFR sites

NONE = 0 LOW = 1 LOW - MEDIUM = 2 MEDIUM =3
MEDIUM - HIGH = 4 HIGH = 5 L = LOW FLOWS H = HIGH FLOWS
Hydraul = Hydraulics Hyd = Hydrology Rip Veg = Riparian Vegetation Amp = Amphibian
Inverts = Invertebrates Geom = Geomorphology L = low flows H = high flows

IFR SITES		IFR COMPONENT							
		HYDRAUL	HYDROL	FISH	RIP VEG	GEOM	AQUATIC INVERTS	PHOTO	
1	L	2-3	2	3	2	2	2-3	Range 1	Visibility: 3
	H	2-3	2	3	3	3	2-3		

CHAPTER 4 : RESULTS -SPIOENKOP DAM TO KLEIN THUKELA (IFR A)

The IFR site A (Skietdrift) is situated in this stretch of river.

4.1 PRESENT STATE

The Present State based on the Habitat Integrity and Ecological integrity was determined and is provided in Table 4.1

Table 4.1 : Present State

COMPONENT	PRESENT STATE
FISH	B/C
AQUATIC INVERTEBRATES	B
RIPARIAN VEG	C
FLUVIAL GEOMORPHOLOGY	C
WATER QUALITY :	B
HABITAT INTEGRITY INSTREAM	B/C
RIPARIAN CONSERVATION STATUS	C

The overall present state of this section was described as a B class which relates more to instream factors. The riparian class was lower, class C, but this was mostly due to non-flow related aspects.

It must be noted that for the last 30 years since Spioenkop has been built, the river within the study
area has been subjected to regulated flows. Flows are released at a steady rate of 1.5 - 2m³/s whenever the dam is not spilling. This has caused the area downstream of the dam to the Little Thukela to have very little seasonal variety or variety within seasons. However, as can be seen in Table 4.1, the present state indicates that the river is 'largely natural' and it would seem that the operation of Spioenkop Dam has not yet had a significant impact on the biota. However the geomorphology indicates that a slow process of aggradation has started and if this continues, the instream biota will not be maintained in the above class. This is explained in 4.4. Added to this is the fact that very little historical information is available on the variety and abundance of species occurring in the Thukela. It is suspected that the diversity of species might still be present, but that the community structures and abundances within the species are declining. Different components of the river system react to changes in flow regime over different time scales, and all the negative impacts of the presence, and operational (release) regime, of Spioenkop Dam have not yet manifested themselves (Newson**)**

4.2 ECOLOGICAL AND SOCIAL IMPORTANCE

The ecological importance was determined using the Ecological Importance ans Sensitivity

Model (Kleynhans) and the Social Importance and Sensitivity Model (O'Keeffe). The results of the importance rating would provide motivation for an improvement of the present state class, or for the present state class to be maintained.

4.2.1 Ecological Importance

The results of the ecological importance are provided in Table 4.2 :

Table 4.2 : IFR site 1 : Ecological Importance

PRIMARY DETERMINANTS	SCORE	COMMENTS
BIOTA (RIPARIAN & INSTREAM) (ENTER NUMBER 0 OR 1 TO 4)		
Rare & endangered	0	
Unique (endemic, isolated, etc.)	4	*Labeo rubromaculatus* endemic to the Thukela system
Intolerant (flow & flow related water quality)	3	
Richness	2	
RIPARIAN & INSTREAM HABITATS (ENTER NUMBER 0 OR 1 TO 4)		
Diversity of types	3	
Refugia	3	
Sensitivity to flow changes	3	
Sensitivity to water quality changes	2	
MEAN OF PRIMARY DETERMINANTS	2	
PRELIMINARY RATING:BIOTA & HABITAT	MODERATE	
MODIFYING DETERMINANTS	SCORE	
IMPORTANCE TO FUNCTIONING OF NEIGHBOURING SYSTEMS (ENTER NUMBER 0 TO 4)		
Migration route/corridor (instream & riparian)	3	Important for eels to migrate, low confidence in value as information not known
PRESENCE OF CONSERVATION & NATURAL AREAS (ENTER NUMBER 0 TO 4)		
National Parks	0	
Nature Reserves	0	
Wilderness Areas	0	
Other areas of natural importance	1	
Maximum	1	
UNMODIFIED ECOLOGICAL IMPORTANCE & SENSITIVITY		
ECOLOGICAL IMPORTANCE & SENSITIVITY:	HIGH	
MODIFIED ECOLOGICAL IMPORTANCE & SENSITIVITY		
MODIFICATION OF ECOLOGICAL IMPORTANCE & SENSITIVITY WHERE: (1)ECOLOGICAL IMPORTANCE & SENSITIVITY IS MORE THAN "LOW" AND, (2)IMPORTANCE AS MIGRATION ROUTE IS "HIGH" OR "VERY HIGH" OR (3)CONSERVATION & NATURAL AREAS IS "HIGH" OR "VERY HIGH" OR (4)INTOLERANT SPECIES ARE "HIGH" OR "VERY HIGH" WHERE HABITAT FLOW SENSITIVITY OR FLOW RELATED WATER QUALITY IS "HIGH" OR "VERY HIGH"		
ECOLOGICAL IMPORTANCE & SENSITIVITY:	**HIGH**	

The above table illustrates a HIGH importance, which supplies motivation for improving the system.

4.2.2 Social Importance

This section refers to the importance of the system to any person dependant on a natural and healthy functioning system. It also includes the importance of cultural issues related to the river. The results of the DSS is displayed in Table 4.3 below:

Table 4.3 : Social importance

CRITERIA	**RATING**
Dependance on a healthy lake ecosystem (value from 0 - 4)	
People directly dependant on a healthy river:	2
People dependent on riparian plants for building, thatching, craft or medicinal plants:	1
People dependant on the river for subsistence fishing:	1
People using the river for recreational purposes:	2
Cultural/historical values (value from 0 - 4)	
Sacred places on the river, and religious/cultural events connected to the river:	3
Historical/archaeological sites on the river:	1?
Special features and beauty spots on the river:	1 (small gorge next to N3)
General aesthetic value of the river:	2
IMPORTANCE RATING	**1.65 - MODERATE**

The social importance rating is moderate and does not add to the motivation to improve the system.

4.3 ECOLOGICAL MANAGEMENT CLASS (EMC) AND ASSOCIATED FLOW REQUIREMENTS

4.3.1 Selected EMC

Based on the present state evaluation and the importance rating, the most realistic EMC was selected for which to determine the IFR (see Table 4.4). The EMC is set in terms of classes A (unmodified) to D (largely modified). The EMC was determined as follows:

Instream EMC: B (present state = C/B) **Riparian EMC : C** (present state = C)
Specific objectives to achieve this class are to:
- Maintain perennial flow & variability.
- Maintain present diversity of instream biota
- Re-establish greater natural flow variability
- Maintain present water quality
- Discourage the establishment of alien fish (eg by i.e. establishing the natural variability)
- Maintain present channel conditions (see geomorphological motivation below)
- Prevent further reedbed encroachment

Geomorphological motivation : Reason for present state and objective
Middle Tugela Catchment is quite densely populated and consists of Ecca formation (shales & mudstones). This gives rise to highly erodible Mizpah and Glenrosa soils or to Carty, Kroonstad or Hutton Soils of moderate to high erodibility. The central Thukela is covered by Karoo and Karoid vegetation and surface runoff tends to be high during heavy storms. The result of high

population density on the land, and low biological carrying capacity produced severe degradation and erosion due to high sediment loads in the river.

Reduced flows as a result of Spioenkop together with high sediments into the system downstream results in an aggrading channel characterised by sand bars (islands) which are populated and stabilised by reeds. Channel narrowing appears to be the result.

Flows to be recommended for Site A should maintain present channel conditions i.e. prevent more aggradation, island formation, channel narrowing and loss of hydraulic habitat. To do this the IFR needs to facilitate the movement of material through the system and to include flow variability to inhibit further reed encroachment.

4.3.2 Flow requirements

The flow requirements were set for maintenance (those flows required to, during years other than droughts years, to achieve the EMC) years and drought (the lowest flows the system can experience during a natural drought).

Assurances were coupled to maintenance and drought flows based on the hydrological characteristics of the flow regime. Annually the system is not very variable which is typical of river which originate in the Drakensberg. The Thukela River shows a moderate base flow contribution with a reasonable variation within months, but flow is reliable annually. Based on this, a lower range of assurance of 55/60% of the time for the maintenance flows were set.

The results are provided in Table 4.4 below

Table 4.4 :
IFR A : Thukela River, Skietdrift **VIRGIN MAR**

IFR MAINTENANCE LOW FLOWS	OCT	NOV		DEC		JAN		FEB		MA R		AP R	MA Y	JUN	JUL	AUG	SEP	TOTAL X6 m3/s	% of MAR
FLOW (m3/s)	2.8	4		6		8		10		9.5		7	4.5	3.5	2.9	2.5	2.6		
DEPTH (m) section	2.7	.32		.4		.47		.52		.51		.44	.35	.31	.28	.26			
FDC% (VIRGIN)	61	90		92		96		95		92		88	84	90	89	90	64		
VOLUME (x6m3)	7.5	10.4		10.1		21.4		24.2		25.5		18.1	12.1	9.1	7.8	6.7	6.8	165.47	18.2
IFR MAINTENANCE HIGH FLOWS																			
FLOW (Instantaneous peak m3/s)		30	20	40	25	50	30	150	30	50	25	40							
DEPTH (m) section		.91	.74	1.05	.83	1.18	.91	2.05	.91	1.18	.83	1.05							
DURATION (days)		3	3	4	3	4	3	4	3	4	3	4							
FDC% (VIRGIN)		24	38	30	50	34	58	13	74	34	65	17							
VOLUME (x6m3)		6.5		9.6		11.6		40.8		11.1		6.5						86	9.5

IFR DROUGHT LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	AP R	MA Y	JUN	JUL	AUG	SEP	TOTAL X6 m3/s	% of MAR
FLOW (m3/s)	1.5	1.8	2.4	2.9	3.3	3.1	2.4	1.8	1.6	1.3	1.2	1.3		
DEPTH (m) section	.2	.22	.25	.28	.3	.29	.25	.22	.21	.19	.18	.19		
FDC% (VIRGIN)	100	99	100	100	100	100	100	100	100	100	100	99		
VOLUME (x6m3)	4	4.7	6.4	7.8	8	8.3	6.2	4.8	4.1	3.5	3.2	3.2	64.29	7.1
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		12	14	16	50	14								
DEPTH (m) section		.57	.62	.66	1.18	.62								
DURATION (days)		3	3	3	3	3								
FDC% (VIRGIN)		58	72	82	52	83								
VOLUME (x6m3)		1.6	1.8	2	9.5	1.7							16.6	2.7

The overall % of the MAR over a time series that includes maintenance and drought flows is 26.2%.

4.3.3 Motivations for flows

The following abbreviations are used in the tables below :
Hyd = Hydraulic. Pers observ = personal observation by the relevant specialist. Hydro = hydrological
Perim = perimeter Profile = cross-section

DROUGHT FLOWS - LOW/BASE FLOWS

AUGUST FLOW : 1.2 m^3/s

Description of flow	**Hyd param**	**Motivation**	**Why not lower**	**Source :**
PRIMARY MOTIVATOR				
Fish : 18cm max depths on Section B	Depth	Lowest base flow acceptable for winter conditions. Pool areas now just deep enough for fish refuge.	Lower level will result in excessive warming of water and restriction of fish movement from pool to pool.	expert judgement
SECONDARY MOTIVATOR				
Aquatic invertebrates	Wetted perim	Habitat availability based on wetted perimeter	n/a	photos, surveys, pers observ

FEBRUARY FLOW : 3.3 m^3/s

Description of flow	**Hyd param**	**Motivation**	**Why not lower**	**Source :**
PRIMARY MOTIVATOR				
Fish: 30 cm max dept on section B	depth	Absolute minimum level acceptable for even reduced degree of fish spawning in nearby rapids.	Excessive siltation of spawning gravel will occur.	Expert judgement

MAINTENANCE FLOWS - LOW/BASE FLOWS

AUGUST **FLOW : 2.5 m^3/s**

Description of flow	**Hyd param**	**Motivation**	**Why not lower**	**Source :**
PRIMARY MOTIVATOR				
Aquatic invertebrates: Sufficient to increase habitat availability and diversity (fringing vegetation based on depth) Section B	Depth	Increase in habitat availability and diversity - fringing vegetation has a distinct invertebrate community that requires that habitat.	No submergence of base of fringing vegetation	photos, profiles
SECONDARY MOTIVATOR				
Fish: 28 cm maximum depth (on section B)	Depth	Acceptable depth for fish survival during winter.	n/a	Profile study

FEBRUARY **FLOW : 10 m^3/s**

Description of flow	**Hyd param**	**Motivation**	**Why not lower**	**Source :**
PRIMARY MOTIVATOR				
Riparian vegetation: Gets water to the top of the marginal vegetation zone i.e. inundates the whole marginal riparian zone (LB). Sufficiently covers a large proportion of the mid channel bars and vegetated blinds.	Depth	Provides sufficient water to the marginal vegetation to maintain it and encourage flowering and seed set. Will also provide suitable wetted and inundated habitat amongst marginal vegetation for fishes and invertebrates. Sufficient depth over mid channel islands will discourage the spread and colonisation of reeds on these islands due to the extended inundation of these during a period of fast reed growth rate:	Would lead to a restriction on width of the marginal zone and reduced habitat for fish and invertebrates. Would encourage the increase in colonisation rate by reeds on mid channel islands and bars.	Pers observ, expert judgement.
Geomorphology: Velocity (0,5m/s) Flows to start scouring the channel bed i.e. rock cobbles - gravel	velocity	0,5m/s (energy slope 0.005) will move sand, gravel and small cobble.	Need the variability to meet the objectives.	Study, expert judgement

SECONDARY MOTIVATOR				
Fish:	depth	Satisfactory inundation of marginal vegetation for juvenile fish habitat. Fines and gravels become cleaned ready for limited spawning of fish.	n/a	profile
Aquatic Invertebrates Flow to clean gravels	velocity	This flow will mobilize gravels, scour them of silts and improve invertebrate habitat.		expert judgement, DWAF data base

MAINTENANCE FLOWS - HIGH FLOWS (in instantaneous peaks)

NOVEMBER, DECEMBER, JANUARY, FEBRUARY, MARCH **Flow : 30&20; 40&25; 50&30;30; 50&25m^3/s**

Description of flow	Hyd param	Motivation	Why not lower	Source :
PRIMARY MOTIVATOR				
Geomorphology (relevant for largest flood in each month)	velocity	A velocity to keep material moving through the system. 30m^3/s = 0,8m/s - moves everything and cobbles 40m^3/s = 0,9m/s - moves everything and small boulders 50m^3/s = 1m/s - moves everything and medium boulders	Sufficient bed material to maintain habitats in acceptable conditions will not be moved.	-
Fish :	Velocity	Nov & Dec : To initiate dispersal and pre-spawning migrations at the end of winter Jan & March : To initiate fish spawning in mid and end summer and to inundate marginal vegetation and cobble beds for spawning purposes.		Expert judgement

Riparian vegetation : 20 - 30m^3/s : Sufficiently cover a large proportion of mid-channel islands during wet season. 50m^3/s : Gets water onto the first riparian terrace : just beyond the marginal vegetation zone on both banks.	Depth	Nov : Extended coverage of mid channel islands and bars during freshes in additional to high base flows will discourage the further spread and colonisation of reeds on these islands. (The exposure of islands during the period of Nov-March with regular provision of sediment drapes encourages the spread of reeds.) The extended inundation of islands during the active growing season will reverse this trend. Jan : Deposits sediment into the marginal vegetation zone and encourages its growth and vitality by the provision of nutrients and fresh substrate. Also maintains the extent of this zone, encouraged by the provision of water and nutrients to areas beyond the zone on the lower terrace.	Would encourage further colonisation and encroachment of reeds on mid channel islands and eventual closing in of active channel. Would lead to a restriction of the marginal riparian zone.	Profile, expert judgement, pers observ.
SECONDARY MOTIVATOR				
Aquatic Invertebrates: Flow variation	-	Flow variation in summer months is desirable for invertebrates as it is the natural state of affairs. Benefit of flow variation is indirect through maintaining channel form, and biotopes diversity.	n/a	expert judgement, pers observ

FEBRUARY **Flow : 150m^3/s**

Description of flow	Hyd param	Motivation	Why not lower	Source :
PRIMARY MOTIVATOR				
Geomorphology : Fill the channel	velocity, depth, width	Will move all material with an average velocity of 1,5m/s	Needs to fill entire channel to achieve objective	-
Riparian vegetation : Flows to cover lower riparian terrace and get to the base of the higher terrace on the left bank.	Depth	To ensure deposition of sediments on lower terrace for provision of nutrients for marginal vegetation and lower terrace. Also moves any accumulated debris in the same area. Movement and distribution of seeds and propagules on lower terrace.	Marginal zone may become restricted in width	Profile, pers observ.
SECONDARY MOTIVATOR				
Fish :	Velocity	To initiate spawning in midsummer and to inundate marginal vegetation and cobble beds for spawning purposes.	n/a	expert judgement

ONCE PER 3 YEARS **Flow : 300m^3/s**

Description of flow	Hyd param	Motivation	Why not lower	Source :
PRIMARY MOTIVATOR				
Geomorphology : To fill channel to the back of the terrace	velocity, depth, width	This is the true channel maintenance flood (i.e. also maintains the flood plain)	Terrace development will not happen	-
Riparian vegetation : Flows to get to terrace on the right bank and to provide water to base of *Combretum erythrophyllum* trees on this terrace.	Depth	To deposit sediment at the base of the *C. erythrophyllum* trees and on the higher right bank terrace to establish the right environment for the distribution of seeds, the germination of seeds and establishment of seedlings of *C. erythrophyllum*. The same flows will also move debris and other detritus into the river which will act as cues for other biota.	The population of C erythrophyllum may not be maintained due to failure and reduction in recruitment rates.	Profile, photos, pers observ. Expert judgement.

DROUGHT FLOWS - HIGH FLOWS (in instantaneous peaks)

NOVEMBER, DECEMBER, JANUARY, MARCH **Flow : 12, 14, 16, 14m^3/s**

Description of flow	Hyd param	Motivation	Why not lower	Source :
PRIMARY MOTIVATOR				
Geomorphology: To provide some sediment movement	velocity	A velocity to keep some material moving through the system. 20m^3/s = 0,65m/s 25m^3/s = 0,75m/s 30m^3/s = 0,83m/s Will move material up to the small cobble range and the variety of size flows add some variability. Some clay to gravels will be moved (Hiulstroom curve) Some clay to cobbles will be moved (Mannings curve)	Up to small cobbles need to move as there are many localised pockets in the system.	-

Fish :	Velocity	Nov, Dec : Increased flow velocity necessary to stimulate pre-spawning migrations and to initiate redispersal of populations after winter. Jan, Feb, Mar : Larger floods required during midsummer, when adult fish are ready to spawn to stimulate spawning, to inundate marginal vegetation and new cobble beds where spawning can take place	Lower flows may not initiate spawning and migration.	Expert judgement

FEBRUARY Flow : 50m^3/s

Description of flow	**Hyd param**	**Motivation**	**Why not lower**	**Source :**
PRIMARY MOTIVATOR				
Geomorphology: To provide some channel maintenance	velocity	50m^3/s = 1m/s will move all material up to medium boulders.	Need to move a wider range of material.	-

4.4 MATCHING OF IFR SITE A WITH IFR SITE 2

When comparing the results of IFR site A and 2 as determined during January 1997, (Table 4.5) the following statements can be made:

- Taking into account the increase in MAR and the fact that floods could be generated in tributaries and not just within the main channel, the match between the high flows seem reasonable.
- The base flows however do not match with flows at IFR site A generally being the same or larger than those recommended for IFR site 2. Taking into account the increase in MAR and catchment area, flows at IFR site A should generally be less than those at IFR site 2. The explanation for this discrepancy was provided by Prof O'Keeffe and Dr Wadeson as follows:

Table 4.5 : Comparison between IFR A and IFR 2 results

IFR MAINTENANCE	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**
IFR A FLOW (m^3/s)	2.8	4	6	8	10	9.5	7	4.5	3.5	2.9	2.5	2.6
IFR 2 FLOW (m^3/s)	3	5	7	8	9	8	7	5	3.5	2.5	2	2
IFR MAINTENANCE HIGH FLOWS												
IFR A FLOW (Instantaneous peak)		30	40	50	150	50	40					
IFR 2 FLOW (Instantaneous peak)	13	20	60	70	200	50	30					

'Floods as a result of Domoina and October 1987 made large changes to the channel morphology of various parts of the Thukela Basin. IFR site A was not seriously affected - probably as a result of the attenuation effect of Spioenkop Dam and its position in the headwaters of the Thukela River. Therefore the macro channel was not affected in as dramatic a way as further downstream. IFR A therefore has an active channel approximately 40 m wide within a macro channel of approximately 70 m width, i.e. a ratio of active to macro of 1:2.

In IFR 2 (approximately 80 km downstream of IFR A), the added inputs of the little Thukela and the Klip produced considerably more runoff and therefore erosion potential. The river morphology was changed dramatically from a narrower-deeper channel with well designed morphology (riffle/pool) to a very wide shallow channel with a homogenous bed of boulders and cobbles. After 1987, the channel has been moving towards a new equilibrium i.e. a narrower channel again, therefore the active channel is approximately 40 m whereas the macro channel is approximately 160 m, i.e. a ratio of 1:4.

For example, a flow of $10m^3/s$ at site A provides a maximum depth of 0.5m and a wetted perimeter of 47 m compared with a flow of 9 m^3/s at site 2 which provides a maximum depth of 1 m and a wetted perimeter of 38m in the active channel. Therefore, similar or smaller base flows at site 2 provides the same (or better) habitat conditions for instream biota than at site A. However, to maintain the bankfull channels, much higher flows are required at site 2 than at site A as reflected in the larger flood recommendations.

At both sites it was accepted that the reduced flows and increased sediment inputs (from catchment land-use changes) will inevitably result in channel constriction and aggradation between major flood events. These recommendations can only be aimed at slowing this trajectory of change, so that intermittent floods will still be able to maintain the channel morphology in a new dynamic equilibrium.

An analysis of the above results led the specialists to conclude that the base flows for the two sites should not be matched in terms of the hydrological simulations.

In summary, the larger recommendations for floods at IFR 2 is to cater for a larger macro - channel scoured out by the floods.

4.5 CONFIDENCE IN IFR SITE A RESULTS

Each specialist evaluated the confidence in the IFR results according to Table 4.6 below.

Table 4.6 : IFR RESULT CONFIDENCE TABLE

PURPOSE : TO ATTACH A CONFIDENCE VALUE TO THE RESULTS OF THE IFR SET BASED ON THE DIFFERENT SPECIALIST VIEWPOINTS

NONE = 0 LOW = 1 LOW - MEDIUM = 2 MEDIUM =3
MEDIUM - HIGH = 4 HIGH = 5 L = LOW FLOWS H = HIGH FLOWS

NOTE :

- Confidence are only attached to low or high flows where motivations are supplied. If, for example motivations were not supplied for low flows, no motivation for confidence for low flows is supplied.
- Motivation for evaluations are supplied whenever necessary, specifically for low flows.

IFR SITES		FISH	RIP VEG	GEOMORPH	AQUATIC INVERTS	WATER QUALITY
1	L	4	-	-	3	-
	H	3	4	4	3	-

CHAPTER 5 : CAPPING FLOWS

Definition:
Elevated base flows which, if exceeded for extended periods, would have undesirable effects on the communities and/or ecological processes in a river.

Examples:
The issue of capping flows generally arises where there is a requirement for large constant flows to be released for downstream users, resulting in unnaturally high and constant base-flows in parts of a river. A typical example occurs in the middle reaches of the Great Fish River, where water is fed from the Orange River, via the Grassridge Dam, mainly to provide for downstream irrigation. As a result, base flows in these reaches are generally maintained at between 3 and 8 cumecs, where in winter under natural conditions, the flow would have ceased or been reduced to a trickle for several months. Major consequences of these constant elevated flows have been a reduction in hydraulic habitat diversity through time, or a maintenance of one set of hydraulic conditions. In the Fish River (as in parts of the Vaal and Orange), these conditions happen to favour one particular species of blackfly (*Simulium chutteri*), females of which are blood feeders. Because of the predominance of favorable habitat, huge swarms of the blackfly emerge from the river in spring, and cause major damage and disturbance to livestock. Such pest-swarms were not experienced prior to the transfer of water from the Orange River in the mid-1970's.

The aim of setting capping flows:
To maintain as much of the natural diversity of flows (and therefore habitats) in a river as possible; to prevent the dominance of any one type of high flow; and to prevent reversal of seasonal flows (eg winter flows higher than summer flows in summer rainfall areas).

Guidelines for setting capping flows:
(The following guidelines were developed at the Maguga IFR Worksession on the Komati river)

1. No constant increase in winter base flows
2. Constant winter baseflows should not exceed summer baseflows
3. Maintain as much of natural flow variability as possible

And for hydro-power releases:

4. No frequent flow rate changes (at daily/weekly scales)
5. Changes in release rates should be gradual.

Quantifying Capping Flows:
It is extremely difficult to set precise limits for capping flows, because it is probably the relative seasonal changes in flow, and the maintenance of variability that is more important than actual discharge levels. For example, to set winter capping flows at 3 cumecs might be interpreted as allowing for constant flows of 2.9 m^3/s through winter. It might also be interpreted as an embargo on **any** flows exceeding 3 cumecs. **Neither of these interpretations would be correct**.

The capping flows that are set should therefore be interpreted in the spirit of the above guidelines. In these terms a winter capping flow of 3 cumecs means that winter flows should fluctuate between the recommended IFR maintenance baseflow and 3 cumecs, but should be allowed to exceed this range in the event of unseasonal rainfall events, and to fall to the IFR drought recommendations during very dry years

CHAPTER 6 : IFR MODELLING AND FINAL IFR RESULTS

The IFR model represents an attempt to generate a representative time series of daily flow ecological requirements that are expected to result from the implementation of the output from an IFR workshop. The actual daily requirements are expected to be made up of a combination of low flow releases with flood event releases superimposed upon them. In keeping with the philosophy of the BBM methodology and the definition of when maintenance and drought flows should occur, the model uses climatic cues to determine the actual daily flow rates. The design flow rates are those which are defined through the workshop process. These are expected to vary from somewhat above the design maintenance low flows down to the drought requirements. In the case of the high flow requirements, the maintenance events represent the largest values and the climatic cues should determine when lower values are appropriate. The IFR model is fully described in a paper by Hughes, O'Keeffe, Smakhtin and King in Water SA, 23(1), 21-30.

The climatic cues within the model are derived by examining the daily flows within a 'Reference Flow' time series. This may be an observed record at an adjacent gauging station, or a simulated time series (by any appropriate model) of flows at the IFR site or elsewhere. The main consideration in the selection of an appropriate reference flow time series is that the patterns of flow are representative of the patterns of flow that would have occurred at the IFR site under natural (or other suitable development state that is considered acceptable to the workshop participants) conditions. The model derives the climatic cues in terms of low flow and high flow status values. These are expressed in terms of percentage points of the calender month 1-day flow duration curves for the reference flow site. Duration curve percentage points are used to allow better comparison across different catchments and are less affected by non-linear scaling effects than if flows were to be used directly. The low flow status value is a smoothed representation of the recent (past 30 days) baseflow conditions that have occurred at the reference flow site. The flood status value is a representation of the size of a flood that is about (within the next 10 days) to occur.

To be able to make use of the climatic cues (low flow and flood status values), a set of low flow and flood 'operating rules' are defined by the workshop participants. These represent threshold values which are compared, in the model, with the daily values of the climatic cues to determine the actual flow rate required on a specific day. For example, while the low flow status is above the relevant operating rule threshold a flow above the maintenance requirement would be simulated. As the low flow status decreases and drops to a level between the maintenance and drought rules, so the required flow decreases to below the maintenance design low flow toward the drought design low flow. A similar approach is used to control the flood or high flow requirements.

The operating rules are calibrated (progressively modified) until an acceptable pattern of time series of modified flows are achieved which satisfies the IFR workshop participants perceptions of the effects of their decision making process on the river. The type of things that they should be looking for is how frequently the modified flows drop below the design maintenance flows, how frequently and for what duration are the flows close to, or at the design drought levels, etc. A statistical summary programme is also provided that calculates (for each calendar month) the percentage of time that the modified flow regime is at, or above, maintenance, between maintenance and drought or at drought levels. These are effectively the recommended assurance levels of the different flows.

Once the model is satisfactorily calibrated, monthly summary data of total release volumes can be generated for the complete time series. These monthly time series data can then be further analysed to determine more detailed assurance values for the full range of flows that form part of the recommended modified flow regime. The time series or assurance levels can then be used in a conventional water resource assessment and reservoir yield model to determine if the planned impoundment can satisfy the expected abstraction demands as well as the IFR release requirement. The IWR at Rhodes University have also combined an existing daily reservoir simulation model with the IFR model to allow the same type of assessments to be made. In this model additional sets of operating rules have been established so that the abstractions are determined by reservoir storage levels and the IFR releases affected by rules based on the cumulative supply deficit as well as the climatic cues. This model is still in the development stage but is currently being applied, tested and evaluated.

Recent considerations and experience of the use of the models within IFR workshops suggest that it will be important in future to give more thought to what the 'maintenance' flows should be representing in terms of assurance levels. The models have conventionally been applied at the end of the workshop and it has been noted that the various specialists often have different perceptions of how frequently the maintenance flows should be occurring. It is suggested that this issue be clarified at the beginning of the workshop and that an approximate idea of what assurance level (or frequency of occurrence) the maintenance flows are to be designed for be agreed upon before setting the actual flow rates. The IFR model can be useful in this respect as it will allow the participants to develop a background impression of the natural variability of the flow regime and apply their specialist ecological knowledge in a better context.

Final IFR results at IFR A after the application of the IFR model:

Table 6.1 : IFR model results

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Monthly summary for Total Release starting 01/10/1965
Time weighted totals

SA Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
01 1965	5912.95	18836.3	19867.2	21137.6	29697.6	26850.7	10073.8	10815.9	5495.48	3494.88	4002.46	5155.17	161340.3
01 1966	5460.16	18803.3	28485.1	35877.5	66638.4	40617.3	26350.4	13048.4	9460.23	8139.06	7003.19	7116.18	266999.6
01 1967	5903.89	16968.6	23628.9	19478.2	31788.7	32866.2	19658.5	13046.2	9460.23	8139.06	6952.04	7116.18	195007.2
01 1968	6875.19	12417.7	26627.9	16481.3	44461.8	38585.8	26350.4	13048.4	9460.23	8101.99	5431.45	5304.01	213146.5
01 1969	7987.62	18841.5	28485.7	34657.1	29089.4	19975.6	12262.6	6678.88	4169.69	3494.88	4263.79	7108.87	177015.9
01 1970	9100.70	18840.6	16388.6	32301.9	65217.2	37960.8	19280.1	11286.3	9448.52	8111.92	5334.00	5236.70	238507.8
01 1971	6054.75	16149.7	23136.5	31728.7	66988.5	40649.2	26350.4	13048.4	9460.23	8139.06	6118.86	4960.45	252785.1
01 1972	6016.69	16087.0	21796.4	9859.26	41550.6	27791.7	25832.6	13008.1	9172.12	3947.23	6494.81	7067.45	188624.3
01 1973	9100.70	18841.5	28485.7	35877.5	66638.4	40649.2	26350.4	13048.4	9460.23	8139.06	7003.19	7070.29	270665.0
01 1974	6205.22	17195.4	28485.7	34492.2	66638.4	40649.2	26350.4	13048.4	9460.23	8139.06	7003.19	7116.18	264784.0
01 1975	9100.70	18841.5	28485.7	35877.5	67631.0	40649.2	26350.4	13048.4	9460.23	8139.06	7003.19	7116.18	271703.5
01 1976	9100.70	18841.5	28485.7	34287.5	51337.0	49626.2	26233.8	13048.4	9460.23	8139.06	7003.19	7116.18	262679.7
01 1977	9100.70	18841.5	28485.7	35877.5	66638.4	40649.2	26350.4	13048.4	9460.23	8139.06	7003.19	7116.18	270710.9
01 1978	9100.70	18841.5	28485.7	35877.5	64482.3	42740.6	24896.1	13195.7	9381.18	8112.69	7003.19	7116.18	269233.7
01 1979	8684.18	16308.9	15903.9	28203.2	61333.6	37791.1	24757.3	9134.64	7390.77	7420.96	6832.72	6682.74	230444.3
01 1980	8181.77	14122.3	26479.1	35186.2	66638.4	38552.1	16168.2	10468.4	8900.27	8097.11	6818.35	7116.18	246728.6
01 1981	7924.96	14879.1	27335.0	31242.4	11753.6	23180.3	25139.4	12905.0	9457.26	8129.29	6746.02	6796.93	185489.4
01 1982	6023.06	17999.3	10339.2	18340.7	15362.4	10837.1	6721.91	4847.04	4155.84	3571.54	3445.96	3443.66	105087.9
01 1983	6683.15	18104.0	28415.4	35741.1	55734.3	30658.2	26350.4	11423.1	7853.51	6400.28	6004.90	6887.80	240256.5
01 1984	5966.65	7314.73	7421.75	22548.6	60532.4	36500.9	6726.13	5443.28	4810.13	4789.83	5388.21	5993.77	173436.6
01 1985	6390.12	17636.2	29123.4	35522.4	66547.3	25951.6	20481.2	13045.7	9433.25	7416.63	6490.89	7116.18	245155.3
01 1986	8839.32	18841.5	28485.7	31694.5	60258.7	35075.4	17059.8	6521.51	5826.15	5883.92	6402.26	7116.18	232005.3
01 1987	9100.70	18841.5	26043.4	30356.2	63841.6	40649.2	26350.4	13048.4	9460.23	8139.06	7003.19	7116.18	259950.4
01 1988	8083.02	17465.4	28485.7	35877.5	66638.4	40570.5	25778.6	13048.4	9460.23	8139.06	6779.04	5228.16	265554.5
01 1989	5381.88	15996.3	28165.0	30947.1	56495.8	21356.3	16063.5	9882.38	8279.80	8021.16	6819.46	6886.57	214295.6
01 1990	6507.44	13079.7	21649.7	32068.6	66638.4	35218.9	16258.1	7361.31	7617.80	6722.59	5768.58	5067.30	223958.7
01 1991	7583.07	18841.5	26216.2	25283.3	47044.3	25229.6	6825.66	4849.43	4545.19	5719.71	4446.37	4025.59	180610.1
01 1992	4852.27	7609.96	9936.43	9059.58	55841.7	22420.7	8928.93	5469.32	4430.18	4824.28	3292.14	3938.83	140604.3
01 1993	8895.26	18837.6	27257.2	35877.5	29706.7	40484.3	25425.2	12938.4	9329.02	8089.01	6878.95	6248.65	229968.1
01 1994	6321.01	8356.34	7421.75	13926.4	31099.4	24883.9	18299.9	10879.9	7689.58	7716.35	4882.57	5062.79	146540.1
01 1995	4901.76	13409.4	28309.9	35877.5	67631.0	40649.2	24970.2	14428.7	9460.23	8139.06	7003.19	7116.18	261896.7
01 1996	9100.70	18841.5	28485.7	35877.5	57048.9	48837.1	26350.4	13048.4	9460.23	8139.06	7002.87	-9.00	-9.00

These results are provided as % rule curves for use in the Water Resources Yield Model.

CHAPTER 7 : IFR SCENARIO MEETING

The IFR results for IFR A, 2, 5, 3a & 3b were modelled using the Water Resources Yield Model (WRYM). The water available after supplying the IFRs served as the available yield for the users. The IFRs had a significant effect on the available yield.

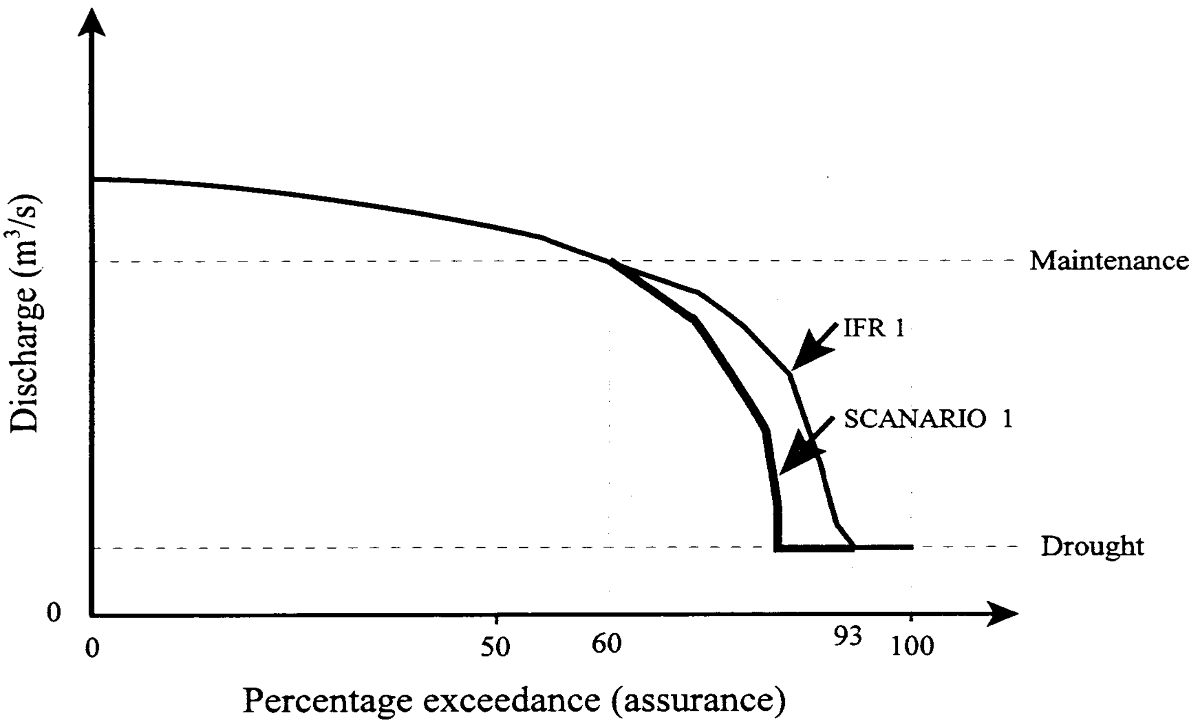
IFR scenarios were then formulated and these were evaluated from an ecological viewpoint and the possible impacts on the river of these scenarios described.

7.1 SCENARIO 1 : EXTENDED DROUGHT

Maintenance flows and the assurances of maintenance flows stayed the same in this scenario. However, the occurrence of drought flows increased by 50%. Therefore, if the drought flows at IFR A occurred 7% of the time (as was determined by the IFR model), it will not occur at 14% of the time. This scenario is illustrated by means of a duration curve in Fig 7.1

Figure 7.1 : Scenario 1

As the scenario meeting was held immediately after the specialist meeting during which IFR A was determined, the impacts for these scenarios where described using IFR A as the indicator site. IFR A was



the site most recently visited and therefore fresh in minds of the specialists.

The impact in general would be to cause
- longer continuous periods of droughts;
- and short periods of droughts occurring more often.

The impacts on the IFR components are described in Table 7.1:

Table 7.1 : Impacts on the IFR components caused by scenario 1

IFR component	Impact	EMC change*
Geomorphology (long term)	Increased aggredation.	½ down (less impact in gorge)
Aquatic Invertebrates	Very low flows will increasingly occur in summer with extreme and probably lethal temperatures and dissolved oxygen concentrations. More precisely low flows o high temperature o low turbidity o increased algal growth o night-time oxygen consumption o low dissolved oxygen at dawn o possibly oxygen stress for invertebrates (and fish). High temperature will also lead to lower dissolved oxygen saturation	½ down
Fish	Detail described below: Less living space for adults - mainly juveniles will occur. Exotic fish will be encourages Communities will change Amphillius habitat will be reduced Increase in Potamogetan.	1,½ down
Riparian vegetation	Shift in species composition from riparian to terrestrial species. Restriction in marginal vegetation	½ - 1 down (less impact in gorge)
General	Reduce resilience Increased risk of ecosystem damage Less opportunities of recovery The above would be superimposed on long-term degradation of the river already taking place.	1 down

* This relates a change in EMC in relative terms. A half a class refers to a 10% change with a class comprising 20%, i.e. if C = 20% then ½C = 10%.

It must be noted that for the Spioenkop Reach, these flows still represent a better scenario than the continued present operation of Spioenkop Dam.

Detail impacts on fish:
Age-composition effect:
Extended periods of shallow water conditions especially over cobble and boulder habitats will prevent adult fish from occupying these areas for longer, leaving only juvenile fish resident. Adult fish will withdraw downstream to deeper pools - which are limited in the reach between Skietdrift and the N3 road bridge.
Predation effect:
Predation by kingfishers (eg) is greater in shallow water. Therefore juvenile populations could be more severely reduced than would otherwise happen.
Breeding failure:
Extended drought will reduce the flows needed for removing silt from the spawning gravel beds used by scaly and labeos. In some years these species may therefore not spawn at all.
Amphillius habitat :
Extended droughts will prolong the period over which cobble beds and riffles suitable for Amphilius are exposed and uninhabitable. The abundance and distribution of Amphilius would be greatly reduced.
Waterweed abundance:
Potamogeton will proliferate in backwater areas. This could be an advantage for juvenile fish which shelter amongst it.
But *Spirogyra* will also proliferate more than before, and the combined effect of oxygen depletion by waterweeds could adversely affect fish.

Alien fish:
Under low flow conditions, more carp and bass juveniles are likely to survive in the main river. Increased abundance of aliens will lower the EMC of the site.

7.2 SCENARIO 2 : 10% REDUCTION OF ALL FLOWS

All flows were reduced by 10% (See Fig 7.2). IFR A were again used to evaluate the impact and all the recommended flows were reduced by 10% and then converted to depths and the other relevant hydraulic parameters. The decrease in habitat (Table 7.2) was then evaluated.

Figure 7.2 : Scenario 2

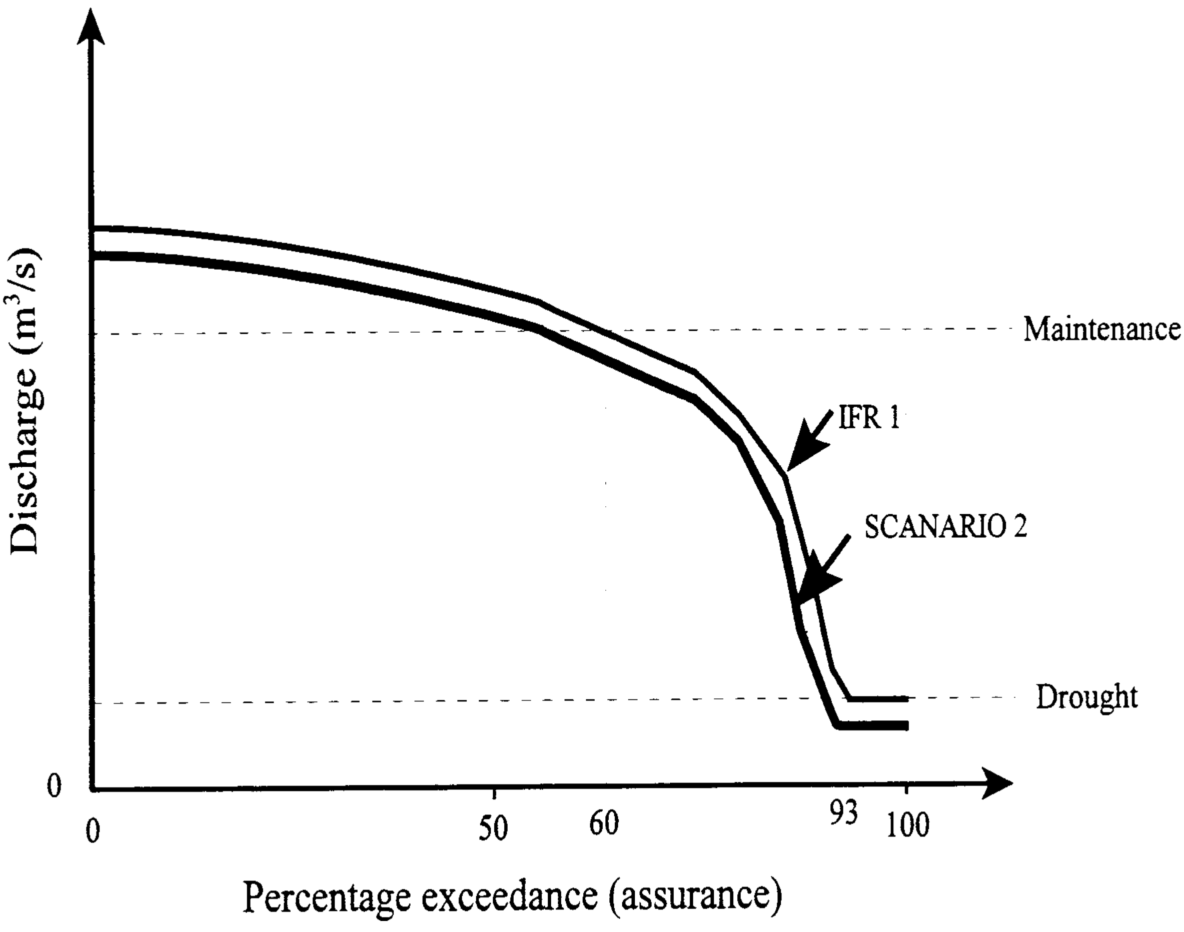
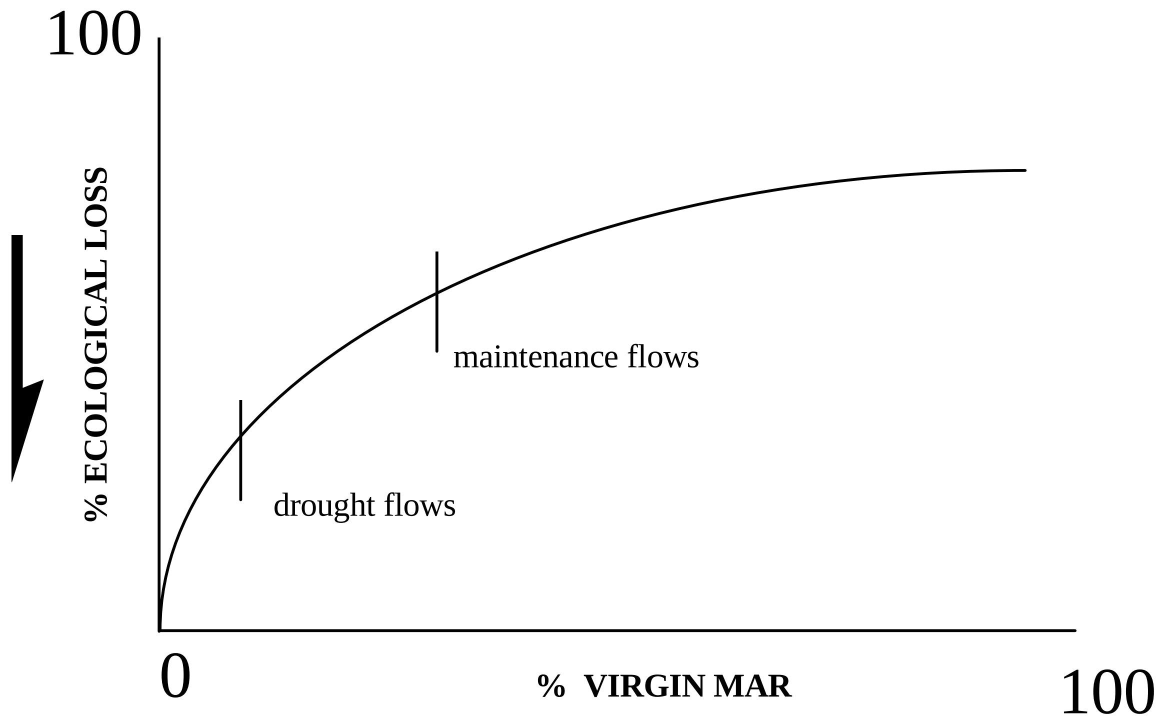


Table 7.2 : Decrease in habitat at IFR A 10% less than the recommended IFR are modelled.

TYPE OF FLOW	SCENARIO	FLOW RATE (m^3/s)	DEPTHS (m)	DIFFERENCE (DEPTH)(m)
Maintenance August Low	IFR	2.5	0.254	0.01
	Scenario 2	2.25	0.241	
Maintenance February Low	IFR	10	0.512	0.027
	Scenario 2	9	0.485	
Drought August Low	IFR	1.2	0.175	0.009
	Scenario 2	1.08	0.166	
Drought February Low	IFR	3.3	0.292	0.015
	Scenario 2	2.97	0.277	

In general it was difficult to determine exact impacts as the small decreases in depth were beyond the level of resolution that impacts could be coupled to. However, an attempt was made to quantify these impacts based on a % loss of habitat (composite loss of depth/width/velocity) (Table 7.3) and the following figure (Fig 7.3) to describe the implications on the aquatic ecosystem. This figure also illustrates the fact that the impacts of this scenario on drought flows are probably worse than on maintenance flows. Decrease in drought flows leads to a proportionately larger loss of ecological quality and a higher possibility of ecosystem failure.

Figure 7.3 : Loss of ecological habitat vs the IFR as % of virgin MAR



This scenario leads to a loss of habitat diversity of 10 to 15%. This translates to a loss of 5-6% depth, 1-6% perimeter and 2-3% velocity. This scenario will still create better conditions than at present at IFR site A.

Table 7.3 : Impacts on the IFR components caused by scenario 2

IFR component	Impact	EMC change*
Geomorphology (long term)	Increasing bank instability over the long-term. For example, a drought followed by a large flood will lead to bank erosion. The river will still be aggrading due to reduced flow and constant sediment input from tributaries.	1 down (long-term - 50 years and is a combination of flow and increased catchment degradation.
Aquatic Invertebrates & Fish	Loss of habitat diversity in depth, wetted perimeter and velocity which will have short-term effects on the distribution and abundance of instream biota.	½ long term
Riparian vegetation	Short & long term effects leading to the lowering of wetted capillary areas (shrinks in dry times and faster in droughts) to beyond the rooting zone. The rate is more important than the size of decrease. Increasing moisture stress will lead to increasing risk of die-off, in sensitive riparian species (medium term impact). This could be seen as a Threshold of Potential Concern	reduction within class (short term) ½ down long term

* This relates a change in EMC in relative terms

7.3 SCENARIO 3 : DRY SEASON DECREASE OF ASSURANCE

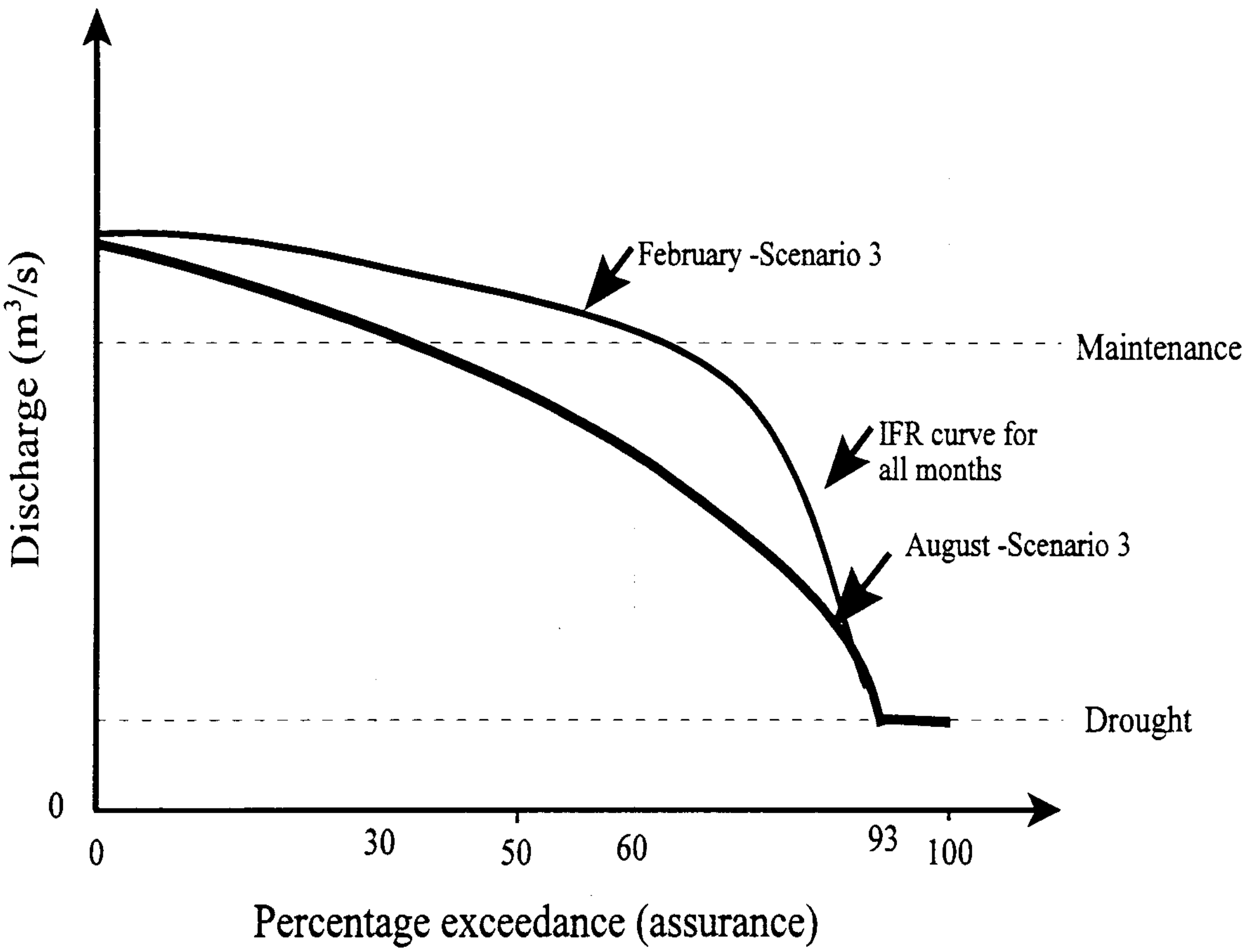
The scenario (Fig 7.4) consists of

- the summer flows (December to March) to be maintained at the assurance set during the IFR determination
- winter flows with a decreased assurance compared to the assurance set during the IFR determination. Flows in the month of August therefore were specified to have an assurance of 60 % and will no have an assurance of 30 %. Winter flows for the other months will proportionately decrease to the following:
-
    - April 54%
    - May 48%
    - June 42%
    - July 36%
    - Aug 30%
    - Sep 38%
    - Oct 46%
    - Nov 54%

- High flows stay the same.

Figure 7.4 : Scenario 3 - Impacts on February and August.

The specified flow IFR for August at Skietdrift was 2.5 m^3/s at 60% assurance. This flow now only occurs 30% of the time in Scenario 3 and the flow that occurs 60% of the time in the scenario is 1,9 m^3/s. Therefore the following situation will occur not for an additional 30% of the time:



- Depth reduction of 3,5 cm, i.e. 13%)
- Wetted perimeter reduction of 2%
- Velocity perimeter reduction of 3%

The impacts of this is described in Table 7.4.

Table 7.4 : Impacts related to Scenario 3 on the IFR components

IFR component	Impact	EMC change*
Geomorphology (long term)	Unquantifiable effect since there is low sediment inputs during low flows.	No short term change
Aquatic invertebrates	Minimal impact, will recover	No short term change
Fish	Minimal impact as long as the first fresh occurs.	No short term change
Riparian vegetation	Minimal impact as vegetation is document during winter	No short term change

* This relates a change in EMC in relative terms

7.4 PRIORITISATION OF THE SCENARIOS

The scenarios in the order of least to most damage to the riverine ecosystem are as follows:

- Scenario 3
- Scenario 2
- Scenario 1

It must be noted that scenario 3 is by the least deleterious of the three scenarios.

7.5 FURTHER WORK AND RECOMMENDATIONS

General discussion led to the following observation and recommendation:

- To date IFRs have never been released from a dam. Even though the allocation for the IFR volume could be available from a dam, the operation to achieve the specified flow regime, i.e. small freshes and floods over a certain period of time and with a certain peak must still be determined. It is possible that this could be problematic the further from the dam due to attenuation in the channel.

- IFR specialists should be involved during all phases of the development, especially the design, construction and operating phase. This is the area where the most development of the IFR process is required, as well as developing of engineering mechanisms to accommodate the IFR.

- It is preferable for the ecological Reserve to be determined for the River System as a whole, instead of doing it section for section. This is advantageous as the whole system would be then be investigated and continuity would be assured. If the IFRs are set independently for each section of the river, they will almost inevitably have to be revisited due to inconsistencies between tributaries and mainstream, and between up and downstream sections.

- The process of determining the Ecological Reserve should not stop at the point where the flow has been determined, but should follow through to consider how it will be supplied, and how dams on the system should be operated.

- Accordingly where an existing dam is present in the system for which an IFR or Reserve is being determined, it would be useful to have a person present who is knowledgeable about the practicalities of operation of such a dam. This person should be involved when designing the Scenarios to be investigated.

- Scenario 3 above was generated at the Scenario Meeting and was not modelled. The scenario must now be modelled and then the results distributed to the participants.

APPENDIX A

HIGH FLOW CALIBRATION

Thukela River water project feasibility study
Refinement of 1997 instream flow requirement

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Contents

1 Introduction

During the 1997 instream flow requirement (IFR) refinement specialist meeting (21 to 24 January, Weenen, Kwazulu-Natal) floods were experienced at the IFR sites on the Thukela and Bushmans Rivers. No flood data were available for the refinement study (refer to Tables 1 and 4), and consequently the opportunity was taken to measure surface flow velocities from the high-level bridges downstream of site 2 (Thukela) and across the Bushmans River at the town of Weenen. Stage levels were also recorded at the river cross-sections at sites 2 and 3B during the specialist site visits. In order to estimate the flood discharges and utilise the additional rating data, it was, however, necessary to survey the bridge profiles from which the flow measurements were taken - a task undertaken in September 1998. This document presents the refinements to the rating relationships and changes to the January 1997 recommended discharges based on the refined hydraulics.

2 Refinement based on additional flood rating data

2.1 Thukela River IFR site 2

The rating data used to develop the hydraulic relationships utilised at the 1997 specialist meeting are given in Table 1, with a highest measured discharge of 28.9 m^3/s (DWAF, 1997a). Surface velocity measurements were taken from the high-level bridge 2 km downstream of site 2 on 21 and 24 January 1997, and are given in Tables 6 and 7, respectively. A plot of the bridge profile showing the flood levels is illustrated in Fig. 3, and Fig. 4 is a photograph of the structure (facing downstream).

Table 1 1997 rating data for site 2 (DWAF, 1997a)

Discharge (m^3/s)	Flow depth (m)	
	Active channel	Backwater
2.2	0.73	1.01
3.4	0.86	
9.6	1.07	1.44
28.9	1.38	1.81

The average velocity in the vertical is obtained by multiplying the surface velocity by a coefficient. BS 3680 notes that the coefficient generally varies between 0.84 and 0.90 depending upon the shape of the velocity profile, with the higher values (0.88 to 0.90) obtained when the bed is smooth. Values outside this range may occur under special conditions. During the survey of the bridge profile, it was noted that the bed was highly irregular, containing large remnants of demolished concrete structures, backwater areas and scour holes around the piers. These will result in non-logarithmic velocity profiles through the vertical and the coefficient applied to the surface velocity to provide estimates the average velocity will consequently be low, particularly for low stage levels. For this reason, a coefficient of 0.8 was applied for the maximum recorded flood level (21/1/97) and a value of 0.5 (reflecting a triangular velocity distribution) was applied to the flood level measured 3 days later (refer to Fig. 3).

The January 1997 observed flood flows have been estimated at $145m^3/s$ and $312m^3/s$ - a substantial improvement in the high flow data for site 2. The 1997 and refined rating curves are plotted in Fig. 1 together with the observed stage-discharge data.

The modelled and measured flow depths (maximum) for these gauged discharges are given in Table 2. The observed flow depths represent reductions by only 6% and 11% for the gauged discharges of $145m^3/s$ and 312 m^3/s, respectively, and conversely an increase in discharge by 15% and 24% to achieve the observed flood depths.

Table 2 1997 and observed flow depths for IFR site 2

Discharge (m^3/s)	Flow depth (m)	
	1997 modelled	Measured
145	2.43	2.29
312	3.21	2.90

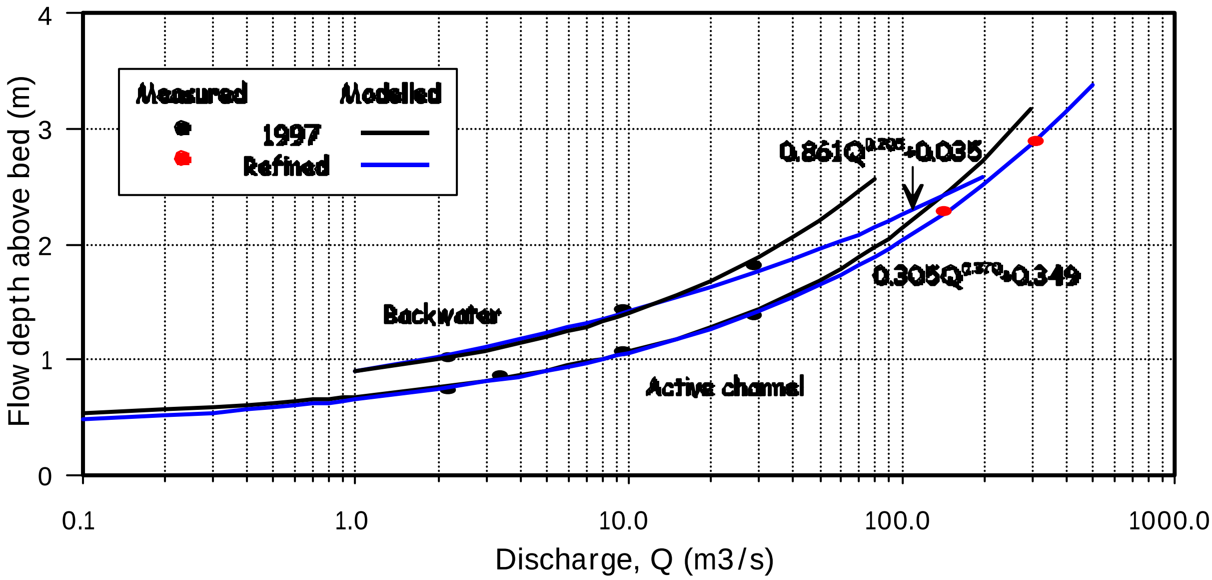

Figure 1 1997 and refined rating relationships for IFR site 2 on the Thukela River

The 1997 recommended discharges (DWAF, 1997b) have been refined (Table 3) based on the additional flood data.

Table 3 1997 and refined discharges based on flow depth

1997 discharge (m^3/s)	Flow depth (m)		Refined discharge (m^3/s)
	1997 modelled	Refined	
30	1.44	1.43	31
55	1.69	1.65	55
60	1.79	1.74	67
70	1.89	1.82	80
100	2.13	2.03	118
200	2.72	2.51	255

2.2 Bushmans River IFR site 3B

The stage-discharge data used to develop the hydraulic relationships utilised at the 1997 specialist meeting are given in Table 4, with a highest observed discharge of 20.1 m^3/s (DWAF, 1997a). Surface velocity measurements were recorded from the high-level bridge through the town of Weenen on 21 January 1997 (Table 8) and stage levels at the site were measured later on that day. Weenen is 19 km upstream of site 3B, somewhat compromising the accuracy of the flood measurement due to intervening flows and flood attenuation. A plot of the bridge profile showing the flood level is illustrated in Fig. 5, and Fig. 6 is a photograph of the structure (facing downstream).

Table 4 1997 rating data for site 3B (DWAF, 1997a)

Discharge (m^3/s)	Flow depth (m)	
	Section 1	Section 3
1.3	0.58	0.88
2.2	0.60	0.88
2.6	0.60	0.93
5.9	0.76	1.17
20.1	1.03	1.50

A coefficient of 0.8 was applied to the surface velocity to estimate the average velocity, and the cross-sectional flow area was reduced by 10% to account for the effects of debris snagging around the bridge piers and vegetation on the right bank (Fig. 6). The January 1997 flood discharge is estimated at $50m^3/s$. The 1997 modelled and measured flow depths are given in Table 5, and the additional rating data are plotted in Fig. 2 as well as the 1997 rating relationships for cross-sections 1 and 3.

Table 5 1997 and observed flow depths for IFR site 3B

Discharge (m^3/s)	Cross-section	Flow depth (m)	
		1997 modelled	Measured
50	1	1.39	1.38
	3	2.02	1.74

The additional data point coincides exactly with the extrapolated rating curve for cross-section 1 (transect used to assist with the determination of flows to meet fish requirements), whilst plotting lower than the extrapolated equivalent for cross-section 3 (section applied for riparian vegetation flow levels). Site 3B was, however, applied as a matching site to site 3A, and therefore no specific motivations were supplied for this site. Furthermore, according to DWAF (1997b), " the overriding component for site 3B is the fish component; the riparian vegetation is not likely to be affected". Also, there are only two high flows that will increase as a result of the refinement for riparian cross-section 3, viz. 33 m^3/s and 67 m^3/s. Consequently, there is no reasonable justification for increasing the two matched flood discharges at site 3B.

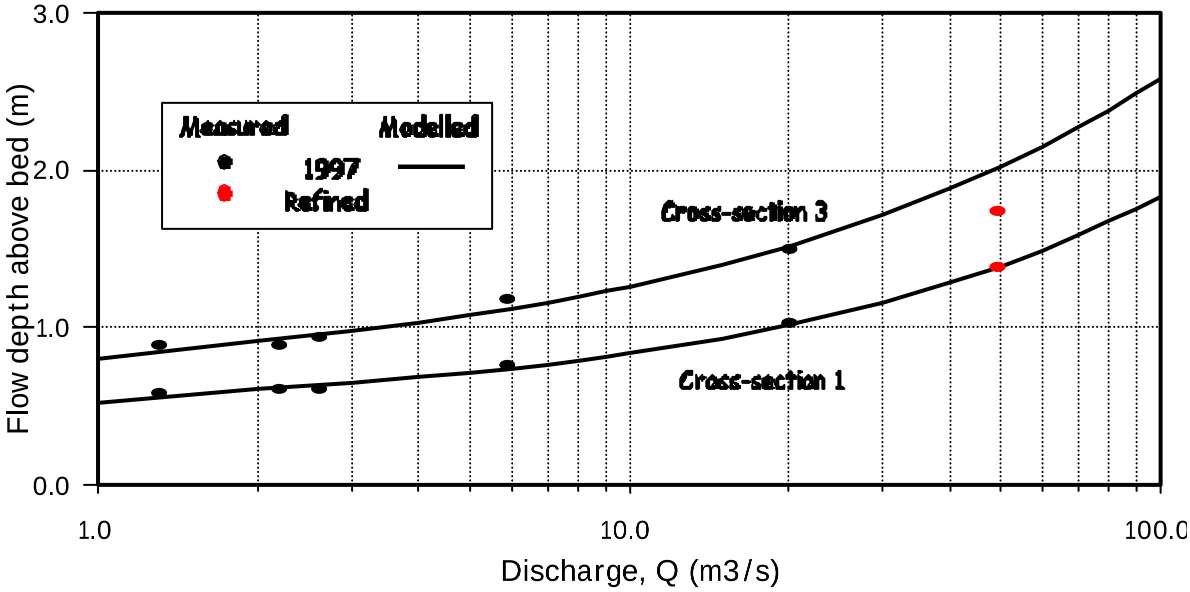

Figure 2 1997 and additional rating data for IFR site 3B on the Bushmans River

3 References

BS 3680. British standard for the measurement of liquid flow in open channels. Part 3A: velocity-area methods.

DWAF, 1997a. Thukela IFR refinement site visit hydraulics.

DWAF, 1997b. Thukela IFR refinement report (southern tributaries).

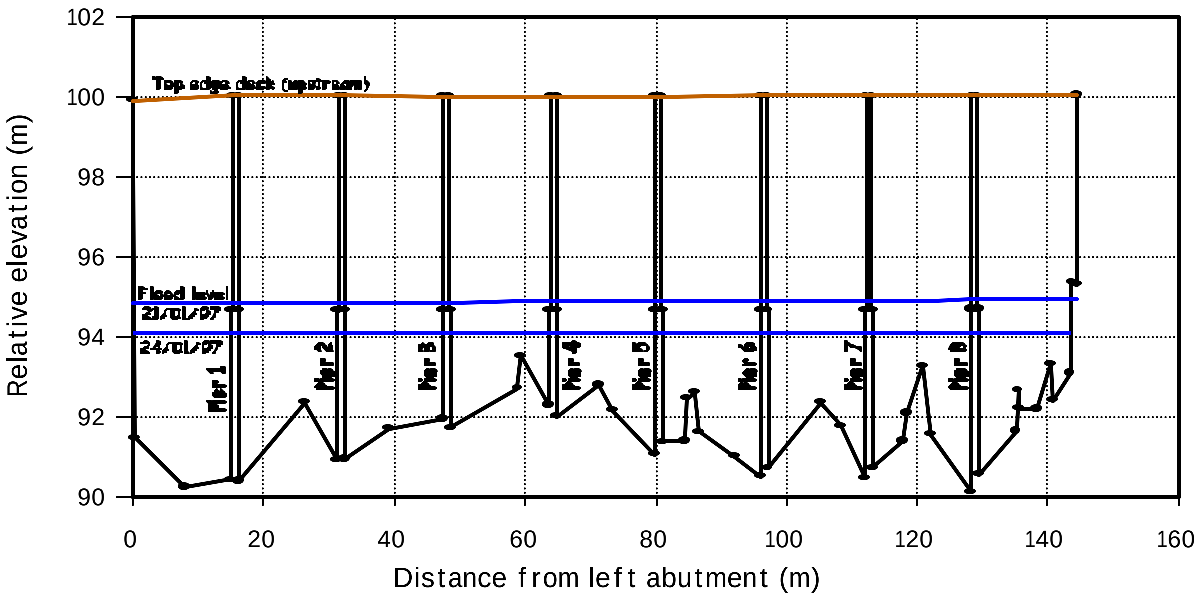

Figure 3 Cross-sectional profile of high-level bridge 2 km located downstream of IFR site 2 on the Thukela River

Figure 4 Photograph of bridge profile plotted in Fig. 3, facing downstream

Table 6 Surface velocity measurements: bridge over Thukela, 21/1/97

Pier	Measurement distance between piers (%)	Velocity (m/s)
LB-1	25	0.50
	75	1.10
1-2	25	0.45
	75	0.00
2-3	25	1.47
	75	1.60
3-4	25	1.64
	75	1.38
4-5	25	0.88
	75	1.10
5-6	25	1.45
	75	1.06
6-7	25	1.22
	75	0.63
7-8	25	0.74
	75	0.40
8-RB	25	0.44
	75	0.25

LB - left bank abutment
RB - right bank abutment

Table 7 Surface velocity measurements: bridge over Thukela, 24/1/97

Pier	Measurement distance between piers (%)	Velocity (m/s)
LB-1	50	0.58
1-2	50	0.00
2-3	50	0.57
3-4	50	0.57
4-5	50	026
5-6	50	0.66
6-7	50	0.49
7-8	50	0.75
8-RB	50	0.47

LB - left bank abutment
RB - right bank abutment

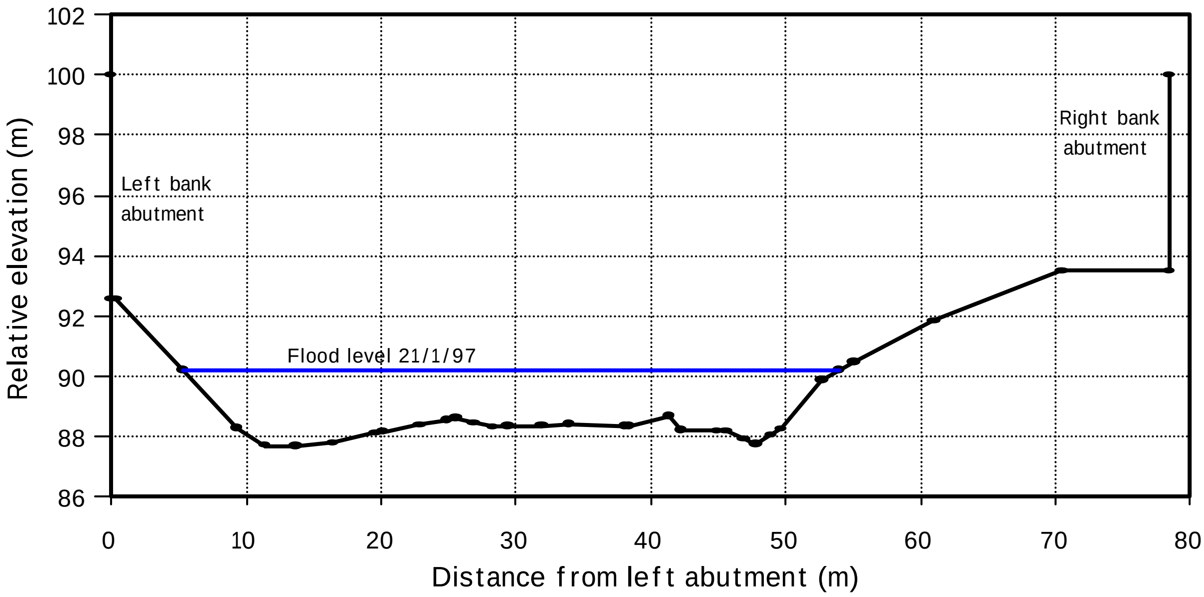

Figure 5 Cross-sectional profile of high-level bridge over the Bushmans River at Weenen

Figure 6 Photograph of bridge across the Bushmans River, facing downstream

Table 8 Surface velocity measurements: bridge over Bushmans 21/1/97

Distance from right bank abutment (m)	Velocity (m/s)
30	0.84
34	1.21
47	1.12
52	1.04
56	0.84
62.5	0.51

PBV000-00-9900

Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

STRATEGIC IMPACT ASSESSMENT OF THE HYDROPOLITICAL ASPECTS

MARCH 2001

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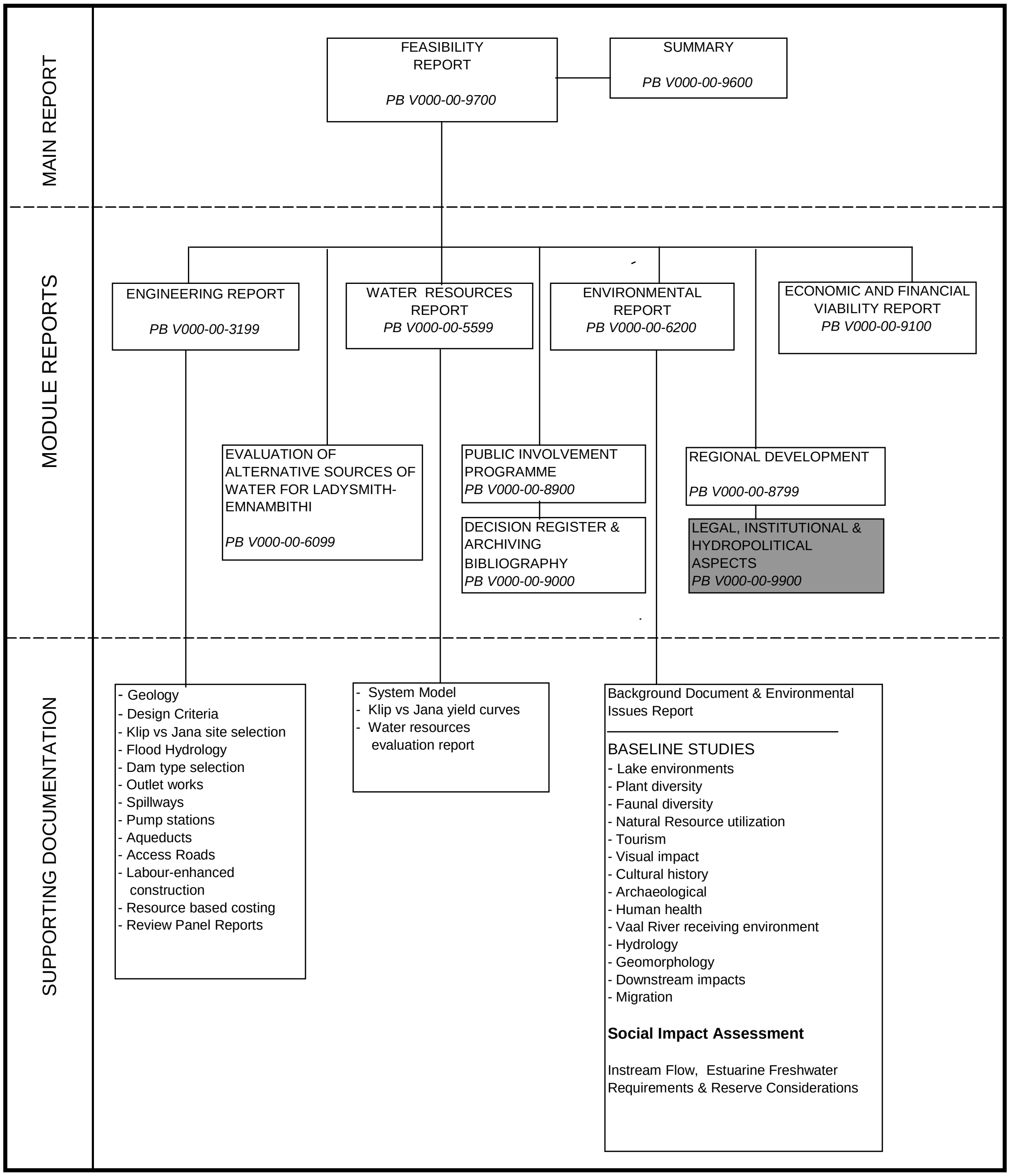

THUKELA WATER PROJECT FEASIBILITY STUDY
STRATEGIC IMPACT ASSESSMENT OF HYDROPOLITICAL ASPECTS

AFRICAN WATER ISSUES RESEARCH UNIT (AWIRU) MARCH 2001

Approved for AWIRU by:

...	**...**
A.R. Turton	**R. Meissner**

THUKELA WATER PROJECT FEASIBILITY STUDY
STRATEGIC IMPACT ASSESSMENT OF HYDROPOLITICAL ASPECTS

SUMMARY

This study has shown that there are a number of factors within the hydropolitical dimension of the Thukela Water Project (TWP). These are of such a magnitude that they have the potential to impact negatively on the overall viability of the project. Two factors are particularly relevant.

The Large Dam Debate: This is an exogenous factor that has a global dimension to it. Underlying this debate is the question about the relevance of large water resource engineering projects. One of the main driving forces of this debate is what is known as "reflexivity", which is a Northern Hemisphere phenomenon associated with "risk society" or "post modernity". Two major manifestations of this debate are highly relevant to the TWP. Firstly, the World Commission on Dams (WCD) has not yet made its final report available. It is anticipated that this will not place a moratorium on the construction of large dams, but that it will propose a complex set of rules and guidelines to be followed when making a decision to construct a large dam. Secondly, international Non-Governmental Organizations (NGOs) are a virulent manifestation of Northern-inspired reflexivity. As such, they derive their legitimacy from the global nature of the debate and for all intents and purposes, can be regarded as near-permanent role-players in the international water sector. This position has been endorsed in the World Water Vision that proposes a tripartite alliance between Government, Civil Society and the Private Sector. Significantly, NGOs as a component of Civil Society, overlap with both the environmental movement and the human rights movement, increasing their relevance to large water resource engineering projects.

"Our Water": This is an endogenous factor, which has a number of unique dimensions that are peculiar to the geographic location of the proposed TWP. Some of these dimensions are potentially damaging if left unmanaged. Three are particularly relevant to the viability of the proposed TWP. Firstly, there is the issue of centralized economic development in the Vaal River Supply Area. In this regard, the two poles of the debate are focussed on either continuing to match demand with supply (Vaal River Supply Area), or using the increased strategic vulnerability that this creates as an incentive to move demand closer to the source of supply. Secondly, there is the issue regarding the strategic decision to develop the Upper Thukela Basin in the short-term, but by placing a ceiling on the longer-term development of the Lower Thukela Basin. Thirdly, there is the purely political factor of nationalism, secessionism, warlordism and general political tensions that are known to have existed in the Thukela Basin in the recent past. While the transition to democracy that occurred in South Africa after CODESA has gone a long way in normalizing the politics of the area, it is felt that these issues are still present in a latent fashion. If the proposed TWP is managed in a politically insensitive manner, then they can become patent and virulent again, to the detriment of the project as a whole.

Identification of the Problem: The hydropolitical problem of the proposed TWP is the result of a coincidence of two major issues - the Large Dam Debate and *"Our Water"* - simultaneously. The problem is derived from an imbalance caused by the coincidence of these two major issues.

The Solution - *Izimpondo Zenkunzi*: Having isolated the hydropolitical problem, a solution has been developed. This solution enables the imbalance that is inherent within the problem to be addressed. Central to the solution lies the strategic decision to use the proposed TWP as a vehicle for deepening the democratic experience in South Africa. This can be likened to the "body of the bull". The potential legitimacy is derived from the moral implication of using major water resource projects to become the vehicle through which the democratic principles that were highlighted during CODESA, and that became enshrined in the South African Constitution (Act 108 of 1996) and subsequently encapsulated in the National Water Act (Act 36 of 1998), can be cascaded down to all elements of South African society. In other words, by adopting this approach, then water can become a social resource in addition to being both a natural and an economic resource.

Hydropolitical Critical Path Assessment: For the proposed strategy of *Izimpondo Zenkunzi* to occur, a strategic decision will have to be made regarding the proposed TWP. In order to assist the decision-maker, a hydropolitical critical path assessment was made. This isolated five critical factors. If any one of these five critical elements is missed or inadequately dealt with, then managers of the proposed TWP can anticipate severe hydropolitical opposition, to the extent that the project may need to be aborted. These five critical elements have been encapsulated in strategic questions that need to be answered. These questions are as follows:

- Is the future demand forecast for the Vaal River Supply Area capable of withstanding intense scrutiny by the public and NGOs and still retain its validity?
- Is the decision to augment supply for the Vaal River Supply Area supported by, and made within, the framework of a national WDM policy?
- Is there a process of adequate public participation in which all role-players have a reasonable chance of expressing their opinions and viewpoints?
- Is there an active communication strategy (public relations) that is aimed at informing the general public of the strategic need and benefit of the project, that is sustainable over time, and that changes public perceptions in a measurable way?
- Is there provision in the planning for using the project to deepen the democratic experience in South Africa?

In addition to these five critical elements, twelve contributing factors were isolated in the hydropolitical critical path assessment. These are of such a nature that they will contribute to the overall hydropolitical environment of the proposed TWP, but neither is capable of derailing the project on its own.

Elements of the Proposed Solution: The proposed solution - *Izimpondo Zenkunzi* (Horns of the Bull) - combines traditional African culture that is particularly relevant to the Thukela Basin area, with modern hydropolitical principles. In this regard there are six key elements that the strategic decision-maker would need to consider.

- The decision to use the proposed TWP as a vehicle to deepen the democratic experience in post-Apartheid South Africa is the main element. This places the TWP in a league apart, and renders it safe from the negative aspects of the Large Dam Debate. This can be likened to the body of the bull.

- Planning is the next critical component. This planning process must factor in two strategically significant objectives. Firstly, it must strive to develop an overall policy framework within which the ultimate decision can be made. Secondly, it must strive to change perceptions about the proposed project. The head of the bull becomes the planning process in keeping with the chosen analogy, with the two horns being the two strategic objectives (policy & perceptions).

- Policy is the next critical element. This policy should have a coherent national WDM component to it. If this is the case, then the final decision to proceed with the proposed TWP will be regarded by the public as being legitimate, thereby reducing hostility to manageable proportions. This becomes the tip of the one horn of the bull, in keeping with the analogy.

- Public participation in the policy-making process is a fundamental democratic principle. If adequately allowed for, then the feelings of the public can be gauged and factored into the final decision. In short, participation by the public is what gives the policy its overall legitimacy, and legitimate policy is seldom questioned or opposed to any significant extent.

- Perceptions are also a critical element. It is a negative perception that de-legitimizes policy. Therefore perceptions can be regarded as the tip of the second horn of the bull, in keeping with the analogy.

- Public relations (PR) are the vehicle through which perceptions are changed and support is generated for policy, so an active and culturally appropriate PR element is vital. This should not be confused with propaganda, but should focus on presenting the necessary information on which role-players can make informed decisions.

Conclusion: Some major hydropolitical obstacles are confronting the proposed TWP. None of these are unmanageable however. The study has isolated the key elements and suggested a rational and comprehensive solution to the hydropolitical problems of the proposed TWP. In short, the democratic principles that are inherent within the proposed *Izimpondo Zenkunzi* solution, are sufficient to enable project managers to make the TWP viable from a purely hydropolitical perspective.

THUKELA WATER PROJECT FEASIBILITY STUDY

STRATEGIC IMPACT ASSESSMENT OF HYDROPOLITICAL ASPECTS

CONTENTS

THUKELA WATER PROJECT FEASIBILITY STUDY: STRATEGIC IMPACT ASSESSMENT OF HYDROPOLITICAL ASPECTS

1. INTRODUCTION

The Strategic Impact Assessment of the Hydropolitical Aspects of the Thukela Water Project (TWP) is specifically designed to equip the decision-maker with the relevant information needed to make strategic decisions. The report is therefore designed to be short and specific, focussing clearly on the strategic level only. If any clarification is needed as to why a specific point has been made, then a more detailed report regarding that specific aspect will be provided. The report is structured as follows:

- Methodology
- Terms of Reference (TOR)
- Hydropolitical Dimension as the Problem
- Hydropolitical Dimension as the Solution
- Hydropolitical Critical Path Assessment
- Recommendations for Additional Research
- Conclusion

2. METHODOLOGY

This report is a desktop study only. There has been no attempt made to do in depth fieldwork, as this was beyond the scope of the TOR, budget and time available. The list of interested and affected parties as found in Appendix A of the Background Document and Environmental Issues Report of the Thukela Water Project Feasibility Study was consulted. This was divided into categories. A sample was taken from each category based on an assessment of their relevance in strategic terms and these people were interviewed telephonically, or where readily available, in person. From this a broad set of issues emerged. These issues were then tested against the specialist knowledge of the subject that already exists within the African Water Issues Research Unit (AWIRU). These refined issues were again tested for veracity against a small sample of respondents who are familiar with the Thukela Basin. All questions that were presented in the TOR have been answered, but only to the extent that the questions are relevant to the hydropolitical dimension. A major emphasis in the study has been on clustering small sub-issues under broad generic headings, as this is what is relevant to the decision-maker at the strategic level. A hydropolitical critical path assessment has then been distilled from the answers to the questions that were posed in the TOR. The final phase has been an attempt to illustrate both the problem and the solution in a diagrammatic format as experience has shown that this is the most relevant way for non-hydropolitical specialists to grasp the ramifications effectively. An attempt has been made to develop an African solution as this is entirely consistent with the South African political culture and is thus likely to increase the chance of success.

3. TERMS OF REFERENCE

3.1 Export of Water

What effects can be expected from the export of water out of the Thukela Basin to the receiving economic, social and biophysical environments of the Vaal River Supply Area?

3.1.1 Hydropolitical relevance

Analysis reveals that this issue has two critical components. These are:

In essence, the rationale for the TWP is encapsulated in the notion of resource capture. In other words, at the most basic level, the economic potential of the Vaal River Supply Area is being assured at the expense of the economic potential of the Thukela Basin. The equation boils down to the fact that the Vaal River Supply Area can survive only at the expense of capturing the resource base from another geographic entity. This is not a new phenomenon and is widely found in the world at large. Resource capture has both good and bad aspects to it, and this is where the strategic nature of decision-making becomes relevant. The good aspect is that the greatest good is being done to the greatest number, to coin a political concept. Essential to this however, is the aspect of redistribution of possible benefits that are derived from the receiving entity to the donor entity. The bad aspect of resource capture is that it leads ultimately to structural scarcity, which in turn has a number of debilitating elements associated with this condition. Firstly, it become a major source of hydropolitical activity because it tends to marginalize people and communities, thereby giving them cause to agitate against the process. As such it acts as a de-legitimizing agent. Secondly, it ultimately results in unsustainability and overall insecurity of supply. This aspect functions in a curious manner. By constantly providing an assurance of supply, additional consumers are attracted to the area concerned. This in turn results in increased demand that is translated into the need to increase supply. This spiral grows in an increasingly vicious manner until it is unsustainable. Early indications of unsustainability can be found in the call for Water Demand Management (WDM) strategies. Current evidence suggests that this is one of a few potential methods of breaking this spiral. Other options include a strategic decision to relocate the consumers closer to the source of supply (referred to elsewhere in this report as spatial development), which has proven to be uneconomic, or to charge for water at its full economic value.

Having noted the above in no way implies that DWAF have not been transparent with respect to planning to date. In this regard, cognizance is given to the fact that since the Pre-Feasibility Study stage the donor basin stakeholders have been consulted with.

Central to this is what can best be described as the strategic trade-off between placing a ceiling on the long-term development of the lower Thukela Basin by providing a short-term boost to economic and infrastructural development in the upper basin. This component can become part of the negotiating strategy between role-players. In other words, resource capture can be legitimized and indeed justified, by redistributing the benefits of the TWP in a more equitable manner between both donor and recipient basins. The recipient basin becomes the economic powerhouse for the country as a whole, whereas the donor basin foregoes long-term development of the lower basin by choosing instead to opt for the shorter-term development of the upper basin. This is hydropolitically justifiable provided that the democratic principles of equity and transparency are adhered to. These principles serve to reduce the conflict potential while enabling a more rational and strategically justifiable decision to be made.

In mitigation of the second point noted above, it is acknowledged that the governing principle that has been used by the project planners has been that in-basin water demands, and in particular the Reserve, take priority over any water transfers out of the Thukela Basin. In this regard it is noted that if demands in the lower catchment are shown to be strategically more relevant in future than Thukela water that is used in the Vaal River System, then it will be possible to discontinue the TWP-Vaal transfer in order to meet these more productive demands. This will have the effect of attenuating the potential debilitating effects of resource capture, which in strictly hydropolitical terms, is a healthy situation.

3.1.2 The effects are thus potentially either positive or negative. They are potentially positive and beneficial if the debilitating effects of resource capture are countered by redistributing the benefits in a more equitable and transparent manner. They are potentially negative if structural scarcity is allowed to get out of control, ultimately leading to a loss of legitimacy for the Government and an increase in political instability, possibly to the extreme point of fuelling latent secessionist desires that exist in parts of the Thukela Basin.

3.2 Legal and Administrative Framework.

What is the legal and administrative framework within which decisions have been made to investigate the feasibility of the TWP and in which it may have to operate?

3.2.1 Hydropolitical relevance

The legal framework is the National Water Act (Act 36 of 1998). This is a new law that has a number of significant changes when compared with the old legislation. From a hydropolitical perspective, this is of major relevance as the new water law is democratic in orientation and is in keeping with the provisions of the Constitution. Specifically relevant are the provisions under Chapter 2.6.2 (b) regarding the social and economic development patterns and (d) the communal interests within the area in question. Furthermore, the Act stipulates under Chapter 2.10 (Guidelines for and consultation on catchment management strategies) that in developing a catchment management strategy, a Catchment Management Agency (CMA) must consult with *inter alia* any persons or their representative organizations whose activities affect, or might affect, water resources within its water management area and who have an interest in the content, effect or implementation of the catchment management strategy. The major impact of this is likely to be felt in what can broadly be defined as "participation". There are two aspects of this "participation" that are hydropolitically relevant. These are:

Firstly, it means that the centralized form of planning and implementation that was the norm in the pre-democratic era is a thing of the past. This centralized decision-making was characterized by a homogenous technocratic elite who shared a common view of the problem and who worked under a strongly defined paradigm. There was a high level of predictability under those conditions.

Secondly, it means that a major variable is introduced into the overall hydropolitical equation. This variable is potentially problematic because it reduces the predictability of a given or known outcome. In other words, the new legislation defines the need to introduce public participation into the process of planning. This in turn erodes into the normal domain of the technocratic elite. It may turn out that a solution that has been developed by an engineer, may be totally unacceptable to the public at large and indeed there is a lot of evidence that this has happened elsewhere in the past. An example of this is the World Commission on Dams (WCD) that will be discussed elsewhere in this report. There is little evidence that this is the case in the TWP however.

3.2.2 The implications of these participatory elements are that detailed planning will be needed. Planning has always been done in the past, so the only difference now is that the planning will have to encompass two significant new components. If one considers the final outcome of planning to be the generation of a series of implementable decisions, then the new legislation requires participation from various actors and role-players. If participation is adequate, then the resultant outcome will be a policy that is seen by the public at large to be fair and reasonable. This will translate into legitimacy and support for the TWP as a whole. If the participation process is inadequate, then the resultant policy will be flawed and significant opposition can be anticipated, even to the extent that the viability of the TWP could be jeopardised. Two hydropolitically relevant components of the planning cycle are:

A phase of adequate public participation will have to be factored into the project time cycle. A critical element of this participation will have to be aimed at the level of the Traditional Leader, because current indications are that it is at this level of society that the potential trigger event can occur. A trigger event can be understood as being a threshold event beyond which a non-linear response results. Central to this aspect is the role of Traditional Leaders as political elites. Indications are that the trigger event is likely to be disaffected Traditional Leaders who mobilise grassroots support along the river reach downstream of the proposed works under the broad banner of *"Our Water"*. This is an emotive issue and can rapidly escalate into an uncontrollable situation if left unattended or unmanaged. It can even result in the intervention by international non-governmental organisations (INGOs) with either an environmental or human rights agenda.

As a result of the non-linearity of a trigger event, a specific component of the planning cycle should be the development of a communication strategy, otherwise known as public relations (PR). The target of this strategy is public perceptions, because it is perception that will ultimately drive the political dynamics that generate legitimacy or support for the project. A specific aspect of this PR strategy will have to be aimed at the level of the Traditional Leader in the affected area. One of the messages within this PR strategy will have to be aimed specifically at defusing the *"Our Water"* dynamic.

Having noted these two points, two additional points need to be emphasised.

The above statement does not imply that no consultation has been had to date. In fact, the participation has included Traditional Leaders, and since 1997 negotiations have been conducted with the local Tribal Authorities with a view to gaining access to the site area. Regular presentations were provided at the Emnambithi Regional Authority meetings. During 1999 all stakeholders downstream of the proposed Jana Dam were also contacted. This included Regional Authority committees that occur alongside the Thukela River. These Tribal Authorities were added to the database and were kept informed through various presentations at these meetings.

Attention needs to be drawn to the possible grassroots perception that a Public Relations campaign is only needed to sell a bad project. This must be understood in the context of the South African historic experience where propaganda was liberally applied to a variety of projects in order to generate legitimacy for them. What is being proposed in this report under the heading of Public Relations is not propaganda. In this regard a clear distinction must be made between information that the public needs to make an informed decision in conjunction with genuine public participation on the one hand, and the deliberate propagation of information designed to deceive the public on the other hand.

3.2.3 There is strong evidence that the current planning for the TWP is already exhibiting healthy democratic tendencies. The very fact that hydropolitical specialists have been mandated to draft a specialist report is an indication of this healthy trend. Other evidence lies in the nature of the questions that have been posed in the Background Document and Environmental Issues Report of the Thukela Project Feasibility Study. That document contains strong evidence of the desire by the Department of Water Affairs and Forestry (DWAF) to enhance the legitimacy of the TWP in a genuine fashion. The broad conclusion in this regard is that the approach being used is entirely appropriate and if followed through systematically will enable the project to proceed.

3.3 Political backlash.

What are the possible consequences that may arise from the political backlash to the export of water out of KwaZulu Natal (KZN) to the Vaal River Supply Area? How can this affect its long-term sustainability?

3.3.1 Hydropolitical relevance.

The study has revealed that there are two distinct components to the political backlash and that if left unmanaged, they can impact on the viability of the project. In fact, a worst case scenario is that the TWP would have to be abandoned, but this would only be likely if the hydropolitical issues are left unmanaged. In a best case scenario, the backlash is managed and the project would proceed unhindered. It is the professional opinion of the authors that the latter scenario is entirely feasible provided that the two major hydropolitical issues are taken on board by the Project Management Team. These two issues are:

At the sub-national level the most important issue is that which has been labeled *"Our Water"*. This is a very powerful dynamic and it seems to be driven by three main components. Firstly, there is the emotive component. This is dangerous in the sense that emotions are irrational and therefore unpredictable, and if left unmanaged, can rapidly escalate the problem in a non-linear fashion. Secondly, there is the perception component. Preliminary indications are that at the level of the local grassroots individual, little negative perception exists at present. Where it does potentially exist however is at the level of the Traditional Leader. It is therefore the Traditional Leader who is likely to mobilize grassroots support, initially being triggered off by the perception that resource capture is taking place, by harnessing the emotive energy that is likely to be unleashed. Thirdly, there is the communication component. In the absence of information on which informed decisions can be made, the emotive component can kick in. In other words, grassroots support can only be effectively mobilized against the background on incomplete information. Word will trickle down the valley that a dam is being built, and in the absence of sufficient information, the affected people will blame everything that happens to them from that time onwards on the construction of the dam. Therefore, if a dry spell occurs as part of the normal hydrological cycle, then the effects of the drought can be blamed on the construction of the dam, that is the product of an existing negative perception that in turn will translate into emotive energy.

At the international level, the most important issue is that which can be described as the changing public perception of the relevance of large dams. This is encapsulated in the work currently being done by the WCD that will be discussed in paragraph 3.11.1 of this report.

Having noted these two points, cognizance is taken of the fact that communities at the grassroots level downstream of the proposed dams have not yet been consulted directly during the Feasibility Study, with consultation during this phase having been focussed more at the Traditional Leader level. The communities that will be directly affected have received regular information via Zulu language newsletters, committee working group meetings, the introduction of specialists working in the area and by means of capacity building workshops which included site visits to the existing transfer scheme.

3.3.2 The *"Our Water"* issue is a generic label that has been given to a number of sub-issues. There are elements of *"Our Water"* that are linked to the international level at present, or can be linked in future. At the strategic level, there are three sub-issues that seem to be relevant at this point in time. These are:

The major debate regarding the question of either moving water from where it is found to where it is needed (resource capture), or of moving the consumers to the source (spatial development), is relevant. This is a strategic decision that government will have to make. There are a number of elements that the decision-maker would have to consider in this. Firstly, sufficient evidence exists to suggest that resource capture is linked in the long-term to the creation of structural scarcity in society. In other words, if resource capture is allowed to continue for a long period of time, a situation develops whereby a highly developed central zone of industrialization results. This in turn attracts more industrialization and with it population migration. Non-linearity starts to manifest itself at some point in time when a race to constantly mobilize more water is begun. This in turn leads ultimately to strategic vulnerability in the sense that a major portion of the industrial development in the country exists in a given geographic entity, and it becomes increasingly difficult to guarantee the minimum level of supply that is needed to maintain that security. Some role-players are arguing that this is occurring already within the Gauteng region, and that this is why the TWP is needed. Secondly, tentative evidence exists that suggests spatial development away from Gauteng may be desirable, but not necessarily feasible. A distinction therefore needs to be drawn between what the ideal situation is versus the best possible situation, and this would need to be effectively communicated to the public. Thirdly, it can be anticipated that components of this debate will be reflected in the ultimate findings of the WCD. It is fruitless to speculate on the outcome of the WCD as this is the product of a highly dynamic process, thereby nullifying the effects of prediction.

The role of Traditional Leaders is pertinent. On the one level, it is possible for Traditional Leaders who may feel aggrieved by Government to use the TWP as a political weapon to mobilize support for their cause. In this sense Traditional Leaders can become the source of the problem, particularly if a given Traditional Leader harbors secessionist sentiments. On another level, it is possible for Traditional Leaders to become part of the solution by providing sufficient scope for adequate participation and thereby taking cognizance of their grievances, and then dealing with them in a forum other than the hydropolitical one. In other words, the hydropolitical threat to the TWP is only likely to manifest itself if other channels of political participation are denied.

Secessionist elements are evident within KZN. It is not known at this time exactly how strong these elements are, or to what extent they manifest themselves. The desktop study indicates two distinct strands to this secessionist dynamic. Firstly, there is an element that was encapsulated in what can be described as the Last Outpost mentality. This was probably more relevant in the pre-democratic era when English speaking Natalians resisted Nationalist Party hegemony. In this case, the dawn of democracy has probably reduced the relevance of this. Secondly, there has always been a strand of political thinking within Zulu politics that is strongly nationalistic. This has probably been reduced in significance in the democratic era, but elements of this can still be found in the constitutional debate of a federal versus a unitary state. It is clear that more information will need to be gathered on this issue as latent secessionist sentiments could be awakened under the cry of *"Our Water"* if the hydropolitical significance of the latter is not taken seriously by the Project Management Team.

Having noted these points, a window of opportunity can be developed in the form of local regional development planning, which may in turn be associated with local government elections, as possible vehicles for deepening the democratic experience. In this regard the legitimate desire of local politicians to kick-start the economies within their respective constituencies can be harnessed, with major infrastructural projects such as the TWP and N3 highway being used as lead projects.

3.3.3 At the international level, backlash can be expected from two distinct quarters. This backlash in general can be linked to the generic label of the Large Dam Debate. These two quarters are as follows:

The findings of the WCD are as yet unknown and difficult to predict. It is likely that the findings will recommend a complex process of consultation and public participation however. This can be channeled back to the sub-national level. It is unlikely that the WCD findings will place a moratorium on dam construction. There is likely to be sufficient latitude in the final report to allow dam construction to take place, but under a complex set of rules that involve a series of checks and balances to be built into the decision-making process.

NGO activity is likely to be enhanced by the current activities of at least three (but probably more) international organizations. Firstly, there is the WCD that is likely to recommend a complex process of public participation. In this context, NGOs with either an environmental or human rights agenda can be drawn into the equation by disaffected groups. Secondly, the World Water Council announced the World Water Vision in The Hague during March 2000. (For a brief synopsis of the World Water Vision refer to paragraph 3.3.5). The aim of this World Water Vision is to create a global water movement along the same lines as the existing environmental movement. This will increase the relevance of NGOs. It can therefore be accepted that NGOs are legitimate role-players and are here to stay. They are also legally empowered by the National Water Act (Act 36 of 1998) in terms of Chapter 2.10.2(c) if a local affected party decides to mandate an NGO to take up an issue on their behalf. Thirdly the United Nations Education Scientific and Cultural Organization (UNESCO) is currently engaged in a project that will result in the publishing of a series of books known as the Encyclopedia of Life Support Systems (EOLSS). This will serve to heighten international awareness of ecosystem sustainability and will probably strengthen the NGO movement.

3.3.4 The conclusion is therefore that the viability of the TWP can be negatively impacted on, even to the extent of making it a non-starter as a worst case scenario. This can be avoided if the recommendations of this report are carefully considered and the relevant strategies are fully implemented.

3.3.5 The World Water Vision that was announced at The Hague during March 2000 did not include any aspect that differs radically from either the recommendations of this report, or current management practices within DWAF. Briefly stated, one version of the Vision is as follows:

"Every human being should have access to safe water for drinking, appropriate sanitation, and enough food and energy at reasonable cost. Providing adequate water to meet these basic needs must be done in a manner that works in harmony with nature" (World Water Commission, 2000:21).

The World Bank interprets this by highlighting the following points (World Water Commission, 2000:21-47):

A holistic approach is needed to integrated water resources management (IWRM). In this regard participatory ***decision-making at the lowest appropriate level*** is to be encouraged, using best available technical information.

There is a need to radically change technology in order to adapt to the needs of a water-conscious world.

In addition to institutional and technological changes, water's economic, social, environmental and political dimensions need to be taken into account.

Major sources of funding will be needed to implement these changes. This will imply the need to attract private sector partners into water projects.

All water management is to take place within a catchment, and the notion of "water use parliaments" is introduced "so that all stakeholders have a voice in the decision-making".

All decision-making should be informed (placing an emphasis on Public Relations and communication) and should be scientifically and technically sound. In this regard the participation of key role-players is recognized as being the foundation of legitimacy and public support.

The effective management of water can become a vehicle of collaboration as much as its absence can become a source of conflict. (While this statement was originally made in the context of international river basins, the sentiment is valid within the context of the Thukela Basin as well).

The systematic adoption of full-cost pricing for all water services is encouraged. The role of Government is identified as being to ensure that safety nets are provided for the very poor, with such people being "offered choices from a menu of services of different costs and qualities". The private sector is seen as being the key to the provision of better services at lower cost. (It must be noted in this regard that the South African Minister of Water Affairs and Forestry, Mr. Kasrils, went on record as opposing this concept as it will impact most on the very poor).

Another form of the Vision is "a world in which all people have access to safe and sufficient water resources to meet their needs, including food, in ways that maintain the integrity of freshwater ecosystems" (Cosgrove & Rijsberman, 2000:1). This version highlights the following key actions as being of critical importance (Cosgrove & Rijsberman, 2000:1-3):

- Involvement of all stakeholders in integrated management.
- Move to full-cost pricing of water services for all human use.
- Increase in public funding for research and innovation that is in the public interest.
- Recognition of the need to cooperate within the ambit of IWRM in international river basins.
- Need to massively increase investment in water.

None of these principles are being flouted in the TWP, and indeed, most of these are already part of the existing South African water management discourse. Nowhere is there mention made of the need to stop building large dams. There was isolated but high profile political activism on the opening day of the World Water

Forum however, where Spanish activists protested against the construction of a dam in Spain.

3.4 Legal protection for rivers.

What legal protection is there for rivers, within the legal system of South Africa at this time? Does the Thukela merit special protection?

3.4.1 Hydropolitical relevance.

There are two elements of this that are hydropolitically relevant. These are as follows:

The existing legislation (Act 36 of 1998) covers South African rivers in general. From a hydropolitical perspective this seems adequate. Evidence in support of a need to change the *status quo* would have to be provided from ecologists and is thus beyond the domain of the authors.

It is not possible to ascertain whether the Thukela River deserves special attention at this time. It is relevant however, that certain special interest groups are talking about the need for additional legislation for the added protection of rivers. Indications are that a Wild and Scenic Rivers Act, along the lines of American legislation, is being called for by some NGOs. This may gain momentum after the WCD findings are published.

3.5 Building and operating of large dams in the global environment.

What significant implications and consequences are there for the DWAF in building and operating large dams, in a global environment where it is seemingly becoming more inadmissible and inappropriate? Is such action by DWAF advisable and appropriate, in the light of legal action and/or international pressure, or other forces or threats, which can be brought to bear on the DWAF?

3.5.1 Hydropolitical relevance.

This is a highly complex issue. Upon deeper analysis it appears as if three elements are of strategic importance to the decision-maker however. These are:

There is a changing global paradigm at work. In fact there are strong indications of the existence of two major paradigms at work, with both interacting in such a way as to create confusion and unpredictability. The first paradigm can be understood as relating to the overall management style that is dominant within a water resource environment. The extreme poles of this debate can be understood as being either "Supply-Sided Management" (mobilizing more water in response to escalating demand) or Demand Management (reducing the overall demand to coincide with the sustainability level of supply). The second paradigm can be understood as relating to equity. The extreme poles of this debate can be understood as being Centralization versus Decentralization. Thus an analysis of the interaction of these two paradigms shows that the Supply-Sided Management phase tended to coincide with highly centralized decision-making and planning, whereas the emerging Demand Management phase is tending to coincide with decentralization. In other words, the construction of large dams cannot be seen in isolation from the purely engineering aspects of the problem, but is increasingly being linked to what has already been described in this report as the process of participation. The key variable in the equation is therefore participation, and if this aspect is adequate, then large dam construction is still likely to be viable in the future.

This impacts on the composition of the technocratic elite. Under a predominantly Supply-Sided Management paradigm, water resource engineers were almost the exclusive members of the technocratic elite, whereas under a Demand Management paradigm, the base of the discursive elite is broadened to include environmentalists, human rights activists, social scientists, and economists amongst others. The implications of this are that the language that is spoken by the broadening range of technocratic elites (known technically as the discursive elites - those elites who determine the nature and content of the dominant discourse also known as the sanctioned discourse) is increasingly complex and at cross purposes. The language register of civil engineers differs fundamentally from that of the human rights activist or the river ecologist. Indeed, the end goal of each component of the elite base is at direct odds with one another. River ecologists in their purist form, wish to have wild and untamed rivers as pristine ecosystems, whereas water resource engineers in their purist form seek to control nature by subduing rivers behind concrete and steel. The debate within this changing discursive elite is thus likely to become increasingly diverse and heated, with the outcome ultimately being a product of compromise. Hydropolitically this means that a process of polarization is likely to be felt initially, as the new members of the discursive elite flex their muscles and mark out the boundaries of their newly acquired territory. This polarization is likely to be acute as each element of the discursive elite effectively presents what can be understood as being their aspiration level. Once this process has been completed, then polarization can be expected to be reversed, as each element of the discursive elite realizes that negotiation and compromise serve their best long-term interest. This is likely to result in the coalescing of a new middle of the road grouping consisting of elites that are willing to cooperate. The product of this coalescing is the emergence of a new language register or dominant discourse, but with the continued existence of small pockets of extremism at each of the poles.

Pure rationality dictates that a developing country such as South Africa has the need to rapidly grow its economy and create employment opportunities. The worst case scenario if this is not achieved is economic stagnation and political instability. The best case scenario is sustained economic growth with minimal ecological disturbance and political stability. In short, this can be described as the sustainable development discourse that recognizes the need to build dams but in a controlled and responsible manner.

The authors acknowledge that the above-mentioned points are a simplification of the problem however. When one is trying to balance out a variety of competing and often conflicting users under conditions of water scarcity, the water resources managers open themselves up to criticism. This is not the intention of the report. Full acknowledgement is given to DWAF who have sought an optimal outcome for society, often under trying conditions.

3.5.2 In light of the above, it seems appropriate to advise that there will be a future in South Africa in which large dams can still play their rightful role. The overriding factor in this regard will be the relevance of these dams to political and economic processes in the overall social context. Whilst it is difficult to predict what the final WCD report will contain, it seems unlikely that it will place an outright moratorium on dam construction. What can be anticipated is the imposition of a complex set of rules and processes that must be engaged in before the final decision is made to construct a large dam. In other words, the critical variable in this regard is the process of public participation. This process will have the following implications:

The first major implication is what can be called a Water Demand Management (WDM) policy. The professional opinion of the authors is that this is probably the most important aspect of the long-term viability of the TWP. If a decision is made to continue with the TWP without having a plausible WDM strategy in place, then major opposition can be expected. There is strong evidence for this even at the desktop level of analysis. The magnitude of this opposition is such that at a hydropolitical level it can reduce the overall legitimacy of the decision to such a level that the project will not be viable. In other words, if a major study of future demand patterns in the Gauteng area indicates that additional augmentation of supply is still needed, then the TWP will be hydropolitically feasible and will not be opposed to any significant degree. It must be noted that there has already been a demand study (Report of the Committee on Water Demand in the Vaal River Supply Area Forecast to the Year 2025, TR134), but this is generally seen by some NGOs as being inadequate and in its present form, is unlikely to stand up to the level of scrutiny that will be required in order to gain the necessary hydropolitical support for the TWP. This perception is particularly relevant in light of the statement that "recent indications are that growth in water requirements in parts of the Gauteng region (sic) may be lower than the current projections" (Basson *et al.,* 1997:47). The object of such scrutiny is to convince these NGOs that augmentation is still needed, even in the face of WDM, and thereby reduce their likelihood of attacking the TWP.

Having noted this point, it is true to say that we do not yet fully appreciate what constitutes a "good WDM study", simply because the concept is still relatively new. A way out of this dilemma may be to consider the drafting of a detailed and more "user-friendly" version of the ideal and best possible water situations in the Gauteng region, and for the communication of this to all interested role-players for their written comment within a reasonable period of time. Within this aspect, provision must be made by planners to take public concerns and alternative propositions on board. It is the act of inviting public and special interest group participation that legitimizes the ultimate decision to proceed with the project.

The prevailing makeup of the technocratic elite will have to allow for diverging opinions to be taken on board. If a senior decision-maker adopts a hard-line attitude and shuts the door to possible alternative solutions, then the overall legitimacy of the TWP is likely to be undermined. There is no indication at present that this is the case. Indeed the opposite holds true. There is evidence that DWAF is willing to engage in participatory processes to the extent that the TWP can become hydropolitically viable.

3.6 Determination of the Reserve in the Vaal and Thukela.

What effects will the determination of the Reserve in the Vaal and Thukela basins have on the supply of water to the Vaal River Supply Area?

3.6.1 Hydropolitical relevance.

This aspect is largely beyond the domain of hydropolitics. There are two aspects that are important however. These are:

The concept of the Reserve gives the moral high ground that is needed to justify the construction of large dams. It is the determination of the environmental component of the Reserve that ensures environmental sustainability and thus acts as a powerful counter-argument to the anti-dam lobby. In other words, by prescribing the minimum flow regime within any given aquatic ecosystem, it counters the type of irrational dam building that is likely to be the major target of the WCD report.

By leaving a minimum flow in the river downstream of the proposed dams, this will act in mitigation of the emotive aspects of the *"Our Water"* dynamic noted elsewhere in this report.

3.7 National AIDS epidemic.

What implications and consequences for the TWP should be considered, both from the side of the receiving environment as well as the source environment, as the spread of AIDS takes hold on the country, over the next two to three decades?

3.7.1 Hydropolitical relevance.

From a hydropolitical perspective there are three aspects that are relevant. These are as follows:

The most significant aspect of the HIV/AIDS issue is a possible reduction in demand for water in the Gauteng region as a direct result of the attenuation of economic growth. This would undermine the rationale of the project and would provide ammunition to the anti-dam lobby.

A secondary implication is the fact that there seems to be contested conclusions from the HIV/AIDS specialists. At one level some talk about a radical reduction in overall population. At another level some talk of a shift in the demographic configuration of specific cohort groups. The relevance of this contested information is the fact that it provides fuel to the debate, but this leads to an excess of rhetoric at the expense of factual information.

It is also possible that rural areas will be depopulated, causing a migration to cities in the Gauteng area. This scenario would potentially have the effect of increasing demand.

Given the wide range of implications of the above scenarios, it is clear that a specialist study is called for because a more definitive answer is impossible with available data.

3.7.2 It is therefore necessary to factor the findings of HIV/AIDS specialists into the overall planning process. The appropriate forum for this is during the phase of public participation that is being recommended.

3.8 Status of decision record of policies to augment the Vaal River Supply Area.

What is the status of the decision record of policies considered by the DWAF for the future augmentation of water to the Vaal River Supply Area?

3.8.1 Hydropolitical relevance.

It can be assumed that the past record of decisions to augment the Vaal River system will be subject to scrutiny. This is likely to be the case for two reasons:

The perception exists within certain sectors that past decisions were made in a pre-democratic era that was characterized by a low level of public participation and highly centralized decision-making.

These decisions were made at a time when a purely Supply-Sided Management paradigm prevailed.

In this regard it is noted that DWAF has adopted the IEM Process since the 1980s. Both the TWP and VAPS have included this more modern approach in its decision-making. These points are noted merely in order to alert DWAF decision-makers that such perceptions still exist.

3.8.2 The impact of this on the TWP is likely to be manifest in a strong call for WDM strategies as an alternative to dam building. This highlights the importance of having a WDM strategy that has two critical components in it. These are:

WDM should be embraced as a national policy. There is strong evidence that this will be a significant component of the anti-dam building lobby.

A credible demand study of the whole Vaal River Supply Area will act as a legitimizing element for the TWP. In the absence of a credible demand study, the anti-dam lobby will always exploit this vulnerability in the overall planning of the project.

3.9 Non-augmentation.

What are the implications of non-augmentation for the economy of the country?

3.9.1 Hydropolitical relevance.

It is a well-known fact that the Gauteng area is the economic and industrial heartland of South Africa, with the economic impact of this being felt well outside the borders of the country. The essence of this has been noted under paragraph 3.3.2 in the discussion of the relevance of the resource capture versus the spatial development strategic alternative.

3.9.2 At first glance, the answer to this problem seems self evident - because Gauteng is the industrial heartland of the country, it is justifiable to bring the water to where the demand is - but this is a flawed argument. Central to this argument is justification for resource capture that can be rationalized under the broad banner of "the greatest good for the greatest number". The flip side of this coin is the creation of structural scarcity in the long-term. This has major strategic significance because a decision to proceed with the TWP, without a supporting national WDM strategy, will simply mean that South Africa is one step closer to a condition of chronic structural scarcity. Increased structural scarcity results in overall vulnerability rather than security of supply. It is like putting all of ones eggs into one basket. Evidence from elsewhere in the world shows that a point is reached where purely supply-sided options are no longer viable, usually as the result of increased levels of hydropolitical opposition. It is therefore possible that the TWP will be seen in this light. Certainly, special interest groups such as environmental NGOs are likely to embrace this rationale as an element of their strategy. The implication of this is that:

Government will have to make a critical strategic decision regarding the long-term future of the country *vis-à-vis* water use. Central to this decision is the desirability and/or feasibility of decentralizing economic and industrial activities away from

Gauteng. This may be a case of being a desirable but an unattainable condition, in which case the *status quo* will be maintained.

3.9.3 It therefore becomes increasingly important to base the decision to proceed on sound information. To this end, there seems to be three critical components. These are as follows:

The most critical element relates to the existence of a national WDM policy. The existence of this element will take the sting out of the tail of the anti-dam lobby. At present a vulnerability of the TWP is the absence of a national WDM policy.

This is followed by the existence of a credible water demand study for the Vaal River Supply Area. This will serve to justify the decision that dam building is the only alternative and will thus serve two purposes. Firstly, it will reduce the moral high ground of the environmental NGOs. Secondly, it will generate support for the final decision thereby increasing the overall legitimacy of the project.

There is a need to publicize the reasons why past efforts at moving the consumers of water closer to the source of that water have failed. Such information will legitimize the final decision to proceed by showing that alternatives are simply not viable.

3.10 Special interest groups.

Particular attention should be paid to the specific issues that special interest groups at both the national and international levels are likely to articulate, along with their likely method of articulation.

3.10.1 Hydropolitical relevance.

A variety of issues have been identified. In keeping with the structure of this report, they will be clustered together under the two generic headings previously noted. These are as follows:

Large Dam Debate. Under this broad heading, four distinct elements are discernable at this stage of analysis. Firstly, the absence of a national WDM policy is likely to become a core element in the strategy of the anti-dam lobby. If such a national policy is in place, then the TWP becomes justified, as there is no viable alternative. In the absence of such a national policy, the TWP will always be vulnerable to attack on these grounds. Secondly, a credible social impact should be completed prior to the engineering study. The emphasis in this regard is not on the existence of a study *per se*, but rather on the credibility of that study. This aspect was noted by GEM when they were consulted. This social aspect should consider details of compensation and should also result from the widest possible process of public participation in keeping with the democratic principles enshrined in the National Water Act (Act 36 of 1998). Thirdly, a credible Environmental Impact

Assessment (EIA) must be completed in keeping with the principles that are likely to be enshrined in the final report of the WCD. Finally, a credible cost/benefit analysis that enjoys popular support should be completed and made available for public scrutiny.

"Our Water". Under this broad heading, three distinct elements are evident. Firstly, the basic principle of democracy as evidenced in the requirement for participation that the National Water Act (Act 36 of 1998) defines is relevant. This process of participation will allow legitimate grievances to be heard and therefore allow viable alternatives to be developed. Secondly, special efforts will have to be made to allow affected local communities to present their case. In this regard the emphasis is on providing the mechanism for poor rural communities to present their case in a dignified manner. Thirdly, the issue of Traditional Leaders is particularly relevant. In this regard, disaffected Traditional Leaders who may be seeking to increase the relevance of their own constituencies may choose to use the TWP for their own political purposes.

Specific attention is drawn to the fact that communication and negotiation of the full details of compensation did not occur at sufficient depth during the Feasibility Study phase. More negotiation will be needed in order to develop a detailed compensation package at a later stage. It is encouraging to note that the channels for such negotiation have already been opened and that affected rural communities will be given adequate opportunity to present their case. Caution is urged however, as the failure to do this adequately can result in a trigger event where human rights NGOs can pick up this issue. This is doubly important given the fact that the project is in an area with known conflict over land rights.

3.10.2 The method of articulation is likely to be a combination of the following:

Direct communication with DWAF in the form of letters, personal delegations or petitions. The advantage of this form of articulation is that the issues become clearer to the decision-maker and the conflict is contained if the grievances are given an adequate hearing.

Communications via the media including the Internet. The disadvantage of this form of articulation is that it often results in a rapid escalation of the conflict, with resultant loss of face for project managers and loss of legitimacy for the project as a whole. This is the reason why it is favoured by disaffected interest groups and their mandated representative organizations.

Networking with like-minded organizations or interest groups. This could be at three distinct levels. At the basin level, small isolated communities can link up with other communities, thereby increasing their own relevance. At the national level, smaller local communities can link up with NGOs that have either an environmental or human rights agenda. At the international level, small isolated communities can link up with major NGOs that have a significant resource base and with direct access to strategic partners such as financial institutions. This networking usually occurs from a trigger event and can result in a rapid escalation of the problem into an unmanageable situation. Significantly, this networking can include alliance building, so it is under this heading that disaffected Traditional Leaders could find a vehicle for linking their political cause to an otherwise unrelated issue, thereby increasing the relevance and profile of their own agenda.

Litigation can be considered in extreme cases. Funding for this litigation can be mobilized by linking up with international NGOs. This is clearly an undesirable condition and is therefore to be avoided.

Pressure can be placed on funders. This is relevant if funding needs to be raised from the international financial sector.

Demonstrations and public disobedience are a specific method of articulation. This almost always has negative implications. Significantly this option is typically only viable if other more peaceful methods of articulation are not available to the disaffected group.

3.10.3 These problems can be overcome by means of a combination of the following mitigating strategies:

The most important component of any mitigation strategy involves three elements of the hydropolitical process, namely public participation, effective policy formulation and public relations. These are normal elements of any democratic process and are therefore entirely compatible with the current South African political culture.

Another critical element involves the need to bring predictability into the overall hydropolitical equation. The most effective way of achieving this is by means of a Memorandum of Understanding between the relevant role-players. The nett effect of this action is to formalize the relationship between the government and role-players such as NGOs. This introduces a higher level of predictability by effectively reducing the range of actions that any given role-player can consider. This is compatible with the current South African political culture.

3.11 Normative developments at the international level.

Details of the likely impact of current normative developments at the international level on the national decision-making environment should be spelled out. These should include developments in international forums such as the World Water Council (WWC), Global Water Partnership (GWP) and World Commission on Dams (WCD).

3.11.1 Hydropolitical relevance.

There is currently a lot of activity within the international water sector. The outcome of this at strategic level is that it is defining the normative framework within which projects such as the TWP are ultimately considered and judged. Analysis of these activities reveals four issues of relevance. These are as follows:

Dublin Principles. These are the defining principles in the international water sector that have been embraced by the World Water Vision that was announced in The Hague during March 2000. There are four basic principles involved. By taking these principles into consideration, the threat of disruption to the TWP can be greatly reduced. Firstly, water is considered to be a finite and vulnerable resource. Secondly, water development should be based on a participatory approach. This is a critically important element for the TWP and forms a fundamental component of the final recommendations of this report. Thirdly, women play a central role in the management of water. Finally, water has an economic value. By embracing all of these elements, the decision to proceed with the TWP will gain legitimacy.

World Water Council (WWC). The WWC announced the World Water Vision in March at The Hague. This provided the foundation for the development of a World Water Movement, along the same lines as the World Environmental Movement. It endorsed both Agenda 21 and the Dublin Principles. The impact of this is likely to be felt in the normative dimension of what can be loosely described as the "rules of the game". In other words, the final decision to proceed with the TWP will be judged against these rules. If the decision results from elements that are not in harmony with those rules, then that aspect will be latched onto by watchdog NGOs, and the legitimacy for their actions will be provided largely by the gap that exists between practice and the international normative order. The converse is also true however. The World Water Vision recognized the need by developing countries to mobilize water resources as part of their developmental strategy. Nowhere is mention made in the Vision that large dams should not be built. The implication for the TWP is that provided the decision to proceed is made within the normative framework that includes genuine public participation and that embraces the notion of ecological sustainability, then that decision can be morally justifiable. These critical elements are all found within the National Water Act (Act 36 of 1998) so no problems are foreseen in this regard.

Global Water Partnership (GWP). The GWP is concerned mainly with providing assistance to developing countries. Lobbying within this forum is thus a means for gaining support for the decision to proceed with the TWP.

World Commission on Dams (WCD). The WCD is busy with the process of defining the rules, processes and procedures that need to be considered when deciding to construct large dams such as the TWP. The final outcome of the WCD is not yet known, but it is unlikely to place a moratorium on the construction of dams. This implies that provided the rules and procedures are followed, then a final decision to build a dam is justifiable. In fact, by adhering strictly to the recommended procedures, then the exploitable hydropolitical elements that are needed to sustain watchdog NGOs are largely negated.

3.11.2 The major implication of the international normative order can be best be translated into two elements of a mitigating strategy. These are:

The process of public participation is crucial. It is this process that legitimizes the final decision to proceed with the project as it enables public opinion to be tested and factored into the decision. It also allows alternative proposals that the anti-dam lobby will put forward to be tested. For example, it is known at this stage that the anti-dam lobby will say that the TWP is not needed because a national WDM policy is not in place. By testing that call in a public forum and allowing the anti-dam lobby to present its case for scrutiny and comment by all role-players, the sting can be removed from the tail if that proposal is not viable. Attention should be given to adequately structuring this process in order to prevent it from degenerating into a free for all.

The process of public participation means that actors, who wish to form an opinion, can do so against the background of increasing awareness of the issues involved. This increased awareness impacts on perceptions, which in turn generate support for the project. An example of changing perceptions is the advertisement that the WWC was running on CNN at the time of drafting this report. It was designed to increase global awareness of the issues related to water scarcity. This is targeting a wide public and is likely to translate into increased support for environmental NGOs. It also means that the general public will accept a rational decision that results from a legitimate process of public participation, which is presented in a coherent manner, because their perceptions will have changed accordingly.

3.12 Form and content of the public debate concerning the TWP.

Attention should be paid to the likely form and content of the public debate that will in all probability emerge regarding the development of Phase 2 of the Lesotho Highlands Water Project (LHWP) versus the TWP. It is essential that an approach is used which identifies key issues or prioritizes the main elements in the debate. These should be clearly stated as well as their associated implications and consequences for the TWP, and that they are taken up in a report that is structured around them.

3.12.1 Hydropolitical relevance.

There are four major components to this issue. Each will be dealt with separately in order to ensure that all of the strategically significant aspects are covered. The four major components are as follows:

The Large Dam Debate. This is the international dimension to the overall problem, but it manifests internally via the efforts and activities of NGOs.

"Our Water", or the perceptions that exist regarding the "theft" of Zulu water for use in Gauteng, is mainly a sub-national issue, but it can develop into an international dimension if NGOs decide to take it up and run with it.

Problems peculiar to the TWP as a specific project, which embrace both of the above.

Problems peculiar to Phase 2 of the LHWP as a specific project, which embrace both of the above.

3.12.2 The debate on the relevance of large dams is mostly international in origin and can be broken down into five major sub-issues. These are listed in order of priority as follows:

Probably the most important sub-issue is the whole argument over the economic viability of such projects. The essence of this argument is that in a lot of cases large dams cost more than initially anticipated and they seldom deliver the benefits that are originally promised. This is particularly relevant to irrigation dams, or dams where large numbers of people need to be moved. Central to this argument is the strategic choice between taking the water to where the demand is, versus decentralizing consumers closer to the source of supply. This provides a linkage with the *"Our Water"* problem noted in paragraph 3.12.3.

Linked with the first sub-issue, but significant enough to be listed alone, is the whole aspect of the social impact of large dams. The core of the argument is that dam builders often fail to calculate the cost of the project in social terms. In reality, this is difficult to quantify and is mostly reduced to monetary terms as a result, this fact becoming part of the problem. This is probably one of the most important elements of the argument.

Linked with the first sub-issue, but significant enough to be listed alone, is the whole aspect of the ecological impact of large dams. The core of this argument is similar to that used for the social aspects, but it also has another dimension that is critically important to understand. This dimension is encapsulated in the technical concept of "reflexivity". Reflexivity is said to exist when a social grouping becomes concerned with the undesirable and unintended consequences of their actions, such as environmental degradation caused by industrialization and dam building, and actively try to limit these consequences by developing coherent strategies to affect this desire. Reflexivity is largely Eurocentric in origin and as such is a major part of the North/South debate. In truth, reflexivity is at the very heart of the large dam debate and is manifest in both the social and ecological arguments noted above. In fact, the WCD was created from this reflexive response. If reflexivity is at the heart of the problem, then it also provides a clue as to the solution. This lies in a national water policy that embraces WDM as a fundamental principle. In fact, the lack of a coherent WDM policy at the national level is the fifth critical element that has been identified in the study. If a national WDM policy is missing, then any project involving large dams will remain vulnerable as the four sub-issues noted above will then be used as justification for the activities of the anti-dam lobby.

It may be of some value to consider an *ex post facto* study of some of the existing dam projects in South Africa, with specific emphasis on listing all lessons that have been learned. This will also show that DWAF is deeply concerned with the issue and is not simply on a mission to build more dams, but rather to seek the most viable solution to the existing problems of water security.

3.12.3 The *"Our Water"* issue is largely a sub-national issue and can be broken down into three significant sub-issues. These are listed in order of priority as follows:

By far the most important sub-issue relates to what can best be described as political instability in parts of KZN. This has a long history and is deeply entrenched in the political culture of the province. Within this sub-issue there are three critical elements that can be isolated. Firstly, there is a strong tradition of Zulu nationalism, which has manifest on occasion as a secessionist desire. Evidence of this is found in the debate over federalism versus unitarism that is currently part of the South African constitutional development process. Indications are that at present the secessionist desire is latent, but if provoked, could become relevant again. Secondly, there is a history of warlordism, with particular relevance to the Thukela Basin. Elements of this still exist today making it probably more relevant than the secessionist dynamic. Thirdly, there is a debate surrounding the role of Traditional Leaders that has a long history. As noted in paragraph 3.3.2 and elsewhere in this report, it is at the level of the Traditional Leader that the TWP is most vulnerable from the sub-national hydropolitical environment. In essence, the traditional leader is the critical variable that can link up with warlordism and invoke latent secessionist sentiments.

Linked with the first sub-issue, but significant enough to be listed alone, is the whole aspect of the perception that the TWP is about "stealing our water". Such terminology was uncovered during the study, even if it was only at a desktop level. Clearly this is a deeply emotional angle with the potential of becoming the unifying slogan that a disaffected Traditional Leader with a history of warlordism can manipulate.

The final aspect is the whole debate around the strategic choice between taking the water to where it is needed versus using water to decentralize spatially and move the demand to the source. This is clearly an angle that is relevant to both the *"Our Water"* problem and the Large Dam Debate.

3.12.4 Problems peculiar to the TWP can be broken down into three significant sub-issues. These are listed in order of priority as follows:

The most important issue is the debate centered on spatial development as noted in paragraphs 3.3.2; 3.16.1 and elsewhere in this report. The crux of this debate is about matching demand with supply versus using the vulnerability of water deficit in the Gauteng area to stimulate spatial decentralization (taking the consumer closer to the source of supply). The critical issue within this debate can be reduced to the strategic choice between foregoing long-term future economic development of the lower Thukela Basin by providing a significant boost to the development of infrastructure and job creation in the short-term in the upper Thukela Basin. This element also contains the essence of the solution in the sense that it can be demonstrated that the TWP is not about stealing water, but rather about creating jobs and improving livelihood security in a developing country. The key for this is what would be regarded as royalties in the case of the alternative - the LHWP. Instead of paying royalties to a foreign country for the development of their citizens, that same money can be redistributed to the upper Thukela Basin and used for attaining livelihood security for South African citizens.

The second issue is that the TWP is directly within the sovereign competence of the South African Government. This has definite implications, all of which are positive in a hydropolitical sense. Firstly, it means that the potential problems are in essence a sub-national issue. This is not inconsiderable because it means that South African specialists can solve South African problems in a uniquely South African way. There is a deeply entrenched South African political culture in this regard, with the most notable example being the Conference for a Democratic South Africa (CODESA) and the peaceful transition to democracy that resulted from that programme. Secondly, because the problems are largely sub-national in nature, international NGOs can only come in by invitation. This does not mean that NGO activity will be non-existent. What it does mean is that NGO activity is unlikely to become a dominant factor with potential negative implications for the project, provided that the Project Management Team takes all reasonable grievances on board. In other words, NGO activity can become a positive element within the project and will only become problematic if fundamental hydropolitical issues are ignored and the project is pushed forward in a "come what may attitude". It must be noted that there is no evidence that the latter is the case, which bodes well for the future of the project from a hydropolitical perspective.

The major thrust of the anti-TWP debate is likely to be centered on the traditional arguments against large dams. The main element of this is the perceived irrelevance of such a project in the absence of a national WDM policy. The development of a national WDM policy therefore justifies the existence of the project, provided that long-term demand forecasts in the Vaal River Supply Area justify such augmentation, even in the face of WDM. This is particularly true in light of the fact that it is a sub-national project, with the added advantage of redistributing infrastructural development, along with the associated economic boost that accompanies such activities, to a part of South Africa that is deeply impoverished at present.

3.12.5 Problems peculiar to the LHWP can be broken down into three significant sub-issues. These are listed in order of priority as follows:

The most important issue is the fact that the LHWP is entirely an international project. This means that there is always the risk of unwanted and potentially destructive NGO activity from creeping into the project. This is likely to result in the full force of the international NGO community from descending on the LHWP and articulating the argument that is central to the debate on the relevance of large dams.

An added dimension of this is the absence of moral high ground for South Africa, because the perception among some international NGOs and commentators is that South Africa is capturing the resource-base of another country, and therefore stunting its long-term development potential. It should be noted that perceptions are driving this, rather than fact. This is likely to become an added dimension to the large dam debate.

Lastly, there is the complex issue of disbursing royalties to another country. This has two sides to it, making it a strategic choice for senior decision-makers. Firstly, by disbursing royalties and generally investing heavily in infrastructural improvements in Lesotho, South Africa is assisting with the development of that country. In fact, the money that is involved is a major source of revenue for the Government of Lesotho. The impact of this is achieving spatial development outside of South Africa and therefore contributing to the attenuation of the migration-push factor that results from the lack of economic opportunities in Lesotho. If this argument is followed, then the scale tilts in favour of Phase 2 of the LHWP. Secondly, by developing Phase 2 of the LHWP, the full benefit of the project in developmental terms is felt largely outside of South Africa. This is a moral dilemma however. Why develop another country, irrespective of how worthy that cause is, when there are pockets of underdevelopment and poverty within the upper Thukela Basin? In other words, should the South African Government not be more concerned with using South African capital and expertise, to develop parts of South Africa that are underdeveloped? This is clearly a strategic choice that has to be made.

3.13 Major interventions.

The TWP is a major intervention into the functioning natural and social systems. What effect will: sedimentological processes in the catchment, natural functioning of a river of the size and nature of the Thukela, regional and local human activity and development, and biodiversity considerations have on the construction, commissioning, operation and de-commissioning of the project?

3.13.1 Hydropolitical relevance.

Analysis of this aspect has revealed two components that are strategically relevant. These are as follows:

The delivery aqueduct will pass through rural areas that have inadequate or non-existent water services at present. If left unattended, the *"Our Water"* dynamic becomes relevant, fuelled by the visible sight of apparent abundance amid water poverty. This is clearly a debilitating factor. If the uThukela Regional Council is fully functioning by the time the TWP comes on stream, and all of the rural communities have been supplied by water at that time, this factor will become less significant. The lack of water supply security and economic cost considerations for rural water supply within the project area is therefore hydropolitically relevant.

The rural communities downstream of the proposed dams can possibly become the targets of disaffected Traditional Leaders. The emotional content of *"Our Water"* therefore becomes relevant and can be exploited for political purposes.

3.14 Effects of reduced fresh water flows on the natural, social and economic environments.

What effect will there be to the natural, social and economic environments of the Thukela Marine Banks, from the reduction in flow of freshwater to the mouth of the Thukela River, from the construction, commissioning, operation and de-commissioning of the TWP?

3.14.1 Hydropolitical relevance.

Analysis reveals three components to this problem. These are as follows:

Reduced streamflow can become the visible evidence that is needed to justify the *"Our Water"* element as noted elsewhere in this report. This in turn can provide a source of political activism by disaffected Traditional Leaders.

Linked with this is the natural tendency to blame any natural event such as a drought, on the construction of a major hydraulic installation. This can fuel the emotional element of *"Our Water"*.

The solution to the problem lies in the legal concept of the Reserve. By strictly adhering to this legal requirement, streamflow reduction will be managed in such a way as to mitigate against these two elements.

3.15 The Thukela Estuary.

How will the regulation of the Thukela River impact on the freshwater requirements of the Thukela estuary and the associated wildlife?

3.15.1 Hydropolitical relevance.

Purely from a hydropolitical perspective this is not a major issue as the Reserve, if correctly managed and implemented, will attenuate any catastrophic change and thereby limit any social impact to manageable proportions.

3.16 Support infrastructure.

What effect will the provision of support infrastructure for the project, such as roads, and power supply, have on the biophysical environment, people, and regional development of the areas surrounding the dam sites and conveyance routes and the Thukela catchment? Are there possible benefits for the region in terms of utilizing, or expanding on the support infrastructure and services both during and following completion of the construction of the project?

3.16.1 Hydropolitical relevance.

This aspect is arguably one of the most important components of the strategic decision to proceed with the TWP. As noted elsewhere in this report, a pivotal hydropolitical issue in the whole project centres on spatial development. There are two critical sub-issues within this context. These are:

The poles of one element of the debate are the benefits of infrastructural improvement in the short-term within the upper Thukela Basin versus the long-term development of the lower Thukela Basin.

The poles of the second element of the debate are the relative benefits of infrastructural improvements within South Africa versus similar benefits within a neighboring state.

3.16.2 Of particular relevance is the provision of water services to the rural communities in the upper Thukela Basin. While this is the responsibility of the uThukela Regional Council, this is a technical demarcation only, and lack of delivery will likely be blamed on the TWP by an uninformed local public. If rural water supply is linked to the overall project then it becomes morally justifiable to favour the TWP over Phase 2 of the LHWP. This will also serve to mitigate against the arguments that the anti-dam lobby will probably present.

3.16.3 Of considerable importance in a strictly hydropolitical sense is the opportunity that this provides for deepening the democratic experience in South Africa. In essence, the action of developing support infrastructure can be linked with democratic processes such as public consultation and policy-making, in a manner that allows the TWP to attain two critically important strategic objectives. These are as follows:

By embracing the democratic principle of participation and consultation, the infrastructural support can be used to deepen the democratic experience in South Africa. This is entirely consistent with the current political culture.

If this is done effectively, then the TWP can become a flagship of the African Renaissance. In essence, it can show how it is possible to effectively resolve the normal conflict that results from such activities, in a way that is dignified and constructive, in a manner that is entirely consistent with the African Renaissance ideal. In other words, African Renaissance is the catalyst that transforms water-related conflict to water-related cooperation.

3.17 Economic development of the uThukela Region.

In what way will the economic development of the uThukela Region and KwaZulu-Natal be affected by the export of water out of the Thukela catchment? What is the opportunity cost to KwaZulu-Natal of exporting water out of the province?

3.17.1 Hydropolitical relevance.

The essence of this problem is encapsulated in the strategic choice between the short-term development of the upper Thukela Basin versus the long-term development potential of the lower Thukela Basin. The actual economic impact of this in monetary terms is beyond the scope of the current report. The opportunity cost is effectively the ceiling that is placed on long-term development of the lower basin, along with the environmental impact associated with a regulated and reduced streamflow. It can be argued that this is offset by the advantage of the short-term boost to economic development within the upper basin reach of the river. It is recommended that a team of resource economists quantify these issues in a baseline study.

3.18 Local economic affects.

How much will the local economy, or in what way will the local economy be affected by the construction of dams and aqueduct routes? What will the economic effect be on centres such as Ladysmith, Colenso, Winterton and Bergville?

3.18.1 Hydropolitical relevance.

The quantification of this is crucial for the final decision to be made. Two elements of this are important. These are:

A significant threat to the project is anticipated from the anti-dam lobby who are likely to use the whole range of arguments that are present in the large dam debate. The existence of irrefutable evidence of the benefits will therefore be needed to counter this attack and to justify the decision to proceed.

As noted elsewhere in this report, a critical issue is the relative merit of using the TWP as a short-term delivery mechanism in order to achieve rapid economic growth and the attainment of livelihood security in the upper basin.

3.19 Crime and security.

In what way will current levels of crime and security in the region be influenced by the TWP?

3.19 Hydropolitical relevance.

There is not much data available on this aspect. Intuitively it is felt that if crime is driven largely by poverty, then poverty-alleviation is likely to be a component of the solution to crime. If this argument is sound, then the multiplier effect that is normally associated with the injection of large sums of capital into a local community will reduce crime in the long-term. In the short-term the picture is likely to be different however. It is likely to be disruptive to the normal lives of rural communities, when a large concentration of people occurs within their normally tranquil surroundings. Such an introduction of large numbers of people can have the effect of increasing crime in the short-term. There is thus likely to be a short-term/long-term element to this equation. In the short-term, crime can be expected to increase in the localized area of the construction, but in the long-term increased security of livelihood is likely to reduce crime levels in the local area. This opinion is speculative and is not supported at this time by hard evidence.

3.20 Forward and backward linkages of the project.

What are the social, economic, and biophysical forward and backward linkages of a project on the regional resource use and development activities in the Thukela catchment and KwaZulu-Natal?

3.20.1 Hydropolitical relevance.

There is insufficient data available at this time to make a detailed assessment. This is linked with a number of sub-issues, the most relevant being the following:

The process of political transformation that is taking place in South Africa at present is a dynamic one and not yet complete. Central to this process are two key issues. Firstly, there is the notion of redistribution of opportunities and access to resources such as land. Secondly, there is the process of consultation or participation. Both are necessary conditions for a stable political future. The second provides the key to resolving any problem that may arise from a clash between land distribution and land inundation.

The strategic decision that needs to be taken regarding centralization versus spatial development is also relevant. This decision has not yet been made as far as is known, so in the absence of a clear spatial-development policy, there is room for uncertainty. This uncertainty can translate into conflict if left unattended.

3.21 Migration of people.

Will the development affect the movement or migration of people within the catchment area of the Thukela? How does this fit in with the existing regional planning scenarios? Will the project add to or detract from sustainable development in the region? How will this affect the main environmental factors such (e.g. land degradation and resource use)?

3.21.1 Hydropolitical relevance.

The study did not have access to hard data, but at the desktop level it seems apparent that there are two distinct sub-issues that are relevant. These are:

Migrant labour has become a "normal" way of life for many South Africans. This has had a number of long-term debilitating effects, two of which are particularly relevant from a political perspective. Firstly, migrancy can probably be linked with the spread of HIV in the sense that alternative and promiscuous lifestyles become the norm. Secondly, migrancy has impacted socially in the sense that it has contributed to the breakup of the family unit as an important component of society. Clearly these are both negative aspects.

Migration is the result of the interaction of a complex set of factors, two of which are important at the strategic level. Firstly, there are migration push-factors. These cause a person to seek employment away from their normal place of residence. Arguably the most important component of this is rural poverty or the lack of viable employment opportunities at the local level. Linked with this however, is the one component of resource capture that results ultimately in ecological marginalization, if left unchecked. Ecological marginalization occurs when a local ecosystem become so degraded that it is impossible to sustain livelihood security, thereby inducing the person concerned to migrate. Secondly, there are migration pull-factors. These serve to attract migrants away from their place of residence.

3.21.2 There are three aspects of migration that deserve special mention in this report. These are:

Both of the above are evident in the Thukela Basin at present. Providing viable livelihood security within the local area at the basin level can attenuate some of the migration push-factors. This argument therefore favors the development of the TWP as a short-term enhancement to the local economy. By providing employment opportunities through a host of infrastructural projects at the local level, these push-factors will be attenuated.

There is the real danger of ecological marginalization if resource capture is allowed to proceed unchecked. This is an extreme condition however, and seems unlikely for the simple reason that the Reserve, if correctly calculated and applied, will prevent this from occurring. The correct application of the Reserve is therefore vitally important if long-term sustainability is to be achieved.

There is also the real danger that the TWP will ultimately strengthen the Gauteng economy to such an extent that it will contribute to the migration pull-factor. This is an important element of the problem as it contributes to the non-linear nature of the water supply dilemma. The stronger Gauteng becomes, the more the water demand increases so the greater the need to supply more water. This spiral becomes unsustainable over time, so WDM is an appropriate strategy to consider in conjunction with augmentation.

3.22 Land reform programme.

In what way will the TWP affect the current and future projects associated with the Government s Land Reform Programme?

3.22.1 Hydropolitical relevance.

At the level of a desktop study there are two aspects of this that are relevant. These are:

Water is what gives land value in an economic sense. An argument that can be used is that by reducing the volume of water for use downstream, in effect the value of the land is also being reduced. This is diametrically opposed to the concept of the Reserve and existing DWAF policy however. This is not expected to be a major issue as a result, as IFR/Reserve releases will adequately compensate during dry seasons. This factor should be considered in the communications strategy.

Land that is earmarked for the Land Reform Programme could be lost to inundation. Indications at the desktop level are that this is minimal however. Land reform projects border the proposed dam and benefits in the form of increased employment opportunities and the sale of crafts to tourists are a potentially viable economic benefit to the local community.

It is known that consultation between DWAF and the Department of Land Affairs has taken place, and that the latter are not allowing land within the dam sites to be earmarked for reform.

3.22.2 There are two aspects that are relevant in terms of developing a mitigating strategy. These are:

Such matters can be resolved through negotiation.

There is a legal requirement in terms of the National Water Act (Act 36 of 1998) to consult with all affected parties and related governmental ministries. This issue would have to be taken up with the relevant ministries and role-players.

3.22.3 The Ladysmith Project Office has informed the authors that all affected areas have been adequately identified and that full participation has been undertaken where necessary. It is also known that a database of the relevant Departments exists, and that they are represented at Departmental level on the Thukela Transfer Scheme Steering Committee.

3.23 Land use practices.

What are the practices (social/economic/biophysical) in the upper catchment, which are likely to give rise to land use practice that will negatively impact on the long-term sustainability of the scheme?

3.23.1 Hydropolitical relevance.

At the level of the desktop study there is insufficient detailed data on which to make a meaningful assessment. Insufficient time was available for a local field trip and no budget was provided for this. The Ladysmith Project Office has noted certain factors as being relevant however. These factors appear to be linked in a complex relationship that cannot be fully explained at the desktop level of study. These factors are:

Land reform is resulting in a significant shift in population, with indications that there is a population increase in the upper catchment.

An outcome from this is overgrazing, with a resultant potential for soil erosion and siltation.

One of the economic activities in the area appears to be the cultivation of Cannabis Sativa (Dagga), evidently in the absence of other viable ways to earn an honest living. This is illegal however, and police activities are driving the growers deeper into the mountain area, where soils are more fragile with an increased risk of siltation.

This in turn means that sediment loads are increasing. For example, the operation of Woodstock Dam is being negatively impacted due to sedimentation, which in turn will affect the operation of Jana Dam.

Another angle to this is the proposed Thukela Biosphere, with preliminary indications being that Chief Mthembu is not entirely convinced of the merits of such an endeavor. In addition to this, Chief Mthembu appears to be involved in a number of land reform cases, which are not yet fully understood.

3.23.2 Insufficient is known about the detailed dynamics of this issue at the desktop level, but it is clear that a number of sensitivities do exist. From the above simplified rendition of some of the issues, it is clear that the problem is highly complex and potentially problematic in a hydropolitical sense. It is therefore recommended that allowance be made for a more detailed assessment on the ground, with personal interviews of key role-players.

3.24 Loss of habitat.

Will the construction of the proposed dams result in the loss of habitat which is unique and threatened? What is the significance of this for biodiversity?

3.24.1 Hydropolitical relevance.

This is important to the hydropolitical dimension if unique habitat or biodiversity is lost, as this will become an element in the expected attack by the anti-dam lobby. A more detailed analysis will only be possible once a comprehensive EIA has been completed and made available.

3.25 Public health and diseases.

What are the public health and disease impacts associated with the scheme, including HIV/AIDS in the regional context?

3.25.1 Hydropolitical relevance.

This is important to the hydropolitical dimension because a probable component of the anticipated attack by the anti-dam lobby is likely to be the argument that an influx of construction workers will bring the increased incidence of HIV/AIDS. It is therefore necessary to have a baseline study done before the project commences that can serve as the basis for countering that attack. Beyond this, there is insufficient data available at this time to make a more detailed analysis.

3.26 Carrying capacity.

What is the carrying capacity of the biophysical, social and economic environment within which the scheme will be developed and have to operate? In what way will the project affect the carrying capacity?

3.26.1 Hydropolitical relevance.

Whereas the concept of "carrying capacity" has specific meanings within the engineering or ecological community, it is being contested in the hydropolitical community at the global level at present. The implication of this is that the notion of carrying capacity is becoming irrelevant in the hydropolitical domain. Specific contestation is emerging from the discipline that is known as "political ecology", which is starting to argue that the concept of carrying capacity is the result of constructed knowledge that presupposes a so-called "climax condition" that functions within an overall paradigm of "ecological equilibrium". This debate is highly theoretical and beyond the scope of this report. The counter debate is so-called non-equilibrium theory. In this theory, which is currently being developed, elements of the adaptive capacity of society that enable it to cope with changes in the environment become relevant. This implies that there is no such thing as a finite carrying capacity. Within the water sector, Israel is used as an example because at the national level, Israel has developed economically well beyond the expectation of the limitations of the so-called "water barrier".

3.26.2 It is beyond the TOR to present this debate in any more detail. It is therefore fitting to conclude by isolating two elements of this issue that are relevant. These are:

The notion of carrying capacity is becoming contested. Therefore, any argument that is presented by the anti-dam lobby based on this concept is also contestable.

The whole discipline of political ecology as a unique field of study is only starting to filter its way into South Africa at present. AWIRU is involved with this, specifically where it impacts on the water sector, and is therefore in a position to evaluate arguments that are presented along these lines.

3.27 Environmental indicators.

What are the most important environmental indicators that should be used to monitor the long-term effects or sustainability of the implementation of the scheme?

3.27.1 Hydropolitical relevance.

The selection of specific environmental indicators is beyond the scope of a hydropolitical analysis. The only hydropolitically relevant aspect is that the monitoring of such indicators is important for the justification of building large dams. As such, the data generated will be used by the anti-dam lobby to legitimize their views.

3.27.2 A concept that is central to hydropolitical processes is the notion of "natural resource reconstruction". This is the empirically verifiable result of WDM strategies and is used to determine whether such strategies are effective. It would therefore be useful if environmental indicators could be selected that reveal the rate and extent of natural resource reconstruction, because this would enable decision-makers to evaluate the effectiveness of WDM strategies.

3.28 Natural resource utilization.

What will the impact of the TWP be on natural resource utilization in the Thukela Basin? Specifically, what effect will there be on; resource supply and the future consumption of basic goods, game carrying capacity and game hunting enterprises, micro-enterprises associated with natural products, and options for further use?

3.28.1 Hydropolitical relevance.

Insufficient data is available at this time to make an assessment. It can be anticipated that there will be a negative impact as the result of the TWP. This is a very superficial argument however, and is open to contestation. A more complex argument would factor in the increased revenue that the multiplier effect would bring to the upper Thukela Basin, and then determine if this offsets any loss in the lower basin.

3.28.2 There is the need for a baseline study on which these calculations can be made.

3.29 Eco-tourism.

What are the implications of the TWP for eco-tourism in the upper Thukela basin? How will tourism based on important historical, archaeological and cultural sites in the region be influenced?

3.29.1 Hydropolitical relevance.

There is strong evidence that eco-tourism will be negatively affected in some form or other, at least in certain enterprises that need wild and scenic rivers to function. In fact, it is from this quarter that strong opposition is anticipated. This is likely to be in two forms as follows:

At least one NGO intends to start lobbying for a Wild and Scenic Rivers Act to protect the upper Thukela Basin from damming.

The same NGO is likely to lobby for support from other NGOs, which in turn can result in widespread opposition to the TWP as a whole. Some of these international NGOs have considerable resources at their disposal, and they are capable of putting up a significant fight.

3.29.2 It is known that DWAF has opened negotiations with these role-players, with a concept document relating to the establishment of a "River Park" having been drafted. This only fulfils the requirement that these specific stakeholders have been afforded the opportunity to raise concerns, and unless these concerns are acted upon in some form or other, the hydropolitical relevance will remain.

3.30 Legal and administrative factors.

What important legal and administrative factors should be considered at a regional level to ensure that the TWP is constructed and operated in an environmentally sustainable and acceptable manner?

3.30.1 Hydropolitical relevance.

The desktop analysis reveals three elements of this issue that are relevant. These are:

In terms of legislation, there is adequate coverage from at least two pieces of legislation. These are the National Water Act and the National Environmental Management Act. Within the framework of these two pieces of legislation, there seems to be sufficient legal coverage. Particularly relevant in this regard are the Reserve and the classification of rivers. If this is calculated and applied adequately, then environmental sustainability is likely to be achieved within acceptable parameters.

The critical problem is likely to be human capacity to monitor the compliance with legislation. This is a national problem, and hopefully by the time that a decision is made to proceed with the TWP (assuming that such a decision is made), then capacity would have improved.

A separate issue is that relating to democracy. Within the overall parameters of this report, a case is being developed for the use of the TWP to deepen the democratic experience within South Africa. Part of this experience involves the role of NGOs. If used creatively, and provided that NGO activity is governed by a Memorandum of Understanding (MOU), then it is not inconceivable that they can play a useful role in the whole project. The major relevance of democratic components to the TWP is threefold. Firstly, it will enable capacity to be generated over time, as people become increasingly involved with the project. Secondly, it will reduce the conflict potential by eliminating the them/us syndrome that is part of *"Our Water"*. Thirdly, by making people participants in the process, they take ownership of the issues and problems. This in turn develops responsible use of the resource over time. If this argument is followed to its logical conclusion, then sustainability is a product of democracy. An overwhelming amount of evidence is available from outside South Africa that where democracy is deeply rooted, there are also strong elements of sustainable practices and reflexivity. Democracy and sustainability are therefore linked.

3.30.2 A MOU is a significant instrument in mitigating the conflict potential and is strongly recommended for consideration by DWAF. In this regard the experience that has been gained with a similar instrument in the management of the LHWP can be a valuable starting point. Such an instrument is the result of negotiation between DWAF and other relevant role-players. The main benefit is that an accepted understanding of the rules of engagement between the major role-players is the result, with the actions of NGOs becoming more predictable. In short, an effective MOU formalizes the relationships between major role-players, and spells out procedures to be followed in the event of disagreement over an issue.

A major benefit of a MOU is that it locks the role-players into a given relationship that is governed by mutually agreed rules and procedures. This serves to reduce the room that each role-player has for independent maneuver and as such reduces the conflict potential. In essence the role-player concerned concedes their wide range of potential movement to a well-defined set of possibilities in return for being formally recognized.

A major disadvantage of a MOU is that Government effectively concedes its sole right of independent action and locks itself into a new relationship with outside role-players. It can be argued that this erodes state sovereignty to some extent.

The use of a legal instrument such as a MOU is entirely in line with the sentiments of the World Water Vision, which sees future role-players in the water sector being clustered around three main groupings - Government, civil society and the private sector. NGOs form a significant component of civil society, and a formal MOU will give them this formal recognition.

3.31 Loss of land and habitat.

Will the loss of land or habitat and scenic landscape attributes materially effect either present or future land use options?

3.31.1 Hydropolitical relevance.

An assessment of this is beyond the scope of the current study.

3.32 Effects of infrastructure.

What will the direct effects of the construction, commissioning and operation of the dams and aqueduct routes be on existing infrastructure and access, the affected biophysical environment and the directly affected people?

3.32.1 Hydropolitical relevance.

It is likely that these will have a negative effect on the local community in terms of disruption while the project is under construction. While such disruptions are clearly a nuisance for local people, they have limited hydropolitical relevance. The only time that this will be hydropolitically relevant is if one of two conditions are encountered. These are:

If an ecologically sensitive part of the aqueduct route is damaged, then it can attract NGO activity.

If the issues that are indicated as being problematic by the directly affected people are not adequately dealt with, then NGO activity can be expected.

3.33 Provision of roads and other infrastructure.

What effect will the provision of roads and other new infrastructure such as pump stations and power stations have on the people and the biophysical environment on or near to these secondary infrastructural projects?

3.33.1 Hydropolitical relevance.

The hydropolitical relevance is similar to the point raised in paragraph 3.32.1, except that in most cases better access roads will exist. This will impact positively on the tourist potential of the area.

3.34 Ecosystems.

What will be the effect of the construction and operation of the dams on the ecosystems and organisms in the dam basins and downstream riverine and aquatic habitats?

3.34.1 Hydropolitical relevance.

There will clearly be an impact on the ecosystems as the result of construction and operation of the proposed dams. The magnitude of the impact is beyond the scope of this report. There are three aspects that are hydropolitically relevant. These are as follows:

The ecological impact is a major component of the debate on the relevance of large dams.

"Our Water" dynamics can be exacerbated if ecosystem collapse results in the loss of natural resources on which livelihoods depend.

This is likely to be the major trigger event that serves to mobilize international NGOs against the project.

3.34.2 Having noted that there is likely to be a significant ecological impact, in hydropolitical terms there are at least three components that can be harnessed to mitigate against this. These are as follows:

An adequate and comprehensive EIA should be carried out before works commence. An important part of this process is the time allowed for public participation in the review of the findings. If the feedback is taken into the overall management process, then the problem is likely to remain within manageable proportions.

If the Reserve is accurately calculated and stringently adhered to, then the impact is likely to be reduced to manageable proportions.

If a national WDM policy is implemented, then it will attenuate the chances of hostile NGO activity, thereby contributing to a reduction of the problem to manageable proportions.

3.35 Recommendations.

What recommendations should be made to the DWAF for the following: compensation for the loss of arable land, fixed property or other similar loss of patrimony, resettlement as a result of the construction of infrastructure, flooding or other operational aspects of the TWP?

3.35.1 Hydropolitical relevance.

There is a wealth of information that is available from the international dimension of this aspect of water resource engineering. There are probably six major recommendations that can be made. These are as follows:

The WCD recommendations are likely to contain comprehensive guidelines in this regard. These should be studied when available and taken on board where relevant. This will serve to harmonize the TWP with best practice standards at the global level and thereby reduce the intensity of hostile NGO activity.

The notion of equity or fairness should be the guiding norm. This is deeply rooted in the current South African political culture so this should not be problematic.

There should be an adequate process of public participation and consultation on the issue. Underlying this is the notion of transparency and the role of NGOs where appropriate. This is also deeply rooted in the South African political culture so it is not an alien concept.

There should be sufficient money and other resources within the overall TWP budget for these purposes.

Compensation should not always be given in cash, as there is a lot of evidence from elsewhere in the world that this leads to secondary problems that were originally unforeseen. This is particularly relevant for deeply rural communities who may be partially literate and not fully integrated into the cash economy.

A specialist study on the subject should be considered. This can be part of the study suggested in paragraph 3.12.2. This will enable lessons that have been learned from elsewhere to be documented and thereby provide a body of readily available literature on which to base future compensation strategies. In particular, lessons that have been learned from similar ventures in South Africa and the LHWP, should be incorporated into the final compensation policy.

3.36 Environmental management systems.

What environmental management systems and plans need to be put in place for the management of impacts during the construction and operation of the scheme? What are the environmental impacts associated with construction in particular and management framework is needed for: construction camps, batching plants, earthworks, concrete construction, administration, transportation, quarrying or borrow activities, solid waste disposal, water use, and dust?

3.36.1 Hydropolitical relevance.

The hydropolitical relevance is similar to the point raised in paragraph 3.32.1.

3.37 High-risk situations during times of flood.

Large quantities of water with significant energy levels will have to be returned over the dam spillways into a relatively narrow river course in a steep-sided gorge, during times of high flood. This raises major operating concerns and risks. What environmental effects are associated with these high-risk situations?

3.37.1 Hydropolitical relevance.

Whilst this is mainly an engineering-related issue, there are three hydropolitically relevant aspects to it. These are as follows:

The final recommendations of the WCD are likely to contain a comprehensive set of measures that are appropriate. By harmonizing these measures with dam operating regimes, this will comply with best practice norms. It is possible that local dam management regimes (operating rules) can be more stringent than those adopted internationally, in which case significant credibility will be achieved if this information is made known publicly.

Basic democratic principles of participation, consultation and transparency dictate that the affected public should be made aware of the risks. If appropriate, linkages can be established with downstream communities in order to warn them of impending danger. This aspect is not new to South Africa, as similar issues are relevant to the construction of informal houses below the 50-year floodline on a number of smaller rivers. The magnitude of these floods differ fundamentally from the 1:10 000 year events used for dam design however, but the principle of consultation remains the same.

There are strict legal requirements in this regard as stipulated in the National Water Act (Act 36 of 1998). If these are adhered to, then hydropolitical risk will be diminished to manageable proportions.

4. HYDROPOLITICAL DIMENSION AS THE PROBLEM

4.1 From the foregoing analysis it is evident that there are two main hydropolitical problems at the strategic level. These are as follows:

Large Dam Debate. This is an issue that is global in nature and is largely a manifestation of Northern Hemisphere inspired reflexivity. As such it is mainly exogenous but all pervasive. The major vehicle through which the impact of this debate is likely to be felt is the activity of international NGOs. These role-players have access to significant resources and are capable of mounting considerable opposition to any given project. If ignored, then the problem is likely to become unmanageable, to the possible point of causing the project to be aborted.

"Our Water". This is an issue that is sub-national in nature. As such it is mainly endogenous but potentially destructive if left unmanaged. There is the potential to link up with international NGOs if the interests that are articulated by sub-national interest groups are ignored.

4.2 The Definition of the Hydropolitical Problem.

The hydropolitical problem is the result of the coincidence of two major issues - The Large Dam Debate and *"Our Water"* - simultaneously and in such a manner as to cause an imbalance in the overall hydropolitical equation.

4.3 This problem can be represented graphically in the form of a balance as shown in Figure 1.

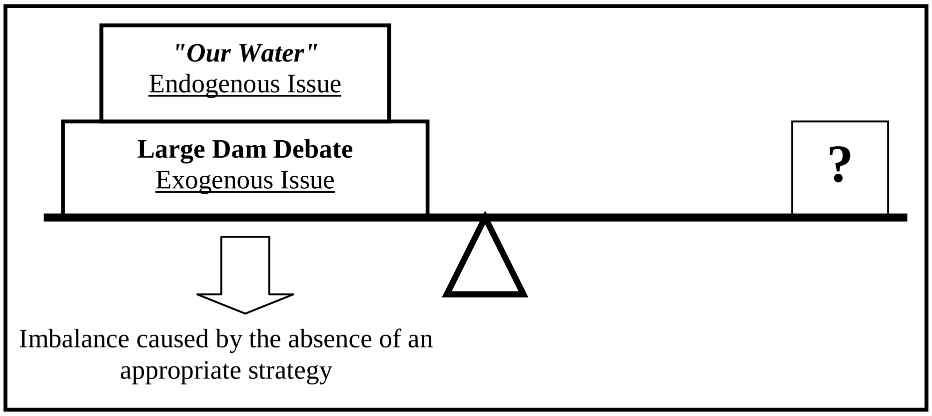

Figure 1. Schematic representation of the hydropolitical problem that is found in the Thukela Water Project.

5. HYDROPOLITICAL DIMENSION AS THE SOLUTION

5.1 Having defined the problem, it is now possible to develop an appropriate hydropolitical management strategy that will enable the equation to be balanced. While the two major problems are significant in their own right, there are viable mitigation strategies that can be developed in all cases. There is no evidence that these problems are of such an unmanageable nature as to cause the catastrophic failure of the TWP, provided that each element of the proposed plan is implemented systematically and in full measure.

5.2 There are three critically important elements of the proposed solution. These are as follows:

Policy. The first key component of the solution involves a rational and coherent policy framework within which the final decision is made to proceed with the TWP. The strategic objective of this component is to determine the ultimate viability of augmentation. The critical interceding variable in the attainment of this strategic objective is the process of public participation. It is the process of adequate and transparent public participation that removes the obstacles and criticisms that fuel the fire of hydropolitical dissent. An inverse relationship can be anticipated between the degree of participation and the extent of opposition to the project.

Perceptions. The second key component of the solution lies in the perceptions that exist within the public or within the opinion making elite that are found in special interest groups such as NGOs. The strategic objective of this component is to gain sufficient legitimacy for the TWP to make it a viable project. The critical interceding variable in the attainment of this strategic objective is the development and implementation of a culturally sensitive communication strategy (public relations) that is sustainable for the entire duration of the project.

Planning. The third key component of the solution is innovative and thorough planning. The strategic objective of this component is to counter every hydropolitical threat to the project by anticipating and addressing every reasonable piece of opposition that is likely to be presented. The emphasis in this component is the concept of being reasonable. The critical interceding variable in the attainment of this strategic objective, is the inclusion of specialists who are capable of working in a multidisciplinary environment in the overall planning team from the feasibility phase, right through to the final operation and decommissioning of the project.

5.3 In keeping with the African Renaissance theme that is hydropolitically relevant, an African solution is being proposed. This solution has been developed in such a way as to creatively combine traditional African cultural experiences with modern hydropolitical theory and practice. The most appropriate solution is thus embodied in the notion of *Izimpondo Zenkunzi* - the horns of the bull. This strategy consists of three components, which embrace the five major hydropolitical variables that are relevant in this case. These are as follows:

Planning. This can be likened to the chest or body of the bull. Planning needs to be creative, innovative, systematic and multidisciplinary. These elements already exist within DWAF. Significantly, the planning process must allow for sufficient public participation, as well as the incorporation of feedback into the final policy, in addition to an appropriate communications strategy.

Policy. This can be likened to the tip of the one horn of the bull, with the body of the horn consisting of public participation. Planning must allow for the feedback that is generated during the participation phase to be incorporated in the final policy. In other words the logical sequencing will be for planning to proceed with public participation, and then for the feedback that is yielded to be reincorporated via the planning process into the final policy. It is as a rational part of this policy that the decision to augment supply for the Vaal River System via either the TWP or Phase 2 of the LHWP must be made. This is important because it will legitimize the decision to build large dams and thereby reduce hydropolitical opposition to manageable proportions.

Perceptions. This can be likened to the tip of the other horn of the bull, with the body of the horn consisting of public relations. Planning must allow for the development of a coherent communications strategy that is targeted specifically at changing perceptions in such a way as to generate legitimacy for the policy. This is important because it will generate public support for the project and will reduce the hydropolitical opposition to manageable proportions.

5.4 The proposed *Izimpondo Zenkunzi* solution can be represented graphically as shown in Figure 2.

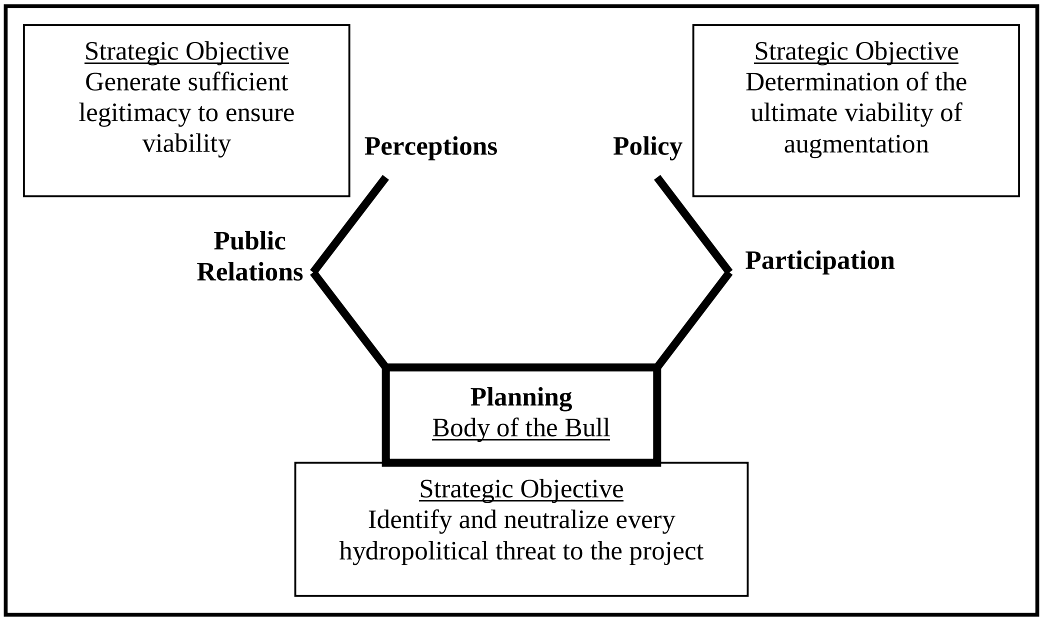

Figure 2. Schematic representation of the proposed Izimpondo Zenkunzi solution showing the body and horns of the bull superimposed on the strategic objective of each component.

5.5 The proposed *Izimpondo Zenkunzi* solution addresses every aspect of the problem that has been isolated from the hydropolitical analysis, and if applied systematically and thoroughly, the risk of derailment of the project is reduced to manageable proportions. Particularly relevant to the viability of the project is the strategic decision to link it to the deepening of democracy in South Africa. This places the project in a special league where factors other than those of a purely environmental or hydrological nature become relevant. If this is done, then the moral high ground that is achieved is of such significance as to reduce the opposition from both the anti-dam lobby and *"Our Water"* to near insignificant proportions. In fact, by linking it to democracy, all of these issues will automatically be factored into the final decision, thereby greatly enhancing the viability of the project.

5.6 The relationship of the proposed *Izimpondo Zenkunzi* solution with the overall problem is represented graphically in Figure 3.

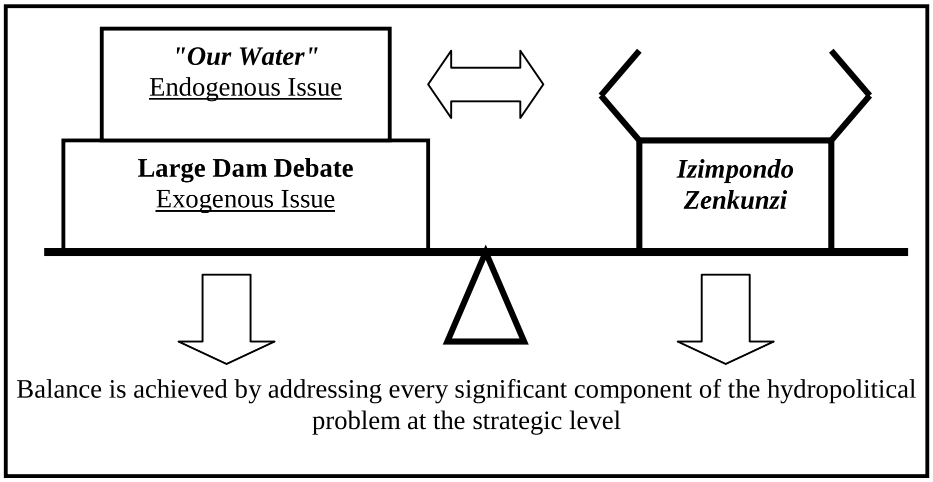

Figure 3. Schematic representation of the relationship between the proposed Izimpondo Zenkunzi solution and the overall problem.

6. HYDROPOLITICAL CRITICAL PATH ASSESSMENT

The following can be regarded as a form of critical path assessment in order to determine the likelihood of hydropolitical opposition to the TWP should a decision be made to proceed with it. It is presented as a series of questions with alternative answers that are linked with the degree of opposition that can be anticipated. The questions are posed in an order of priority. The first 5 questions that are posed first are the most important. They can be regarded as critical factors and the way in which they are answered will probably determine the final outcome of the TWP from a hydropolitical perspective. If any of the first 5 questions are answered negatively, then severe hydropolitical repercussions can be anticipated, to the extent that the project may be derailed. If the project is structured around an affirmative response to these 5 critical questions, then the TWP is likely to be viable even in the face of the Large Dam Debate and the *"Our Water"* issue. The remaining questions can be regarded as being contributing factors, and the way that they are answered will cumulatively contribute to the extent of hydropolitical opposition that can be anticipated.

6.1 Critical Factor # 1. Is the future demand forecast for the Vaal River Supply Area capable of withstanding intense scrutiny by the public and NGOs and still retain its validity?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and unmanageable and the project may be fatally flawed.

6.2 Critical Factor # 2. Is the decision to augment supply to the Vaal River Supply Area supported by, and made within, the framework of a national WDM policy?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and unmanageable and the project may be fatally flawed.

6.3 Critical Factor # 3. Is there a process of adequate public participation in which all role-players have a reasonable chance of expressing their opinions and viewpoints?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and unmanageable and the project may be fatally flawed.

6.4 Critical Factor # 4. Is there an active communication strategy (public relations) that is aimed at informing the general public of the strategic need and benefit of the project that is sustainable over time and that changes public perceptions in a measurable way?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and unmanageable and the project may be fatally flawed.

6.5 Critical Factor # 5. Is there provision in the planning for using the project to deepen the democratic experience in South Africa?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and unmanageable and the project may be fatally flawed.

6.6 Contributing Factor # 6. Is there a detailed EIA available for scrutiny and comment by the public and interested NGOs?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.7 Contributing Factor # 7. Is there a detailed social impact assessment that is available for scrutiny and comment by the public and interested NGOs?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.8 Contributing Factor # 8. Is there an adequate compensation procedure that is based on notions of fairness and transparency, and that incorporates the lessons that have been learned from elsewhere?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.9 Contributing Factor # 9. Is there a Memorandum of Understanding between DWAF and major role-players that spells out the areas of cooperation, principles of cooperation, code of conduct, responsibilities, duties and *modus operandi* of each party?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.10 Contributing Factor # 10. Is the reasonable feedback by role-players incorporated wherever possible into the final planning?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.11 Contributing Factor # 11. Has every reasonable attempt been made to mitigate against negative environmental and social impacts and then communicated effectively to the public as an integral part of the overall plan?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.12 Contributing Factor # 12. Is there a mechanism for local participation as far as is reasonably possible and in keeping with basic principles of democracy?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.13 Contributing Factor # 13. Is there a strategy for accommodating special domestic water requirements by diverting part of the water for distribution to local communities in the upper Thukela Basin?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.14 Contributing Factor # 14. Is there a reasonable and quantifiable benefit to the residents of the Thukela Basin that is sustainable over time?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.15 Contributing Factor # 15. Has a strategic decision been made and effectively communicated to all role-players regarding the implications of a concentration of economic activity in the Vaal River Supply Area in keeping with the democratic principles of transparency?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.16 Contributing Factor # 16. Has a strategic decision been made and effectively communicated to all role-players regarding the implications of a choice between the TWP versus Phase 2 of the LHWP in keeping with the democratic principles of transparency?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

6.17 Contributing Factor # 17. Has every reasonable effort been made to comply with the recommendations of the WCD?

If yes, then hydropolitical opposition will be limited and manageable.
If no, then hydropolitical opposition will be severe and potentially unmanageable.

7. RECOMMENDATIONS FOR ADDITIONAL RESEARCH

7.1 What lessons can be been learned from the resettlement components of major projects both inside and outside South Africa, with a view to developing guidelines that are consistent with democratic principles?

7.2 How can major water resource engineering projects such as the TWP be used to deepen the democratic experience in South Africa, with specific emphasis on processes and structures?

7.3 What is the nature and relationship between migration-push and migration-pull factors that are relevant to major water resource engineering projects such as the TWP, with specific emphasis on the development of viable policies and management plans?

7.4 What are the grassroots sentiments that drive perceptions about large water resource engineering projects such as the TWP, and how can these be incorporated into the overall management strategy of such projects?

7.5 What are the essential components of an appropriate communication strategy that is needed to support the management of large water resource engineering projects such as the TWP?

7.6 What are the reasons for the apparent failure of past spatial development attempts away from areas of water scarcity and closer to the source of supply? Can these failures be overcome though policy intervention, or are they of such a magnitude as to be practically insurmountable?

7.7 What is the nature and extent of secessionist sentiments in the KwaZulu-Natal province of South Africa? Are these sentiments latent and dormant? Can they be expected to become patent and active in the future? If so, to what extent is this likely to be the result of large water resource engineering projects such as the TWP? To what extent can political risk analysis be used as a tool in this regard?

7.8 What are the future water demand forecasts for the Vaal River Supply Area, taking the impact of HIV/AIDS into consideration?

7.9 What is the level of HIV/AIDS infection at present in the upper Thukela Basin? How is this likely to impact on the future of the TWP? How can negative impacts be prevented?

7.10 What is the level of HIV/AIDS infection in the Vaal River Supply Area? How is this likely to impact on future water demand? How do existing migration patterns impact on this? How can negative impacts be prevented?

7.11 What are the relative advantages and disadvantages of developing a spatial development strategy that is based on deliberate policies of decentralization away from the Vaal River Supply Area? Are such strategies viable? Why have they failed in the past? What is needed to make them succeed in the future?

7.12 What are the relative advantages and disadvantages of developing the upper Thukela basin versus Phase 2 of the Lesotho Highlands Water Project?

7.13 What are the dynamics of a trigger event within the hydropolitical dimension of major water resource engineering projects such as the TWP? How can they be anticipated and managed in such a way as to reduce the negative consequences of such events? How does a trigger event feature in the changing hydro-social contract?

7.14 What is the role and functioning of NGOs within the water sector? How can they become meaningful role-players? What is needed to reduce the level of unpredictability that can result from their actions? What role do such organizations play in the overall democratic process?

7.15 What are the implications of the World Water Vision and World Commission on Dams on water management strategies in the future?

7.16 What are the economic advantages in clearly quantifiable terms of the development of the upper Thukela Basin in the short-term, versus the long-term development of the lower Thukela Basin? What economic benefits, in quantifiable terms, can be expected from the development of supporting infrastructure such as roads?

7.17 What are the current land use patterns in the upper Thukela Basin? What land will be affected by inundation and land reform? How do these two components interact? What solutions exist where the interaction is negative? Where possible this should be supported by GIS.

7.18 What is the magnitude and relevance of lost habitat and biodiversity in hydropolitical terms as the result of the TWP? How will this impact on management of the project? What must be done to mitigate against these issues?

7.19 What environmental indicators can be used to monitor and evaluate the process of natural resource reconstruction?

7.20 What is the nature and extent of current natural resource use in social terms within the area affected by the TWP? This should be a baseline study.

8. CONCLUSION

This report is part of a larger study that has as its final goal, the determination of the best possible solution to the future water needs of the Vaal River Supply Area, taking all factors into account. This specialist report covers one of those factors only, and seeks at best to prevent a sub-optimal solution from being chosen when political factors impact negatively on best decisions. From the foregoing study it is evident that there are a number of factors that are present in the hydropolitical dimension of the TWP. These are of such a magnitude that they have the potential to impact negatively on the overall viability of the project. Two factors are particularly important - the effort being made by some hydropolitical elites to change public opinion about the relevance of large dams and *"Our Water"* - and if left unmanaged, can derail the project. This does not mean that the TWP is stillborn. What it does mean however, is that a sophisticated management strategy is called for from the early stages of planning right through to final commissioning and operating. The fundamental principles of democracy that underpinned the CODESA process, as enshrined in the South African Constitution, and as encapsulated in the National Water Act (Act 36 of 1998), provide the framework for the solution. In keeping with the African Renaissance theme that is part of the contemporary South African political culture, an African solution has been proposed. This creative and viable solution - *Izimpondo Zenkunzi* - combines traditional African culture with modern hydropolitical principles. In addition to this, a hydropolitical critical path assessment has been developed. It is the authors opinion that if these recommendations are diligently adhered to, then the TWP is likely to be a viable project from a purely hydropolitical perspective.

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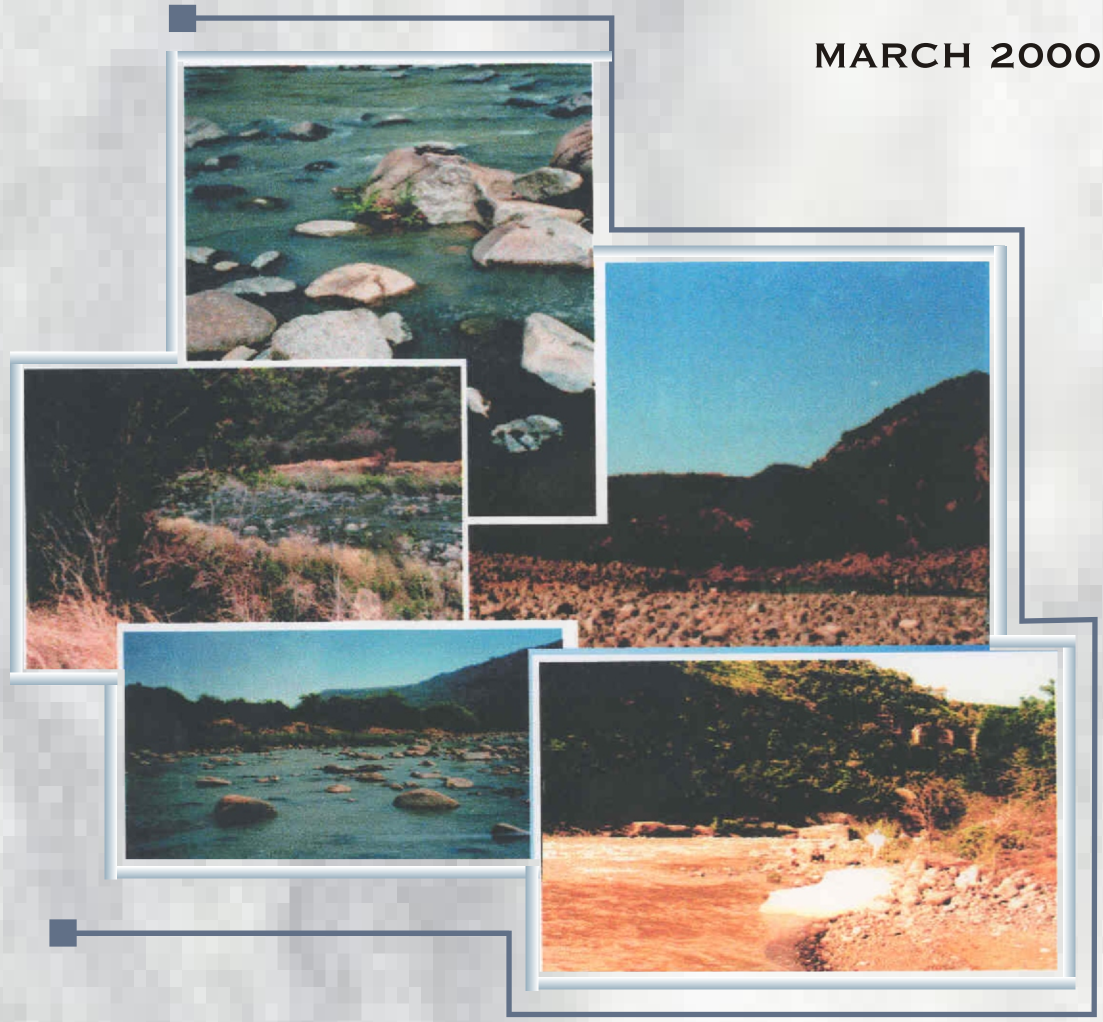
Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

INSTREAM FLOW REQUIREMENTS:

SUMMARY REPORT

MARCH 2000



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THUKELA WATER PROJECT FEASIBILITY STUDY

INSTREAM FLOW REQUIREMENT STUDY: SUMMARY REPORT (1995 – 2000)

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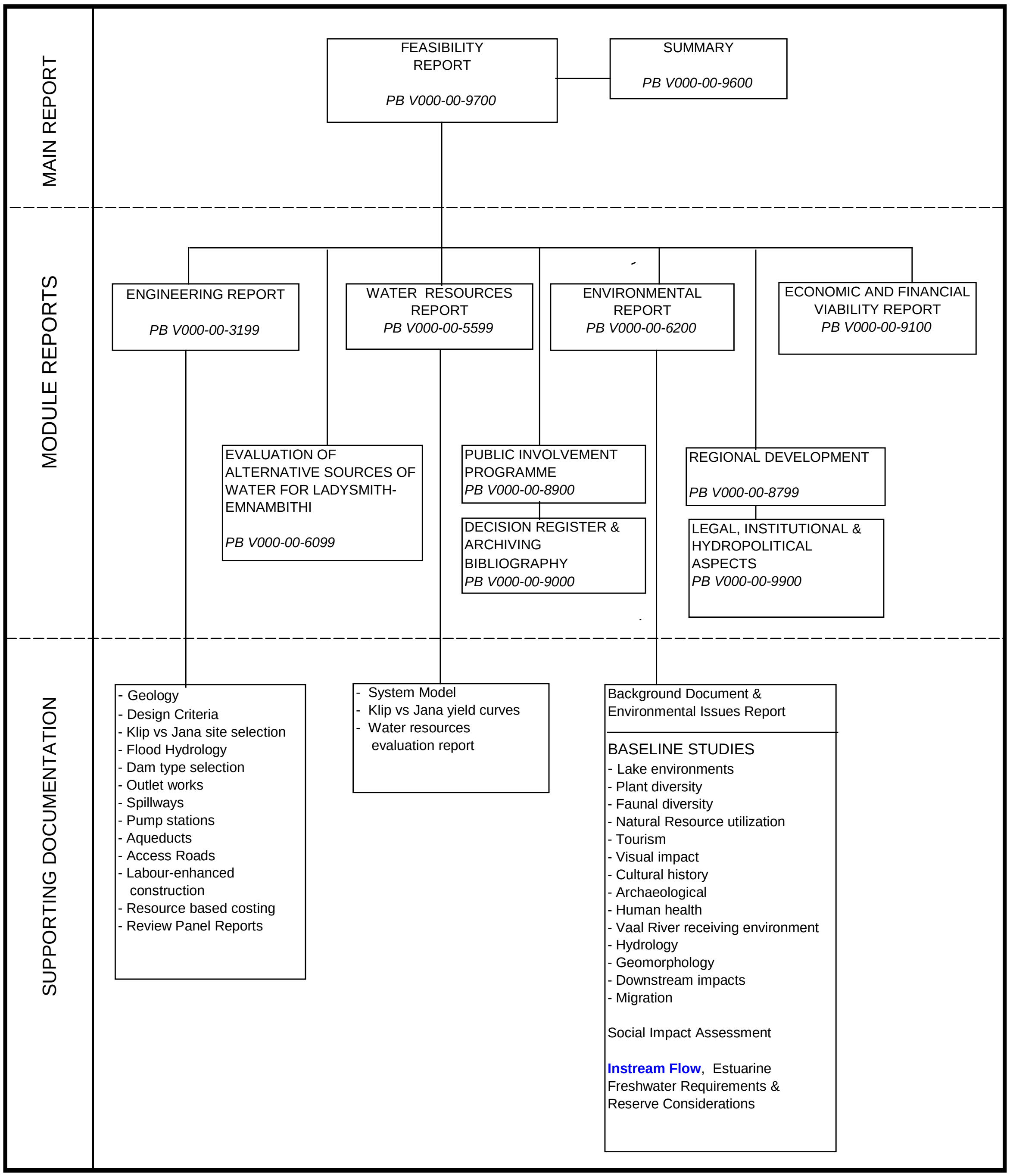
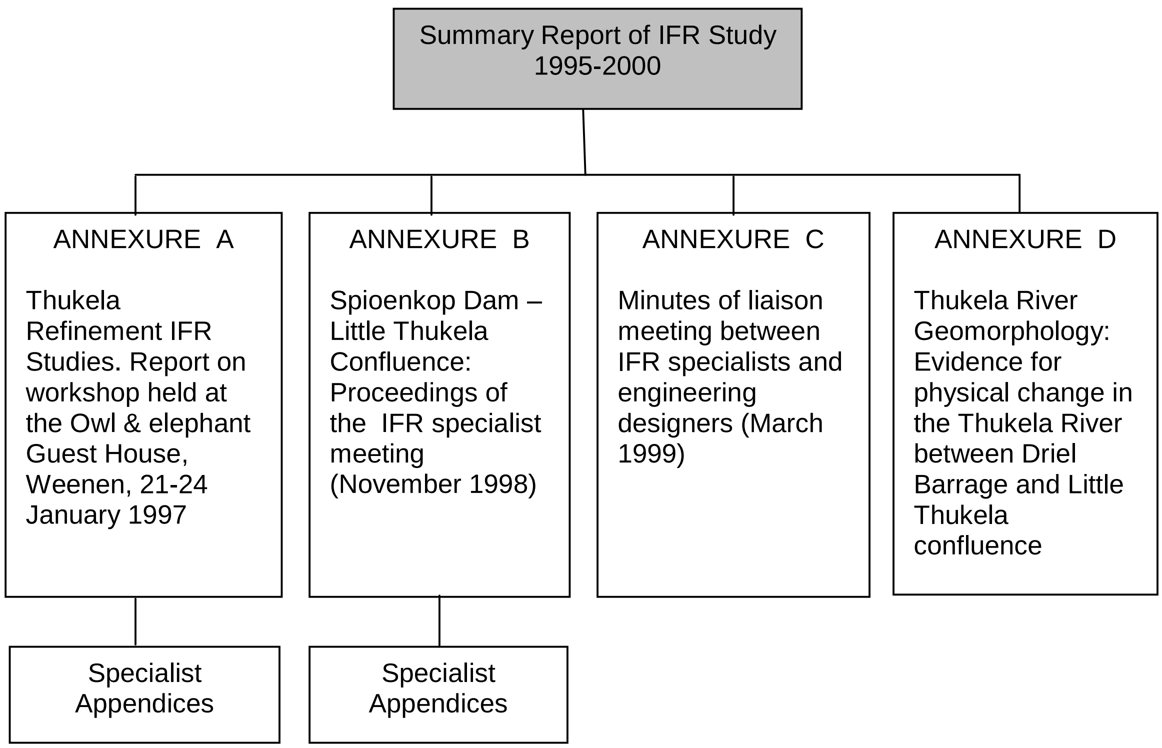
STRUCTURE OF REPORTS



THUKELA WATER PROJECT FEASIBILITY STUDY

INSTREAM FLOW REQUIREMENT STUDY: SUMMARY REPORT (1995 – 2000)

REPORT STRUCTURE



THUKELA WATER PROJECT FEASIBILITY STUDY
INSTREAM FLOW REQUIREMENT STUDY SUMMARY REPORT

IWR ENVIRONMENTAL **MARCH 2000**

Approved for IWR Environmental by:

..

D Louw: Team Leader & Director

PREFACE

This Module Report reviewing the Instream Flow Requirements associated with the Thukela Water Project proposals that emanate from the Feasibility Studies was prepared by IWR Environmental and their team of specialists. The authors were appointed to undertake one of 15 modules in the Feasibility Study and obtained information from and liased, inter alia, with investigating teams assigned to the other modules. The report was prepared under the direction of the Project Management Team.

The report has been accepted as representing the outcome of the terms of reference assigned to IWR Environmental and has been used as an important source document for the preparation of a Main Feasibility Report on the Thukela Water Project. All the views, findings, interpretations and recommendations of the authors may not necessarily have been included in full in the Main Feasibility Report.

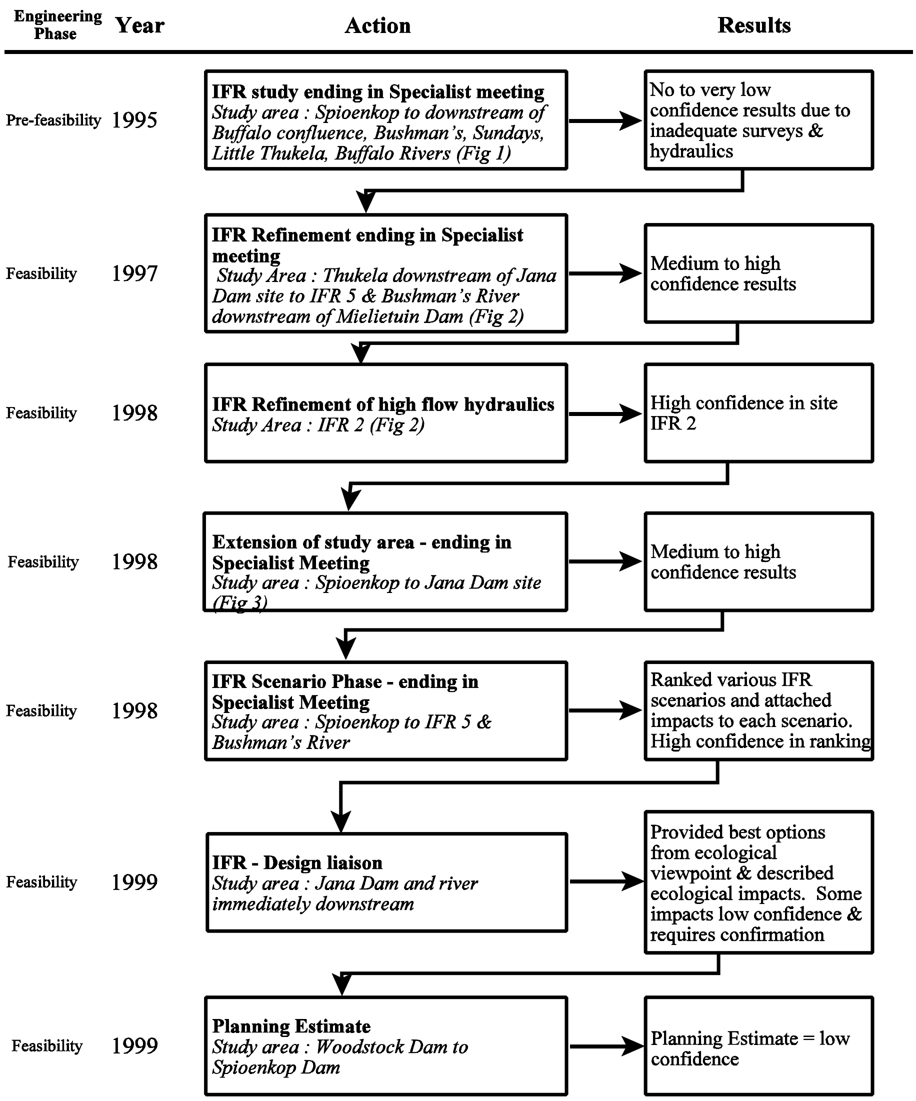
SUMMARY

In 1994 the Department of Water Affairs and Forestry (DWAF) initiated the Vaal Augmentation Planning Study (VAPS) to determine the merits of alternative water resource development options to follow Phases 1A and 1B of the Lesotho Highlands Water Project (LHWP). The VAPS is part of ongoing water resource development and management planning at a national level. The subsequent Thukela Water Project Feasibility Studies was initiated in 1997 as a confirmation of the VAPS in order to further investigate the feasibility of possible water resource development of the Thukela River Catchment. An Instream Flow Requirement (IFR) study was initiated during 1995 as part of the VAPS study and various IFR actions have taken place since 1995.

The IFR actions that were undertaken are the following:

- 1995 IFR Study
- 1997 IFR Refinement
- 1998 IFR Refinement - high flow calibration
- 1998 - Extension of IFR study area
- 1998 - Scenario IFR phase
- 1999 - IFR / Design liaison
- 1999 - Planning estimate: Woodstock Dam to Spioenkop Dam
- 1999 - Evidence for physical change in the Thukela River between Driel Dam and the Little Thukela confluence.

The interlinkages between the various studies are described in the flow diagram below.



The results of the various actions are documented in various reports (referenced later), and *this report* serves as a summary of the results generated by the various studies.

The medium to high IFR confidence results are summarised in the following table:

The values in the table represent Instream Flow Requirements (IFRs) at these positions in the river system. These values include natural flows required and their distribution (and volumes) over the course of a normal rainfall year and during an abnormally dry or drought year. Apart from the normal river flow released as part of the operation of the dam, special releases from a future dam(s) may be required at certain times of the year to meet these requirements.

	IFR A		**IFR 2**		**IFR 5**		**IFR 3A**		**IFR 3B**	
	X 10^6 m^3	% OF MAR	X 10^6 m^3	% OF MAR	X 10^6 m^3	% OF MAR	X 10^6 m^3	% OF MAR	X 10^6 m^3	% OF MAR
MAINTENANCE LOW FLOWS	166	18.2	162.22	10.7	250.92	11.62	51.24	18.11	55.68	17.79
MAINTENANCE HIGH FLOWS	86	9.5	143.04	9.42	157.84	7.31	28.24	9.98	32.36	10.34
TOTAL	***252***	***27.7***	***305.26***	***20.1***	***408.76***	***18.92***	***79.48***	***28.09***	***88.04***	***32.03***
DROUGHT LOW FLOWS	64	7.1	70.1	4.61	106.14	4.91	24.35	8.6	26.05	8.32
DROUGHT HIGH FLOWS	17	2.7	50.43	3.32	44.79	2.07	5.38	1.9	5.98	1.91
TOTAL	***81***	***9.8***	***120.53***	***7.93***	***150.93***	***6.99***	***29.72***	***10.50***	***32.03***	***10.23***

The National Water Act (No 36 of 1998) requires that the Reserve (Ecological and Basic Human Needs) be quantified before allocating water to other new users. The IFR study, even though initiated before the Ecological Reserve came into place, does include some of the steps required for the Reserve and an analysis has been made of the steps required to upgrade the existing IFR results so that it may be regarded as the Ecological Reserve. These actions mostly centre around the need for:

- stakeholder input into the setting of the Environmental Management Class;
- the Water Quality Reserve
- the Groundwater Reserve.

CONTENTS

List of Figures

List of Tables

List of Annexures

CHAPTER 1 : INTRODUCTION

In 1994 the Department of Water Affairs and Forestry (DWAF) initiated the Vaal Augmentation Planning Study (VAPS) to determine the merits of alternative water resource development options to follow Phases 1A and 1B of the Lesotho Highlands Water Project (LHWP). The VAPS is part of ongoing water resource development and management planning at a national level. The subsequent Thukela Water Project Feasibility Studies was initiated in 1997 as a confirmation of the VAPS in order to further investigate the feasibility of possible water resource development of the Thukela River Catchment. An Instream Flow Requirement (IFR) study was initiated during 1995 as part of the VAPS study and various IFR actions have taken place since 1995.

The IFR actions that were undertaken are the following:

- 1995 IFR Study (Pre-feasibility Study)
- 1997 IFR Refinement (Feasibility Study)
- 1998 IFR Refinement - high flow calibration
- 1998 - Extension of IFR study area
- 1998 - Scenario IFR phase
- 1999 - IFR/Design liaison
- 1999 - Planning estimate: Woodstock Dam to Spioenkop Dam
- 1999 - Evidence for physical change in the Thukela River between Driel Dam and the Little Thukela confluence.

The above actions were applicable for different study areas and the results were of various levels of confidence. The actions have also been documented in various reports, minutes, appendices etc and are at different stages of finalisation. This summary report serves to integrate all the information available (with specific emphasis on the final usable result) in the various documents.

The documents from which this report was summarised are the following:

Date	**Author**	**Title**	**Status**	**Available from this source**
Jan 1997	Department of Water Affairs and Forestry, South Africa	Thukela - Vaal Transfer Scheme, Interim Study, Instream Flow Requirements	Final	Department of Water Affairs and Forestry
Aug 1997	WJ Muller, IWR, Rhodes University	Thukela Refinement IFR Studies (Southern Tributaries) Report on a Workshop held at the Owl and Elephant Guest House, Weenen, 21 - 24 January 1997	Final Draft	Thukela Water Project
Nov 1998	Edited D Louw	Starter Document : IFR	n/a	Appendix of next report
Nov 1998	D Louw, IWR Environmental	Thukela IFR study : Spioenkop Dam - Little Thukela : Proceedings of the IFR specialist meeting	Final Draft	Thukela Water Project IWR Environmental
Mar 1999	-	Minutes of meetings	n/a	Thukela Water Project
Dec 1999	R Wadeson, IWR Environmental (PMB)	Evidence for physical change in the Thukela River between Driel Dam and the Little Thukela confluence.	Draft	Thukela Water Project

CHAPTER 2 : 1995 IFR STUDY

2.1 BACKGROUND & PURPOSE

In 1994 the Department of Water Affairs and Forestry (DWAF) initiated the Vaal Augmentation Planning Study (VAPS) to determine the merits of alternative water resource development options to follow Phases 1A and 1B of the Lesotho Highlands Water Project (LHWP). The VAPS is part of ongoing water resource development and management planning at a national level.

A Pre-feasibility Study was initiated and concluded in 1996. As part of the Pre-feasibility Phase, an Integrated Environmental Management (IEM) study was initiated. The IEM process included a rudimentary or reconnaissance level Environmental Assessment (EA) which required an IFR study to identify the impacts of the proposed developments on the riverine ecosystem. The IFR study is phased and linked to the engineering Pre-feasibility and Feasibility Phases. The IFR actions which are required during the Pre-feasibility Phase and which were undertaken are the following:

- Initial pre-specialist meeting investigations, i.e.,
  - Selection of study area
  - Habitat Integrity Assessment
  - Selection of IFR sites
  - Fish, Geomorphology, Riparian vegetation, Aquatic invertebrates, Social utilisation and Water Quality data collection and surveys.
  - Hydrological and hydraulic modelling
  - Determination of Environmental Management Class (EMC)
- Specialist Meeting
- Report documenting the proceedings

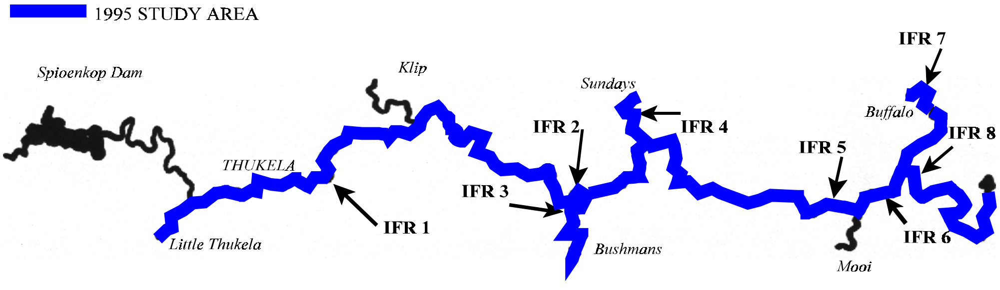
2.2 STUDY AREA

The study area and IFR sites selected are illustrated in Fig 1. The study area included the following:

- Thukela River downstream of the Little Thukela confluence to a point about 30 km downstream from the Buffalo River confluence.
- The Bushman's River downstream of the Wagendrift Dam
- The Sundays River (focus on the downstream section)
- The Buffalo River (focus on the downstream section)

The study area was represented by eight IFR sites of which five were in the main Thukela River. One site each was situated in the tributaries. The arrangement was made prior to the study that the tributary's IFRs would be at a coarse scale as the length and physical/ecological changes along these rivers would require more than one IFR site. It was concluded that if further investigations took place in the tributaries, additional IFR sites would be required during a refinement process.

Fig 1 : 1995 STUDY AREA AND IFR SITES



2.3 RESULTS & CONFIDENCE

During the IFR specialist study it became apparent that both the cross-sectional surveys and the hydraulic analysis were inadequate and could not be used with any confidence to derive meaningful ecological information from the relationships between flow rate and hydraulic parameters such as depth, wetted perimeter and velocity. The final results were therefore worthless until the hydraulic analysis was substantially refined or repeated in its entirety.

No to low confidence was attached to the IFR results and they were consequently NOT used in the Pre-feasibility Phase hydrological modelling.

2.4 FURTHER WORK RECOMMENDED

The recommended further work, in order of high priority to low priority recommended was as follows:

- Cross-sectional re-surveys of all sites
- Repeat of hydraulic calculations for all the sites
- Relocate IFR 2 (it was not representative of the gorge)
- Additional IFR sites in the tributaries
- Model IFRs to determine available yield
- Design a monitoring protocol.

CHAPTER 3 : 1997 IFR REFINEMENT

3.1 BACKGROUND & PURPOSE

The Thukela Water Project (TWP) Feasibility Study is intended to include an evaluation of all factors which may affect the viability of development proposals on the Thukela River to a sufficient degree of detail to:

- Identify all the technical issues likely to affect implementation and to define and evaluate all the actions required to address these issues.
- Provide an estimate of cost with sufficient accuracy and reliability to ensure that management decisions can be made with confidence.

A much more sophisticated IEM investigation formed part of the Feasibility Study, which included a feasibility level Environmental Assessment (EA) and the specialist IFR study as part of this EA. The IFR study actions that normally take place during a Feasibility phase are the following:

- Refinement of the results generated at the IFR specialist meeting.
- Scenario phase during which an investigation of different scenarios of IFRs, their impact and ranking take place.
- Preliminary recommendations regarding the design of the proposed development.
- Design of a monitoring programme.

Linked to the confidence and results of the 1995 Pre-feasibility IFR study the following actions were undertaken during the IFR refinement study during the TWP Feasibility Phase:

- Resurvey of the relevant sites.
- New hydraulic modelling and hydraulic calibration data collection spanning two seasons.
- Additional sites and relocation of sites where necessary.
- Additional specialist studies where necessary.
- Specialist meeting to adjust the IFR results according to the new information generated during the refinement.

3.2 STUDY AREA

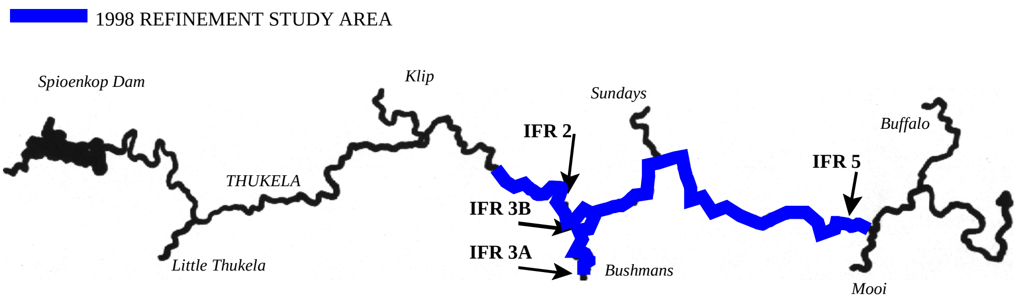
The study area and the IFR sites selected at feasibility level are illustrated in Fig 2. The Feasibility Study only focussed on the more upstream section of the Thukela River and its tributaries. The study area included the following:

- Thukela River downstream of the Jana Dam site to IFR 5 (downstream of the Sundays River confluence) in the Thukela River.
- The Bushman's River downstream of the Wagendrift Dam.

The Thukela River downstream of IFR 5, the Sundays and Buffalo Rivers were therefore not part of the refinement study.

The study area was represented by four IFR sites of which two were in the main Thukela River. Two sites were situated in the Bushman's Tributary. IFR 5 was exactly similar to the 1995 study, IFR 2 (in the Thukela) and IFR 3 (changed to IFR 3B) in the Bushman's River was relocated and a new additional site in the Bushman's River upstream of IFR 3B and downstream of Wagendrift Dam (IFR 3A) was selected. (See Fig 2)

Fig 2 : 1998 REFINEMENT STUDY AREA AND IFR SITES



3.3 RESULTS & CONFIDENCE

The Ecological Management Class (EMC) for the Thukela and the Bushman's River was selected as a B/C (i.e. largely natural to moderately modified).

The results generated for the Thukela and Bushman's River to maintain the EMC are presented in Chapter 9. A medium to high confidence was attached to the results.

3.4 FURTHER WORK REQUIRED

The recommended further work in order of high priority to low priority, was as follows:

- Incorporate additional flood data obtained into the hydraulic modelling. Flood flows occurred during the IFR Refinement Specialist meeting. These flows were measured from bridges and the associated water level surveys undertaken. (If these flows were to be incorporated in the hydraulic modelling to adjust the rating curve and the associated IFR results, the overall confidence of the IFR results would increase).
- Model IFRs to determine available yield.
- Preliminary input into design.
- Design a monitoring protocol.

The work associated with the first three bullets was conducted during the Feasibility study and the findings are provided in this report.

CHAPTER 4 : 1998 IFR REFINEMENT - HIGH FLOW CALIBRATION

4.1 BACKGROUND & PURPOSE

During the 1997 IFR Refinement specialist meeting (21 - 24 January1997) floods occurred at the IFR sites on the Thukela and Bushman's Rivers. No flood data were available for the refinement study and consequently the opportunity was taken to measure surface flow velocities from the high-level bridges downstream of IFR 2 in the Thukela and across the Bushman's River at the town of Weenen. Stage levels were also recorded at the river cross-sections at IFR 2 and 3B during the specialist site visits. In order to estimate the flood discharges and utilise the additional rating data, it was, however necessary to survey the bridge profiles from which the flow measurements were taken - a task undertaken in September 1998. The refinements to the rating relationships and changes to the January 1997 recommended discharges based on the refined hydraulics were then undertaken.

4.2 STUDY AREA

The study area was the same as that for the 1998 IFR. The high flow calibration was only relevant to IFR 2 and 3B, as 3A was not visited on the same day that the flow measurement was undertaken. No stage levels were therefore available for this site.

4.3 RESULTS & CONFIDENCE

The highest flow previously measured was 28,9m^3/s (Thukela River, IFR 2). The new high flows that could be used for hydraulic calibration purposes were 145m^3/s and 312m^3/s. This resulted in changes in the high flows recommended during the 1997 refinement studies. The range of changes are as follows:

IFR 2 :

- 30 m^3/s Y 31 m^3/s
- 60 m^3/s Y 67 m^3/s
- 100 m^3/s Y 118 m^3/s
- 200 Y 255 m^3/s

The resulting IFRs incorporating the above changes had a high confidence evaluation.

These results are incorporated in the IFR tables in Chapter 8.

No changes were made to the IFR results in the Bushman's River.

4.4 FURTHER WORK REQUIRED

Flood measurements in the Bushman's River to increase the confidence in high flow recommendations should be undertaken if possible. However, the high flows recommended do not pose any problems for releases and this information requirement does not have a high priority.

CHAPTER 5 : 1998 - EXTENSION OF IFR STUDY AREA

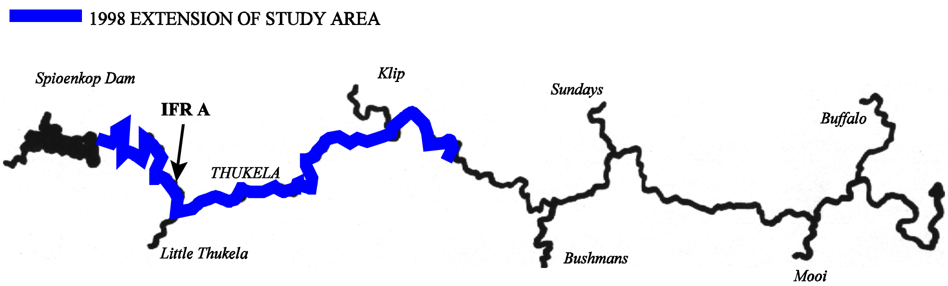
5.1 BACKGROUND & PURPOSE

The sizing of Jana Dam is influenced by the effect of the IFR on the estimated yield. To determine the yield accurately, the operation of the upstream Spioenkop Dam and the proportion of the IFR which it should supply for the reach downstream of the dam needed to be determined. An IFR for this reach was therefore required.

5.2 STUDY AREA

The study area was the Thukela River downstream of Spioenkop Dam to the Jana Dam site. This area was represented by one IFR site (IFR A). (See Fig 3)

Fig 3 : 1998 EXTENSION OF STUDY AREA



5.3 RESULTS & CONFIDENCE

An EMC class of B (largely natural) was allocated to this section of the river. The IFR results were in the medium to high confidence range. However, it must be noted that the evaluation is dependant on the accuracy of the statement that there is a long-term trajectory of change (i.e. degradation) of the river (specifically in its fluvial geomorphology) taking place due to the present operation of the dam. This implies that even though the dam has been operated for the last 30 years at volumes lower than the IFR requirements, continued operation of the dam would in the long-term not maintain the present ecological state.

5.4 FURTHER WORK REQUIRED

The IFR influences the yield of Spioenkop Dam considerably. As the IFR is based on the assumption that there is presently a long-term degradation in the geomorphology of the river, it will be necessary to confirm this by undertaking a geomorphological modelling study. This study was conducted during November 1999 as part of the Feasibility Study.

CHAPTER 6 : 1998 - SCENARIO IFR PHASE

6.1 BACKGROUND & PURPOSE

The IFR results for the Thukela River downstream of IFR A down to and including IFR 5 need to be included in the system analysis to determine the effect on the yield of the system. During a Scenario specialist meeting the results of the system analysis were presented to the IFR specialists. This included a range of different scenarios, which might hold significant advantages or disadvantages to the yield of the system. The advantages and disadvantages from an ecological viewpoint were determined.

6.2 STUDY AREA

The Thukela River, specifically IFR A was used to evaluate the ecological impacts. As the Scenario specialist meeting immediately followed the IFR A specialist meeting, this site was the easiest to relate to. However, the impact must be seen as relevant for the whole area.

6.3 RESULTS & CONFIDENCE

The IFR results for IFR A, 2, 5, 3a & 3b were modelled using the Water Resources Yield Model (WRYM). The water available after supplying the IFRs served as the available yield for the users.

IFR scenarios were then formulated and these were evaluated from an ecological viewpoint and the possible impacts on the river described.

The scenarios were the following:

Scenario 1 : Extended Drought
Maintenance flows and the assurances of maintenance flows stayed the same in this scenario. However, the occurrence of drought flows doubled. Therefore, if the drought flows at IFR A occurred 7% of the time (as was determined by the IFR model), it will now occur 14% of the time.

This scenario would result in a lowering of the EMC of the river.

Scenario 2 : 10% reduction of all flows
All flows were reduced by 10%. The impacts were evaluated by converting the recommended flows (IFR) to depths and the other relevant hydraulic parameters. The decrease in habitat was then evaluated.

This scenario would result in a lowering of the EMC by half a class (10 % vs 20% for a full class) in the long-term.

Scenario 3 : Dry season decrease of assurance
The scenario consists of

- the summer flows (December to March) to be maintained at the assurance set during the IFR determination;
- winter flows with a decreased assurance compared to the assurance set during the IFR determination. Flows in the month of August therefore were specified to have an assurance of 60 % and will now have an assurance of 30 %. The other months will proportionately decrease;
- High flows stay the same.

The changes in measurable parameters (eg. depth, velocity, wetted perimeter) are relatively low, and the resulting impacts on the riverine ecosystem are therefore difficult to quantify with any confidence.

The impact on the riverine ecosystem is of a resolution that is difficult to quantify. No short term change in EMC is expected.

Ranking of scenarios
The scenarios in the order of least to most damage to the riverine ecosystem are as follows:

- Scenario 3
- Scenario 2
- Scenario 1

It must be noted that Scenario 3 is by far the least deleterious of the three scenarios.

High confidence was attached to the ranking of the scenarios.

6.4 FURTHER WORK REQUIRED

The results of the IFR A and the refined IFR 2 must be incorporated into the WRYM model.

CHAPTER 7 : 1999 - DESIGN/IFR LIAISON

7.1 BACKGROUND & PURPOSE

Some flexibility exists in the design of Jana Dam for incorporating features which could hold a range of implications for the riverine ecology.
A Jana dam design scenario which entailed

- concrete dam (160 m high)
- two bottom outlets that can release in total 300m^3/s and need to be tested on a monthly basis (worst case scenario)
- multilevel outlets that can release 80m^3/s in total
- tailpond dam (27 m high, 300 m long, 100 m wide and with no operable sluices)

was discussed at a specialist meeting. The ecological issues were identified and where applicable, options different from the above (eg tailpond dam vs plunge pool) was discussed.

7.2 STUDY AREA

The study area was the riverine ecosystem downstream from Jana and Mielietuin Dams to IFR 5.

7.3 RESULTS & CONFIDENCE

The design and operation issues from an ecosystem viewpoint are closely related. Some operation issues were discussed, and although not relevant to *design* specialist meeting, the issues were noted. Low confidence is reflected in question marks where impacts are evaluated.

7.3.1 Tailpond Dam vs Plunge Pool

- Stratification : One of the major problems is the temperature of releases due to stratification in the dam. In summer, water temperatures at the bottom of the dam may be considerably colder than at the surface or in the river. The tailpond dam would allow mixing of the water released from the dam, allowing the temperature to adjust to a situation more similar to the river temperature. The possibility of stratification in the tailpond dam however also has to be investigated and whether, under certain operating scenarios, this could negatively influence the flow to the river. However, the plunge pool option will allow for no mixing or adjustment and the impact on temperature compared to the tailpond dam is probably much higher. This impact will especially be critical during the summer when the temperature of the monthly 'testing' release will be much colder than the ambient water temperature. The confidence is low in these assumptions as a water quality modeling study needs to be undertaken to confirm this.
  Impact of tailpond dam LOW? Impact of plunge pool VERY HIGH?

- Fluvial geomorphology : The tailpond dam will attenuate the release and dissipate the energy considerably. Without the tailpond dam, significant erosion and aggredation will take place in the river reach downstream of the dam. The 300m^3/s releases from the bottom outlet without a tailpond dam could have significant impacts on the channel geomorphology and hydraulic habitats. Seasonally during winter, the vegetation could be reduced so that banks might be more unstable than during summer and the releases could cause erosion. Also, the consequences on biotopes could be significant as this would be an unnatural flooding regime, with large floods, and no other medium and small floods. The suite of actions that take place to maintain these habitats would be disrupted by such an unnatural flooding regime. These high-flow releases could however be 'caught' completely in the tailpond dam (if not full) and would then have no impacts downstream.
  Impact of tailpond dam LOW - NONE Impact of plunge pool VERY HIGH?

- Instream biota : The tailpond dam will be biologically impoverished due to the large dam releases into the tailpond dam. A plunge pool could have major negative effects, as the biota immediately downstream of the dam wall will be wiped out by the releases. As there is nothing to prevent biota moving back into the impacted river stretch (through migration eg), this could create a repetitive scenario.

Impact of tailpond dam ***NONE*** ***Impact of plunge pool*** ***VERY HIGH?***

7.3.2 Tailpond dam operable vs tailpond dam not operable

The design of the tailpond dam is such that, at present, operation will be on a stand-alone basis and does not include operable sluices. This could however have negative ecological consequences. At some stages the 300m^3/s would need to be caught in the tailpond dam and, if the tailpond dam at that stage is full and flow cannot be released from the tailpond dam, the tailpond dam will not be able to mitigate the possible unseasonal release. This design of the tailpond dam will therefore require additional engineering investigation.

Impact **LOW** ***Impact*** ***HIGH?***

7.3.3 Flood release - combination between bottom and multi-level outlets

A yearly flood of 255m^3/s is required according to the IFR recommendations. To enable such a release, a combination other than two 150 m^3/s from the bottom outlet might be required. However, this is not a major engineering issue. At this stage there are no specific reasons to change this. The water quality problems associated with the bottom release are independent of the sizes from the two outlets.

7.3.4 Initial operating when dam starts storing water

Quantity : The initial closing of the dam could cause problems with a no-flow or low flow situation with limited releases. This is an engineering issue that can be addressed. The IFR specialists emphasized that the river should not stop flowing, even for short period. Quality : The issue of dam basin clearing was discussed as this could have implications on the initial water quality of the dam. This needs to be investigated and is an operation issue, not design. The IEM team would consider this matter further.

7.3.5 Attenuation of floods

Attenuation of required floods at points downstream of the dam is a major problem. Larger releases from the dam might be required to achieve the required peak at downstream sites but these may have undesirable effects nearer to the dam.

7.4 FURTHER WORK REQUIRED

Certain operational issues and some engineering issues such as the possibility and necessity of adjusting the tailpond dam into a more operable structure must be investigated. These issues must then be brought to the larger IEM group for their input.

A water quality modeling study of the dam and tailpond dam has to be undertaken and this will quantify the relevant assumptions made.

CHAPTER 8 : 1999 - PLANNING ESTIMATE : WOODSTOCK DAM TO SPIOENKOP DAM

8.1 BACKGROUND & PURPOSE

It was found that for accurate yield modelling, as well as to distribute the IFR proportionately, an IFR estimate was required downstream of Woodstock Dam. Due to time constraints, the Planning Estimate method was undertaken which provides a conservative and low confidence answer.

8.2 STUDY AREA

The study area is the Thukela River downstream of Woodstock Dam to the Spioenkop Dam. A hypothetical point is selected for a Planning Estimate and this would be near the inflow of Spioenkop Dam.

8.3 RESULTS & CONFIDENCE

An estimate based purely on visual observations by one specialist in the area was made regarding the Environmental Management Class which resulted in a low confidence class B. As there is no chance of the river being a class higher, i.e. A = pristine, a lower class C/B was also investigated. The IFR results for class B and B/C class are presented in Chapter 9. As the method used is the Planning Estimate, the confidence is by definition low.

8.4 FURTHER WORK REQUIRED

A detailed IFR study is required.

CHAPTER 9 : 1999 : EVIDENCE FOR PHYSICAL CHANGE IN THE THUKELA RIVER BETWEEN DRIEL DAM AND THE LITTLE THUKELA CONFLUENCE

9.1 BACKGROUND & PURPOSE

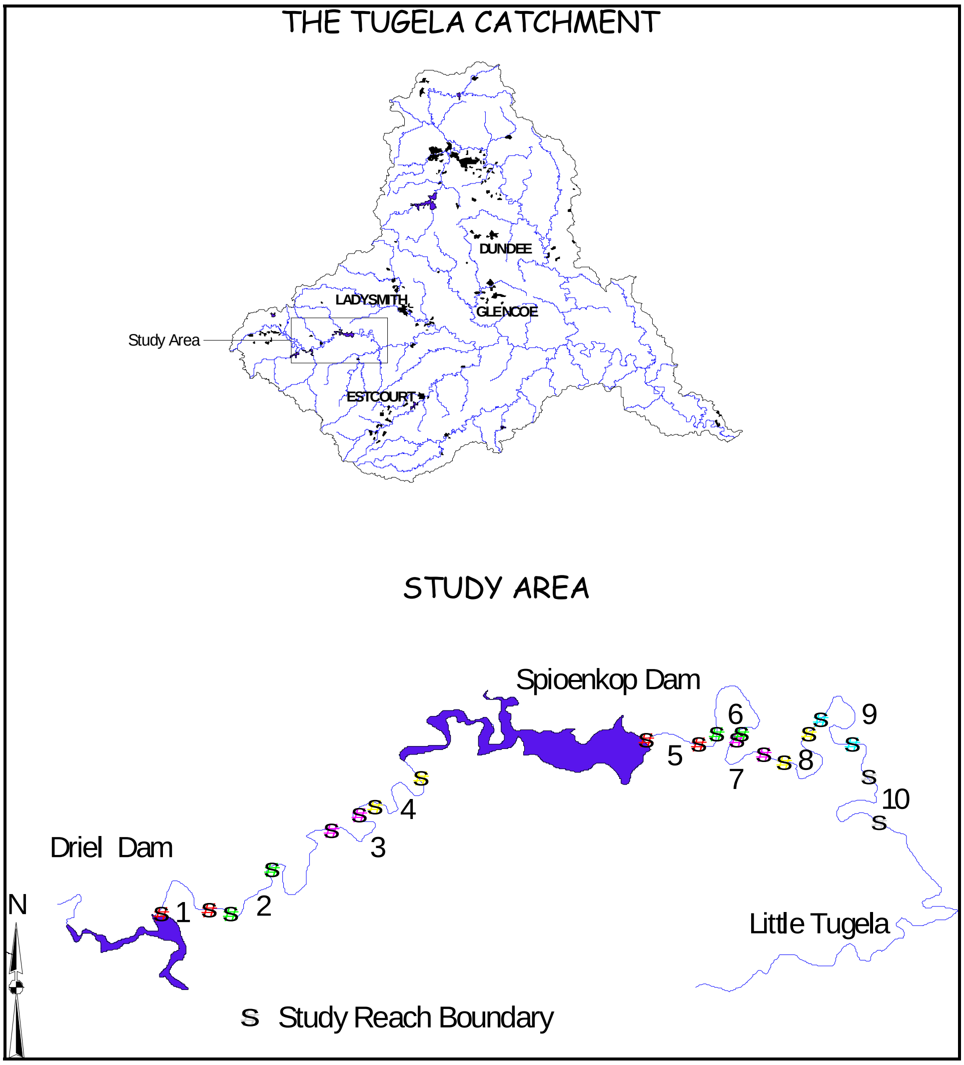
During the IFR determination work on this section of the Thukela river it was suggested by the geomorphological specialist that the channel morphology was in a state of change as a result of instream impoundments. Cursory evidence indicated that increased catchment erosion together with reduced flows was causing channel aggradation and the gradual loss of instream habitat. The primary motivation for ecological flow requirements were thus based on the geomorphological requirements of the channel.

In 1999 a more detailed geomorphological study was commissioned by DWAF to try and

determine the natural progression for morphological change in this part of the river and the affect of dams on channel morphology. The technique used for this study was simply an aerial photographic analysis of channel morphology over a period of time which included the pre- and post-dam eras.

The study had as its focus an area between Driel Dam and the Little Thukela confluence. This area includes a section of the Thukela river below the Spioenkop dam (Figure 4).

Fig 4 : Thukela Catchment and Study area



9.2 METHODS

The method utilised in this study was to obtain a succession of aerial photographs for the study area and to compare the physical form of the channel over time. Four sets of photographs were obtained. The first period was for 1944 which is the earliest available photographic record and shows the river in its pre dam form. The second period is for 1964, also pre dam. The third period is for 1985, post dam but prior to the 1987 floods. The final set is for the most recent available aerial photography which was flown in 1996. For some consistency the records were photographically adjusted to an approximate scale of 1:10 000. This is a large enough scale to allow the recognition of various features in the channel. 10 sections of the river were selected, 4 between Driel dam and Spioenkop dam and 6 between Spioenkop dam and the Little Thukela confluence.

9.3 RESULTS AND CONFIDENCE

Section 1: demonstrates a change in width and depth as lateral bars develop. There is no change in channel pattern as the river is entrenched into the landscape.

Section 2: there is evidence of sediment accumulation over time. This section of the river is getting narrower and shallower in places.

Section 3: the active channel appears to be getting narrower due to sediment accumulation and reduced discharges. The most significant change occurs from 1985 to 1996.

Section 4: aggradation is demonstrated by channel narrowing as lateral bars develop and by loss of depth as transverse bars fill the channel width.

Section 5: there have been small changes in the channel immediately below Spioenkop dam, there are virtually no sediment inputs from tributaries in this section.

Section 6: sedimentation appear to be occurring in this section, particularly downstream of small tributary inputs from the northern banks of the river. As with previous sections of the river, the most significant impact occurs post dam construction.

Section 7: there is evidence of bar growth post dam construction but this appears to have stabilised by 1996.

Section 8: sediment aggradation and channel constriction is the dominant process in this section.

Section 9: post dam construction appears to have caused reductions in stream flow and therefore increased sediment accumulations.

Section 10: this section of the river appears to act naturally as a sediment accumulation zone.

The available photographic evidence indicates that many physical changes occurred in this river after 1964. This would suggest that some geomorphic thresholds were crossed causing changes in channel morphology. It seems reasonable to suggest that the catalyst for change was the construction of Driel and Spioenkop dams.

The geomorphological response to this regulation has primarily been the deposition of sediment along the channel margins. Other changes that have occurred are the deposition of sediment in the channel causing a loss in depth, and deposition on or behind existing bars causing bar growth.

The fact that there has been little change in channel pattern serves to illustrate the stability of the Thukela system. The river appears to be entrenched in a historical flood plain and therefore confined within a “macro” channel. The reason for entrenchment is likely to be as a result of an increased energy gradient due to tectonic uplift. There is an area of rejuvenation in the channel long profile immediately downstream of this study area.

9.4 FURTHER WORK REQUIRED

The motivation for various flows in the IFR workshop was primarily to maintain the present physical characteristics of the channel. Flows were requested utilising velocity requirements for the movement of sediment. The velocities required to move various sediments were based on fairly simplistic and generalised data. To ensure that further sedimentation does not take place it is necessary to collect data on bed load particle size distribution and then run the sediment model of Dollar (2000).

CHAPTER 10 : CONCLUSIONS

10.1 FINAL IFR RESULTS

The medium to high confidence IFR results which incorporate all the refinement changes, as well as the result of the Planning Estimate, are presented in the following tables.

Table 1 : IFR 5 (Thukela River, Tugela Ferry)   **VIRGIN MAR : 2160**

IFR MAINTENANCE LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m^3/s)	4.3	7.7	10.7	13	15	13	10.2	7.3	5	3.6	3.1	3		
DEPTH (m) section	0.77	1	1.01	1.1	1.1	1.06	1	0.93	0.81	0.72	0.68	0.7		
VOLUME (10^6m^3)	11.5	20	28.7	34	37	34.8	26.4	19.6	13	9.6	8.3	7.8	250.9	11.6
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)	15	20	30 70	30 80	60 200	30 60	30							
DEPTH (m) section	1.1	1.2	1.3 1.7	1.3 1.8	1.6 2.48	1.3 1.64	1.3							
DURATION (days)	4	4	4 6	4 7	6 15	4 6	4							
VOLUME (10^6m^3)	2.1	2.2	16.1	19	99	15.8	3.6						157.84	7.31

IFR DROUGHT LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	1.9	3.1	4.6	5.6	6.4	5.6	4.4	2.8	2	1.4	1.4	1.4		
DEPTH (m) section	0.57	0.7	0.8	0.9	0.9	0.85	0.78	0.66	0.58	0.51	0.51	0.5		
VOLUME (10^6m^3)	5.1	8	12.3	15	16	15	11.4	7.5	5.2	3.7	3.7	3.6	106.1	5
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		20	30	30	100	30	30							
DEPTH (m) section		1.2	1.3	1.3	1.9	1.3	1.3							
DURATION (days)		4	4	4	7	4	4							
VOLUME (10^6m^3)		3.1	4.6	4.4	24	4.4	4.6						44.79	2.07

Table 2 : IFR 2 (Thukela River, Gorge) **Virgin MAR : 1519**

IFR MAINTENANCE LOW FLOWS	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**TOTAL** 10^6m^3	**% of MAR**
FLOW (m3/s)	3	5	7	8	9	8	7	5	3.5	2.5	2	2		
DEPTH (m) section	0.8	0.9	0.98	1	1	1.01	0.98	0.91	0.84	0.76	0.71	0.7		
VOLUME (10^6m^3)	8	13	18.7	21	22	21.4	18.1	13.4	9.1	6.7	5.4	5.2	162	11
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)	13	20	31 67	31 80	255 55	55 31	31							
DEPTH (m) section	1.14	1.3	1.44 1.8	1.4 1.9	2.7 1.69	1.69 1.44	1.44							
DURATION (days)	4	4	4 5	4 5	10 5	5 4	4							
VOLUME (10^6m^3)	1.8	2.7	17.2	20	83	14.3	4.4						143.04	9.42

IFR DROUGHT LOW FLOWS	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**TOTAL** 10^6m^3	**% of MAR**
FLOW (m3/s)	1.3	2	3	3.5	4	3.5	3	2	1.5	1	1	1		
DEPTH (m) section	0.62	0.7	0.8	0.8	0.9	0.84	0.8	0.71	0.65	0.57	0.57	0.6		
VOLUME (10^6m^3)	3.5	5.2	8	9.4	9.7	9.4	7.8	5.4	3.9	2.7	2.7	2.6	70	4.6
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		20	31	31	118	31	31							
DEPTH (m) section		1.3	1.44	1.4	2.1	1.44	1.44							
DURATION (days)		4	4	4	7	4	4							
sVOLUME (10^6m^3)		3.3	5.1	4.7	28	4.7	4.9						50.43	3.32

Table 3 : IFR 3A (Bushman's River, Weenen Nature Reserve) Virgin MAR 283

IFR MAINTENANCE LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	1	1.8	2.2	2.5	3	2.5	2	1.5	1	0.7	0.7	0.7		
DEPTH (m) section	0.46	0.6	0.58	0.6	0.6	0.62	0.57	0.52	0.46	0.41	0.41	0.4		
VOLUME (10^6m^3)	2.7	4.7	5.9	6.7	7.3	6.7	5.2	4	2.6	1.9	1.9	1.8	51.2	18.1
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)	5	12	20 10	30 10	60 10	20 10	10							
DEPTH (m) section	0.75	1	1.18 0.9	1.4 0.9	1.8 0.93	1.18 0.93	0.93							
DURATION (days)	2	3	3 3	3 4	5 3	3 3	3							
VOLUME (10^6m^3)	0.5	1.6	4	5.4	12	3.9	1.2						28.24	9.98

IFR DROUGHT LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	0.5	0.8	1	1.2	1.3	1.2	0.9	0.7	0.5	0.4	0.4	0.4		
DEPTH (m) section	0.37	0.4	0.5	0.5	0.5	0.48	0.44	0.41	0.37	0.34	0.34	0.3		
VOLUME (10^6m^3)	1.3	2.1	2.7	3.2	3.1	3.2	2.3	1.9	1.3	1.1	1.1	1	24.4	8.6
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		5	8	8	12	8								
DEPTH (m) section		0.8	0.87	0.9	1	0.87								
DURATION (days)		2	3	3	3	3								
VOLUME (10^6m^3)		0.5	1.1	1.1	1.7	1.1							5.38	1.9

Table 4 : IFR 3B (Bushman's River, Darkest Africa)   Virgin MAR : 313

IFR MAINTENANCE LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	1.1	2	2.5	2.7	3.3	2.8	2.2	1.6	1.1	0.77	0.77	0.8		
DEPTH (m) section	0.54	0.6	0.63	0.6	0.7	0.64	0.62	0.59	0.54	48	0.48	0.5		
VOLUME (10^6m^3)	2.9	5.2	6.7	7.2	8	7.5	5.7	4.3	2.9	2.06	2.06	2	55.68	17.8
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)	5.5	13	11 22	11 33	11 67	11 22.2	11.1							
DEPTH (m) section	0.73	0.9	0.85 1	1.3 1.8	1.3 2.24	1.29 1.77	1.29							
DURATION (days)	2	3	3	3 4	3 4	3 3	3							
VOLUME (10^6m^3)	0.5	1.8	4.4	7.1	13	4.3	1.4						32.36	10.34

IFR DROUGHT LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	0.55	0.9	1.1	1.3	1.4	1.3	1	0.7	0.5	0.4	0.4	0.4		
DEPTH (m) section	0.42	0.5	0.5	0.6	0.6	0.57	0.52	0.48	0.42	0.39	0.39	0.4		
VOLUME (10^6m^3)	1.5	2.3	2.9	3.5	3.4	3.5	2.6	1.9	1.3	1.1	1.1	1	26.05	8.32
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		5.5	8.8	8.8	13	8.9								
DEPTH (m) section		0.7	0.81	0.8	0.9	0.81								
DURATION (days)		2	3	3	3	3								
VOLUME (10^6m^3)		0.6	1.2	1.2	1.9	1.2							5.98	1.91

Table 5 : IFR A (Thukela River, Skietdrift) **VIRGIN MAR : 878**

IFR MAINTENANCE LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	2.8	4	6	8	10	9.5	7	4.5	3.5	2.9	2.5	2.6		
DEPTH (m) section	0.27	0.3	0.4	0.5	0.5	0.51	0.44	0.35	0.31	0.28	0.26			
FDC% (VIRGIN)	61	90	92	96	95	92	88	84	90	89	90	64		
VOLUME (10^6m^3)	7.5	10	10.1	21	24	25.5	18.1	12.1	9.1	7.8	6.7	6.8	165.47	18.2
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		30 20	40 25	50 30	150 30	50 25	40							
DEPTH (m) section		0.9 0.7	1.05 0.8	1.2 0.9	2.1 0.91	1.18 0.83	1.05							
DURATION (days)		3 3	4 3	4 3	4 3	4 3	4							
FDC% (VIRGIN)		24 38	30 50	34 58	13 74	34 65	17							
VOLUME (10^6m^3)		6.5	9.6	12	41	11.1	6.5						86	9.5

IFR DROUGHT LOW FLOWS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL 10^6m^3	% of MAR
FLOW (m3/s)	1.5	1.8	2.4	2.9	3.3	3.1	2.4	1.8	1.6	1.3	1.2	1.3		
DEPTH (m) section	0.2	0.2	0.25	0.3	0.3	0.29	0.25	0.22	0.21	0.19	0.18	0.2		
FDC% (VIRGIN)	100	99	100	100	100	100	100	100	100	100	100	99		
VOLUME (10^6m^3)	4	4.7	6.4	7.8	8	8.3	6.2	4.8	4.1	3.5	3.2	3.2	64.29	7.1
IFR MAINTENANCE HIGH FLOWS														
FLOW (Instantaneous peak m3/s)		12	14	16	50	14								
DEPTH (m) section		0.6	0.62	0.7	1.2	0.62								
DURATION (days)		3	3	3	3	3								
FDC% (VIRGIN)		58	72	82	52	83								
VOLUME (10^6m^3)		1.6	1.8	2	9.5	1.7							16.6	2.7

The overall % of the MAR over a time series that includes maintenance and drought flows is 26.2%.

Table 6 : Planning Estimate - Reach downstream from Woodstock Dam : B EMC : Planning Estimate

Annual flows (Million cubic metres or index values):

MAR	825.167
Total IFR	296.904 (35.98% MAR)
Maintenance low flow	200.389 (24.28% MAR)
Drought low flow	60.507 (7.33% MAR)
Maintenance high flow	96.515 (11.70)

Monthly distributions (million cubic metres) Distribution Type : Drakensberg

MONTH	LOW FLOWS		HIGH FLOWS
	MAINTENANCE	**DROUGHT**	**MAINTENANCE**
OCT	8.54	3.01	2.3
NOV	15.18	5.44	9.72
DEC	19.25	6.16	18.18
JAN	28.42	8.53	9.09
FEB	35.3	9.83	44.34
MAR	37.24	10.15	9.09
APR	22.24	6.22	3.8
MAY	10.91	3.28	0
JUNE	6.82	2.23	0
JULY	5.45	1.92	0
AUG	4.81	1.69	0
SEP	5.36	1.82	0

Table 7 : Planning Estimate - Reach downstream from Woodstock Dam : C/B EMC : Planning Estimate

Total IFR	239.169 (28.98% MAR)
Maintenance low flow	160.801 (24.28% MAR)
Drought low flow	60.507 (7.33% MAR)
Maintenance high flow	78.368 (9.50)

Monthly distributions (million cubic metres) Distribution Type : Drakensberg

MONTH	LOW FLOWS		HIGH FLOWS
	MAINTENANCE	**DROUGHT**	**MAINTENANCE**
OCT	7.13	3.01	1.87
NOV	12.71	5.44	7.9
DEC	15.75	6.16	14.76
JAN	22.97	8.53	7.38
FEB	27.5	983	36.01
MAR	29.61	10.15	7.38
APR	17.76	6.22	3.08

MONTH	LOW FLOWS		HIGH FLOWS
	MAINTENANCE	DROUGHT	MAINTENANCE
MAY	8.82	3.28	0
JUNE	5.61	2.23	0
JULY	4.55	1.92	0
AUG	5.01	1.69	0
SEP	4.44	1.82	0

10.2 COMPARISON BETWEEN THUKELA IFR STUDY & ECOLOGICAL RESERVE PROCEDURES

The supreme law of the Republic is the Constitution of the Republic of South Africa (Act No. 108 of 1996). This includes the Bill of Rights, which is human-centred. The two rights most directly relevant to water are:

- Section 27: the right of access to sufficient food and water; and
- Section 24: the right to an environment not harmful to health and well being, and to have the environment protected for the benefit of present and future generations.

The White Paper on a National Water Policy for South Africa was approved by Cabinet in April 1997, and incorporates the constitutional requirements described above, as “the Reserve”. “The Reserve” has subsequently been codified as a legal requirement in the National Water Act (No 36 of 1998) which was signed into law by the President on 28 August 1998.

The priorities in the use of water are the following:

- The Reserve, i.e. basic human needs and ecosystem protection. These are the only two rights to water, and the Reserve may not be allocated to other users.
- International obligations
- All other uses require authorisations

It is therefore necessary to quantify the Reserve before allocating water to other new users. In some areas it is possible that allocations of water to existing users may need to be adjusted to meet the requirements of the Reserve.

The new Act was signed into law during August 1998, i.e. well after the IFR study on the Thukela River was initiated. DWAF is at present determining methods to determine the Ecological Reserve and a generic seven step procedure has been identified. The method acceptable to determine the quantity Ecological Reserve is the Building Block Methodology, i.e. the same method used for the Thukela study.

The seven steps are described below and an analysis of what needs to be added to the present IFR study for the results to constitute the Ecological Reserve follows:

Step 1 : Delineate geographical boundaries or resource
Step 2 : Eco-regional or geo-regional type
Step 3 : Determine reference conditions
Step 4 : Determine present state
Step 5 : Determine EMC
Step 6 : Set the Ecological Reserve (quality & quantity)
Step 7 : Monitoring

10.2.1 Thukela River downstream of IFR 5

Steps 2 to 7 are still required.

10.2.2 Thukela River from Jana Dam site to IFR 5 & Bushmens River from Mielietuin Dam to the Thukela confluence

Steps 1 to 4 have been undertaken for the quantity aspects.
Step 5 has been undertaken but without the required public input.
Step 6 has been undertaken for quantity aspects for an estimated EMC.

To enable the existing results to conform to the procedures for determining the Ecological Reserve, the following is required:

- A stakeholder process must be initiated to provide input into the selection of the EMC.
- If the resulting EMC is different to the EMC on which the IFR is based on, Step 6 will require re-evaluation
- A water quality Ecological Reserve must be set.
- The ground water Reserve must be set.
- A monitoring procedure must be designed and initiated.

10.2.3 Thukela River downstream of Spioenkop Dam to the Jana Dam site

Steps 1 to 3 have been undertaken for the quantity aspects.
Step 4 has been undertaken, but low confidence is attached to the results
Step 5 has been undertaken but without the required public input.
Step 6 has been undertaken for quantity aspects for an estimated EMC.

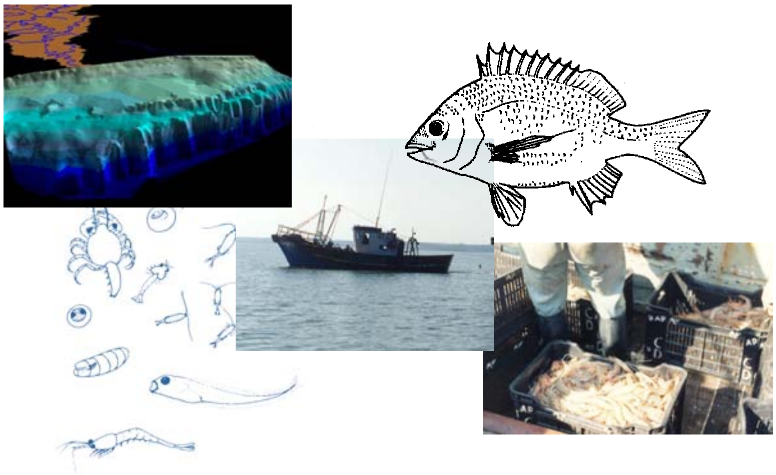
To enable the existing results to conform to the procedures for setting the Ecological Reserve, the following is required:

- A stakeholder process must be initiated to provide input into the selection of the EMC.
- Reference conditions with emphasis on the geomorphological aspects must be established.
- Based on the results of the above reference conditions and the stakeholder process, Step 6 might require re-evaluation.
- A water quality Ecological Reserve must be set.
- The ground water Reserve must be set.
- A monitoring procedure must be designed and initiated.

10.2.4 Thukela River downstream of Woodstock Dam to Spioenkop Dam

As a Planning Estimate has been determined which does not constitute the Ecological Reserve, all seven steps will have to be undertaken.

IMPACTS OF PROPOSED DAMS
ON THE
THUKELA ESTUARY AND INSHORE MARINE ENVIRONMENT:
A SYNTHESIS



A.T. FORBES & N.T. DEMETRIADES

JUNE 2000

Prepared for
DEPARTMENT OF WATER AFFAIRS AND FORESTRY

by

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EXECUTIVE SUMMARY

The following is an attempt to reduce the accompanying five specialist reports, into an overview of the salient points arising out of this eight month programme. This study was undertaken by marine and estuarine research with the aim of assessing on the basis of existing information the potential ecological and economic impacts of the proposed Thukela catchment dams on the coastal and shelf environments. Additionally, the consultants were given the mandate to assess the impact on the estuarine environment using the information synthesised in the estuarine flow requirement (EFR) documents.

The east coast of South Africa presents an entirely different picture from the west coast where upwelling and high nutrient levels control the physico-chemical nature of the environment and the associated biological processes. On the east coast the warm Agulhas current, the much higher rainfall, the steep coastal gradient and the absence of any significant upwelling generate a very different environment where events and processes on land have, in both geological and historical time, had a major effect on the nature of the coastal marine environment. The Thukela Bank itself is a manifestation of this history representing the result of many millions of years of erosion of the KwaZulu Natal (KZN) land mass and the river borne transport of the resulting sediments into the adjacent sea where the shape of the coastline and the deflection of the Agulhas current has allowed sediments to accumulate and the Bank to develop.

In more recent geological time, the northward longshore drift and deposition of sediments has allowed the shore line south of Mtunzini to prograde significantly. This has produced a unique series of parallel coastal dunes which support a remarkable example of vegetation succession from dune pioneers to climax forest. Photographic records dating back barely 60 years indicate that, while the beaches have shown a net advance, significant retreats associated with drought periods may also occur. Effects of changed sediment input on beaches due to reduced water flow and scour may therefore be expected to manifest themselves within decades rather than centuries.

The estuary will also show early effects of reduced river flow in terms of increased frequency and duration of mouth closure, especially during winter. Such closure will reduce the likelihood of seawater intrusion and generate a temporary freshwater lagoon situation. This will certainly favour some species but it represents a major deviation from the pristine condition and the extent to which it does occur will mirror the impacts on other environments.

The impacts on the shelf systems will be less visible but no less significant. While it is still extremely difficult to quantify this impact, the basic nature of the broader system, as outlined above and as has been found in other situations around the world, drives us inexorably to this conclusion. The geomorphological assessment is that muddy areas on the Banks will increase at the expense of more sandy areas, due to the selective retention of coarser sediments within the catchment, and the lesser effect on transport of fine sediments. It was also suggested that there could be an increased exposure of reef areas.

The fauna of the Banks is not unique but the particular nature of the environment is the only one of its kind on the south-east African coast. The community structure is accordingly biased towards species favouring more turbid conditions and/or the muddier type of soft bottom. As there is no evidence of significant upwelling and enhanced primary productivity, which might ultimately bolster the productivity and carrying capacity of the Banks, and because the system supports a prawn trawl fishery and a hook and line recreational and commercial fishery which produces a higher catch rate than elsewhere in KZN, one is forced to accept the significance of terrestrial inputs. The Thukela, which provides some 40% of the KZN M.A.R., and debouches onto the Banks will therefore immediately acquire significance. Aspects of these processes and their potential significance are covered in this synthesis report and in more detail in the specialist reports. Surprisingly little relevant biological research data exist. The major sources of information on the Bank fauna unfortunately come down to fisheries records and catch data. These presently show that the line fish species are under heavy pressure and catches have dropped significantly. It could therefore be difficult to separate over-fishing effects from environmental effects.

Catch records from the prawn fishery since 1984 indicate a highly significant positive correlation between Thukela River flow volumes and prawn Catch Per Unit Effort (CPUE) data. Although it might have been expected, this is the first strong indication of a cause and effect relationship between a component of the shelf biota and river flow. The natural fluctuations in river flow can therefore be used with a high level of confidence to predict the effects of artificial reductions in river flow on at least one component of the Bank biota. CPUE values vary naturally by three to four fold. Maintenance of "average" flows could be expected to reduce catches to *ca.* 50% of peak values and sustained reduction of flows to below average could simulate drought years when catches drop to about 25% of peak values.

Although there are no equivalent data from the Thukela Bank, a strong correlation has been found between the seasonal abundance of planktonic fish eggs off Scottburgh on the KZN south coast and flows in the nearby Mkomazi River. As in the case of the prawns above, the abundance of eggs has varied three to four fold during the study period and the same argument as above would hold. As the Thukela contributes *ca.* 40% to the total KZN runoff it can be stated with a similar high level of confidence that there will be impacts on the pelagic community of the Thukela Bank. The only question is that of scale.

In conclusion it can be stated unequivocally that there will be guaranteed effects, some anticipated, some not, on the physico-chemical environment of the Thukela estuary, the coastline and beaches to the north and finally the Bank which will feed through to the biota of these habitats. Disregarding the effects of climatic change and sea level rise, which could over-ride any human impacts, the timing and extent of these changes will be proportional to the modifications of the natural behaviour of the Thukela system. The responses of the beaches and prawn populations to wet and dry years give a good indication of the very short lag time that is possible in certain instances. Greater understanding will fill some of the present gaps and allow more confident predictions in other areas, but in many ways the final certainty is that we will only appreciate the full significance if and when the experiment is actually run.

CONTENTS

LIST OF FIGURES

IMPACTS OF PROPOSED DAMS
ON THE
THUKELA ESTUARY AND INSHORE MARINE ENVIRONMENT:
A SYNTHESIS

TERMS OF REFERENCE

This study was undertaken by marine and estuarine research with the aim of assessing on the basis of existing information the potential ecological and economic impacts of the proposed Thukela catchment dams on the coastal and shelf environments. Additionally, the consultants were given the mandate to assess the impact on the estuarine environment using the information synthesised in the estuarine flow requirement (EFR) documents.

More specifically the study had the following objectives:

- Assess the available marine geophysical and sediment data held by the Council for Geoscience in order to evaluate current patterns of sedimentation on the Bank and the adjacent coastline. The effects of the TWP were then to be assessed in terms of any changes in the patterns and rates of sedimentation under post-dam conditions. The anticipated key products were a digital terrain model of the shelf, a map of surface sediment distribution and transport and sediment thickness maps.
- Describe the biotic components of the Thukela Banks ecosystem in relation to the beaches, subtidal and deepwater habitats as well as the water column. The relationship between river flows and catches in the prawn fisheries was to be a particular focus.
- Combine the above two objectives into an assessment of the possible impacts of changes in water flow, sediment supply and structure of the Banks on the biodiversity and functioning of the Thukela Banks ecosystem including the estuary. Identify the probable ecological and economic significance of any change in the natural processes or impact on the biodiversity of the system.
- Identify requirements for further investigation and provide guidelines for both pre- and post-dam monitoring.
- Provide documents covering the different specialist inputs as well as an overall synthesis document in the prescribed and agreed format.

IMPACTS OF PROPOSED DAMS
ON THE
THUKELA ESTUARY AND INSHORE MARINE ENVIRONMENT:
A SYNTHESIS

1 INTRODUCTION

South Africa is a dry country with a national rainfall average less than 500 mm. This is about half the global average. Rainfall is patchy and variable, declining rapidly from peaks of *ca.* 1250 mm *per annum* in parts of the east to less than 200 mm in the extreme west. Areas of high water demand do not coincide with areas of high availability with the result that virtually all major rivers are dammed and South Africa is one of the world's leaders in techniques of inter-basin transfer. Present forecasts indicate that despite innovative techniques in relation to the use of national precipitation, demand will outstrip supplies in the next 10 to 20 years. It is probably fair comment that the water associated problems faced by the country revolve primarily around availability of the resource rather than simply water quality, although water pollution problems do exist and salinisation and eutrophication are becoming more significant.

In the coastal zone many estuarine systems have already been impacted on through physical development of the banks and floodplains including inconsiderate placing of road, rail and bridge systems and the development of harbours in estuaries at East London, Durban and Richards Bay. Water quality can be a problem in these environments but in many ways the biota of estuaries and coastal water bodies is still surprisingly rich even in harbour areas. Inshore water quality, despite the presence of marine outfalls, is typically high as a result of the generally narrow continental shelf, the high energy, wave washed coastline and the associated strong currents, all of which combine to generate high dispersive powers. Marine pollution events are primarily the result of periodic but relatively uncommon oil spills.

At this stage one of the greatest threats faced by South African inland waters and estuaries arises out of the demand for fresh water described above. This has resulted in the construction of large numbers of dams which have greatly modified natural flow patterns. Concomitantly there have been major changes in environmental legislation which now recognizes the functioning of riverine ecosystems and the need for minimum flow levels in rivers. Simultaneously there has been an increasing appreciation of the significance of freshwater inputs into estuaries and most recently the significance of freshwater inputs into the inshore marine environment. These concepts are now becoming embodied in legislation. The South African Department of Water Affairs and Forestry, which formerly concerned itself largely with artificial, landlocked, freshwater bodies, now finds itself at an interface between the freshwater and marine environments and having to concern itself with the potential environmental impacts of dams in the Thukela catchment on the Thukela Banks, the only significant coastal shelf area in the sub-tropical part of the country. Although there are impoundments, much of the Thukela catchment remains undammed and the possible impacts of the proposed two dams on the greater system require attention and consideration.

2 PURPOSE OF REPORT

The purpose of the present report was to provide an overview and synthesis of the accompanying specialist reports and to summarise their major conclusions and recommendations into a single document.

3 METHODOLOGY

This was a multi-disciplinary study involving different organizations and a variety of inputs. As a first step, existing data bases and available expertise were used to construct a picture of the most likely physical effects of the proposed dams on the estuary, the local coast and the Thukela Banks. The anticipated effects on the estuary were drawn from existing Estuarine Flow Requirement (EFR) studies commissioned by Department of Water Affairs and Forestry (DWAF). Although the emphases and approach differed from this study it was possible to use the information provided in the E.F.R. programme in the present synthesis. The task of ascertaining the coastal and offshore effects was undertaken by the Marine Geoscience Unit of the Council for Geoscience based at the University of Natal in Durban (Specialist Report # 1). This information was then made available to three teams of biologists who were given the task of translating these effects and changes into a possible biological scenario. This part of the study was carried out by staff of the Oceanographic Research Institute (Specialist Report # 2), the Environmentek Division of the Council for Scientific and Industrial Research (CSIR) in Durban (Specialist Report # 3), Marine and Estuarine Research cc, *i*Sineke Developments and the Centre for Environment and Development of the University of Natal, Pietermaritzburg (Specialist Report # 4). Interaction and mutual reviewing of the syntheses generated by the different groups were facilitated by workshops and this final synthesis and overview was produced by Marine and Estuarine Research. The bulk of the synthesis was based on the reports listed above, and which accompany this document, but significant information was also derived from the estuarine freshwater requirement studies commissioned by DWAF and prepared by Mackay & Cyrus (1998) and Quinn & Whitfield (1999).

4 THE THUKELA RIVER: PHYSICAL ENVIRONMENT

4.1 Catchment processes

The Thukela River catchment (Figure 1) lies on the east coast of South Africa in the province of KwaZulu-Natal (KZN). The area has the distinction of having one of the steepest gradients in the world, rising from sealevel to the Drakensberg plateau at an altitude of *ca.* 2 000 m, with peaks of *ca.* 3 000 m, within a distance of 180 – 200 km from the coast. This mountain massif is the country's major water shed.

The catchment of the Thukela has an area of 29 100 km^2 and a Mean Annual Runoff (MAR) of *ca.* 4 600 x 10^6 m^3. It is the largest eastward flowing river in the country being exceeded only by the Orange-Vaal system which rises on the same plateau but flows westwards to the Atlantic Ocean. The Thukela source lies at an altitude of 3 100 m at a point 250 km from the coast. Along its 405 km course it flows through an incised bedrock channel within a narrow floodplain never more than 1 km wide.

The average annual sediment load is 6.79 x 10^6 m^3 of which 1.02 x 10^6 m^3, or roughly 15% is bedload. Accelerated erosion occurred from the 30's onwards, due, depending on the authority quoted, to bad farming practices or climatic factors. Present trends are towards less erosion.

Flooding is a characteristic of virtually all South African rivers and the Thukela is no exception. Major floods were recorded in 1893, 1925, 1984 and 1987. The

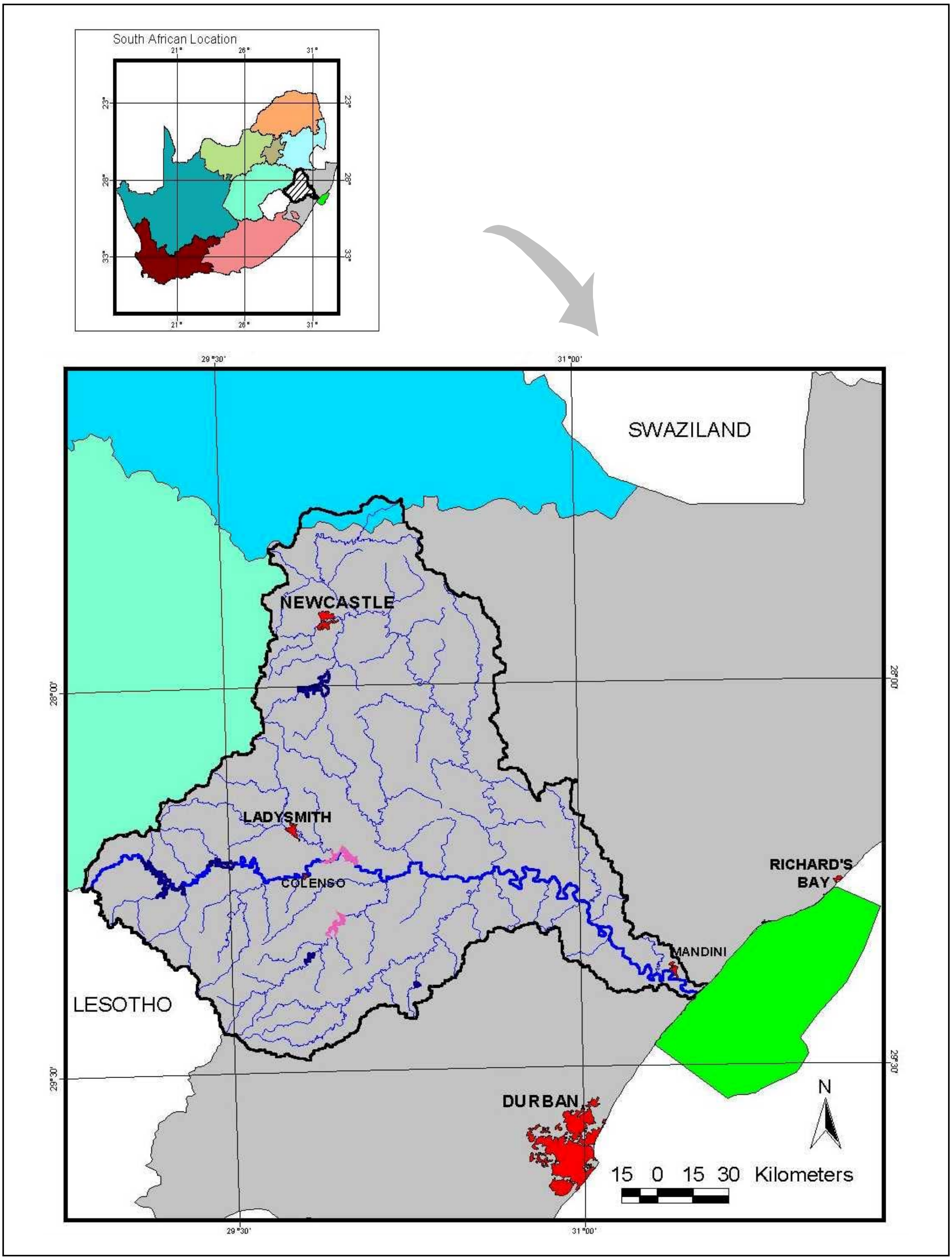

Figure 1: The Thukela catchment. Proposed dams shown in pink. Study area shown in green.

peak flood volume in the 1925 event reached 15 100 cumecs and a total sediment discharge of 42.8 x 10^6 m^3 or nearly six times the annual average. 60% of the sediment was derived from channel scour and 40% from the catchment.

The Thukela River lies in a summer rainfall area. Floods in September at the end of the austral mid-year dry season carry more sediment than floods in the tropical cyclone season (January-February). The catchment straddles the zones influenced by sub-tropical, frontal systems and tropical cyclones which peak in September and December-March respectively. Both weather systems can produce significant floods. The September 1987 event was caused by a frontal system and caused a peak discharge of 10 500 cumecs. The tropical cyclone of March 1925 generated a peak of 15 100 cumecs.

The geological interpretation of the appearance of the river course is that extreme flood events are responsible for channel formation. The regional maximum flood has been calculated at 20 000 cumecs and the estimated sediment load during such an event has been estimated at several orders of magnitude higher than the 1987 figure. This would make such extreme events highly significant in the sediment dynamics of the shelf. Flood conditions result in major sediment efflux and a plume extending three to five km offshore and up to 15 km northwards with a limited extent to the south because of the prevailing northerly long shore drift. Two of the six sub-catchments of the system will be affected by the proposed dams and these are responsible for 40% of the total discharge and 25-30% of the total sediment load.

There is relatively little industrial development in the catchment where human activities are mainly agricultural and pastoral. There is consequently relatively little industrial pollution and the major anthropogenic effects on the river come about through water abstraction and the still controversial anthropogenic effects on rates of soil erosion.

4.2 The Estuary

The Thukela estuary (Figure 2) is a shallow system nowhere exceeding 2 m in depth. It is dominated by river flow. This qualifies it as a "river mouth" rather than a true estuary in that a combination of fresh water input, bed gradient and elevation results in fresh water or very low salinity conditions, < 2.5, prevailing for much of the time. There is consequently no development of an axial salinity gradient. Turbidity levels are generally high due to fine inorganic material in the incoming silt load. The system is generally well aerated due to a constant throughput of freshwater. Available nutrient analyses indicate periodically raised levels of nitrites, nitrates, phosphates and silicon allowing the system to be classified as mesotrophic-eutrophic. The source(s) of these nutrients is/are unknown. High flushing rates which exist for much of the year prevent build-ups of algal material.

Figure 2: The Thukela Estuary. Note areas under cultivation, mainly sugar cane, sandbanks and the position of the mouth. See text for further details on these points.

The northern limit of the highly dynamic estuary mouth is fixed by a rocky promontory towards which the mouth tends to meander (Figure 2). The normal cycle is for a flood to scour the barrier, after which the barrier begins to re-establish itself, usually with the mouth located to the south side of the estuary. It then begins to migrate northwards under the influence of long shore drift until again breached. A shallow, braided channel forms during low-flow conditions. Backwaters are characterised by deposition of fine materials but the channels are dominated by fine to coarse sand. Under present-day low-flow conditions, as opposed to virgin conditions when closure was extremely rare, the mouth may close for a few days at a time and this occurs in winter between June and October.

4.3 The Coastline

The coastline south of the mouth consists of a Holocene beach backed by a stabilised dune which forms part of the river mouth barrier. Beaches are narrow and controlled by bedrock outcrops. This contrasts strongly with the coastline to the north which is one of only two accretionary areas along the South African coastline. The prograding coastal zone has given rise to a beach ridge plain characterised by wide beaches which grade into a series of low, shore-parallel, aeolian sand dunes. The accretion process dates back to the earliest photographic records of 1937 and probably to 5 000 B.P. The recent records show that after 1937 there was an erosion period during the drought years of 1978-83 coinciding with a strong El Nino. Coastal retreats up to 11 m/yr were recorded. During 1957-1960, the end of the 1953-61 wet period, the process was reversed and progradation in excess of 30 m/yr was recorded.

4.4 The Shelf

The south-east African continental shelf is generally narrow, being about 12 km wide off Durban but widening to more than 45 km off the Thukela River (Figure 3). Much of this shelf is derived from sediments transported by the river. It is the only shelf area on the east coast of the country. The frequently turbid conditions associated with the output of the Thukela and the extensive areas of muddy sediments contrast with much of the rest of the east coast where the continental shelf generally extends less than 12 km offshore and the water, especially to the north, is clear and warm enough to support the country's only significant coral growth areas.

A feature of the shelf is a series of submerged aeolianite outcrops which represent submerged coastal dune cordons, formed during lower Pleistocene sea levels and which were drowned during subsequent Holocene transgressions. The shelf break is at approximately 100 m depth. The southern part of the shelf is dominated by terrigenous sediment; it has the thickest sediment accumulation and has extensive flat areas. The northern part of the shelf is more uneven with a greater proportion of reef areas. The influence of the Thukela River on the shelf is most apparent during summer rains via the silt plume. Slight salinity reductions can be detected offshore.

The most important oceanographic feature of the area is the southward flowing Agulhas current. This is a major western boundary current with a mean width of 100 km and speeds of > 2.5 $m.sec^{-1}$. Its depth has been traced to 2 500 m. It is largely responsible for gyres and counter currents on the shelf which significantly affect sediment distribution patterns.

4.5 Effects of the proposed dams on the estuarine, coastal and shelf environments

4.5.1 Estuary

Available estimates indicate that a flow of >$10m^3. sec^{-1}$ is required to keep the mouth open and closure will occur more frequently and for increasingly longer periods as the flow rate drops below this threshold. Forecasts of the dam effects indicate a 30% increase in the number of months during which flow rates will drop < 1 $m^3. sec^{-1}$ and this will occur predominantly between May and October. Closure periods of three to five months can be expected.

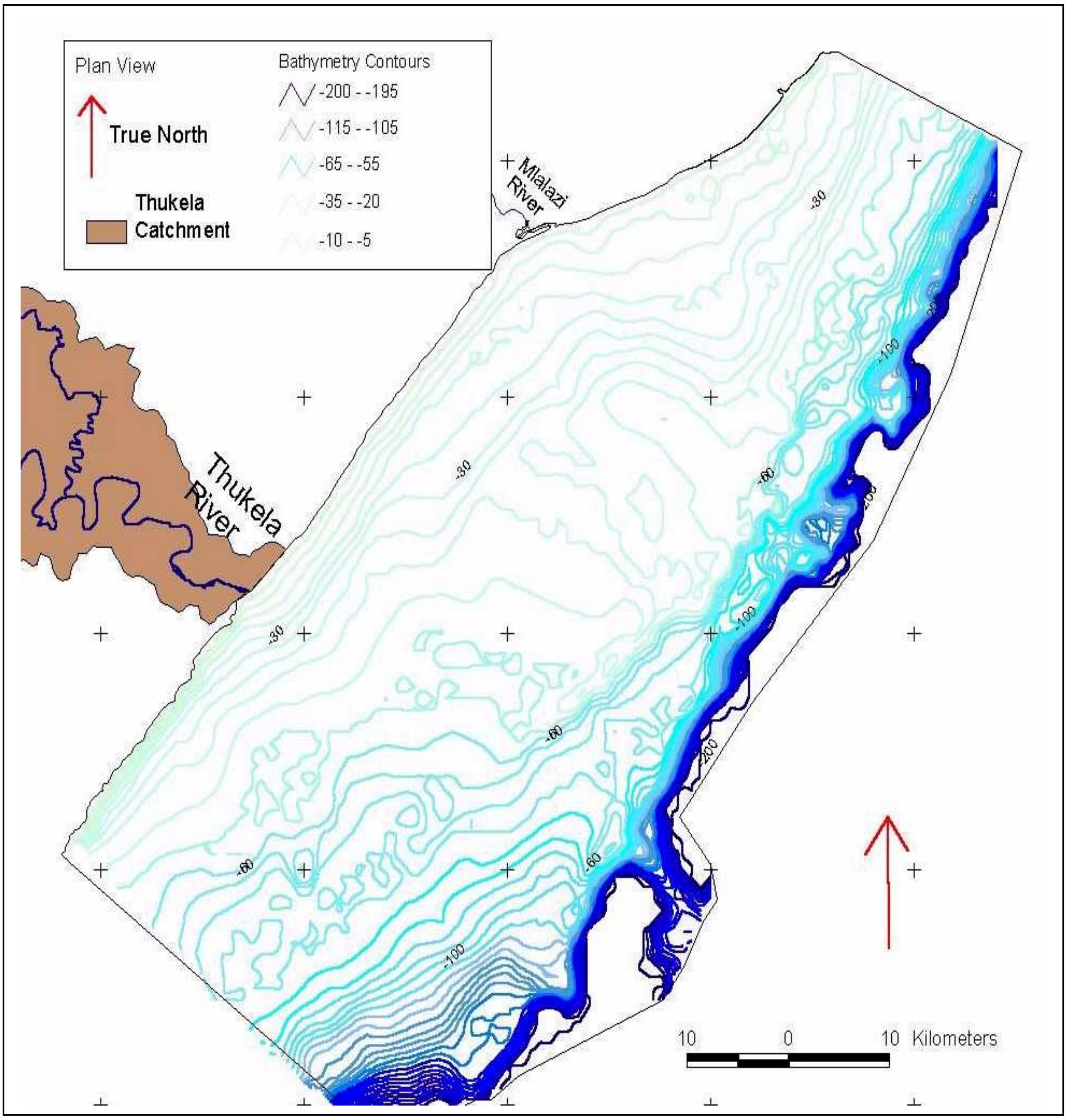

Figure 3: Bathymetry of the Thukela Bank.

4.5.2 Coast and Shelf

In assessing the potential effects of the dams on these environments it was realised that these could be modified or over-ridden by climatic changes. Wet and dry phases are products of prevailing climatic factors which have been shown to have major effects on the coastline north of the Thukela. In addition a sea level rise of 20 cm is forecast in the next 35 years and 1.5 m in the next century. Available estimates indicate a consequent loss of 25 m of shoreline in the next 100 years. Projected climatic changes suggest that the local climate will become more dominated by tropical cyclonic weather. Changes in predominant wind patterns could reverse current conditions and foster accelerated erosion of the presently accreting beach zone. More cyclonic weather could, however, produce fewer swells, moving less sediment offshore and allowing fair weather waves to move it inshore, thereby favouring beach progradation.

The anticipated scenario in terms of physical effects is as follows:

Dam building will cause a short term increase in the sediment load. In the longer term, however, the dams will affect the outflow and sediment input from 30% of the catchment. Floods will be attenuated and scouring and sediment output reduced. At the same time climatic change appears to be directed towards a slowing-down or halting of coastal progradation. Sediment retention by dams would accentuate this process.

It is expected that any dam-induced changes in the coastline will extend progressively northwards from the mouth and the effect(s) will be greater during dry phases than wet. Estimated distance and time scales indicate that effects in the area up to 13 km north of the Thukela mouth will be noticeable within 10 years and up to 30 km north within the next 50 years.

Effects on the shelf are less certain. The shelf-coastline system is in dynamic equilibrium and any changes in one component will be reflected in others.

The following are two of the presently significant expected changes:

- *Muddy areas of the Bank are expected to grow at the expense of more sandy areas;*
- *A general sediment decrease will result in the exposure of more sub-tidal reef.*

The extent of these changes is illustrated in Figure 4 which clearly indicates the anticipated expansion of shelf muddy areas (grey) at the expense of shelf sand (yellow) and the expansion of reef areas (brown), particularly in the south.

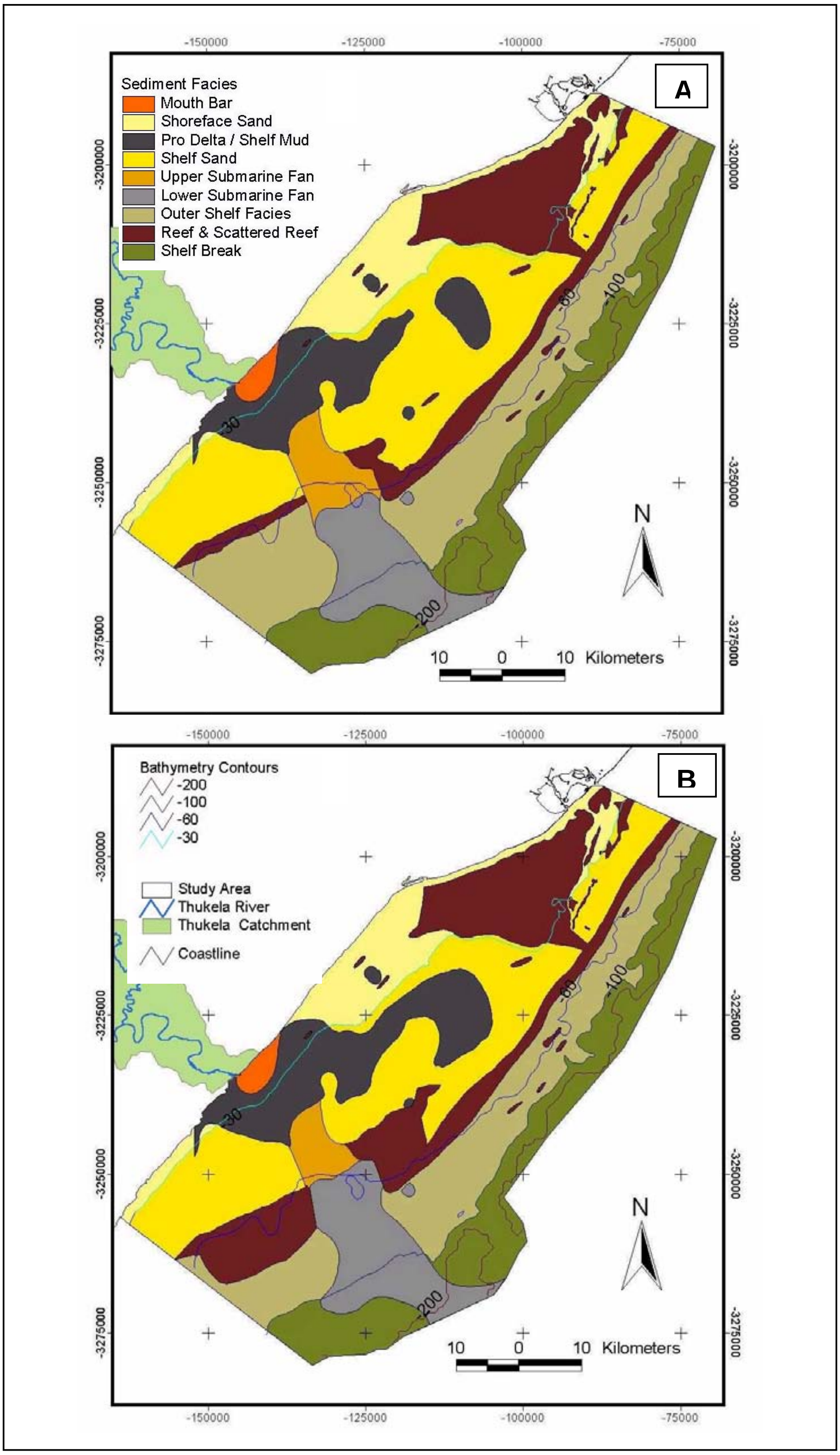

Figure 4: Present (A) and post-dam (B) sediment distribution on the Thukela Bank. Note relative changes in muddy, shelf sand and reef facies.

5 NATURAL COMMUNITIES AND THEIR BIOLOGICAL AND ECONOMIC SIGNIFICANCE

5.1 The Estuary

The flood plain has been extensively modified by forestry activities and the planting of sugar cane. Within the estuary the combination of a narrow intertidal area, steep river banks and the flooding regime has excluded mangroves and any macrophyte development apart from scattered patches of reeds *Phragmites sp.* and the freshwater swamp tree *Barringtonia racemosa.*

Surveys of the invertebrate fauna of the estuary (Mackay & Cyrus 1998) have produced a remarkable list of 170 “species”, including “oligochaete eggs”. This should be treated as a preliminary statement requiring further validation. Approximately 22 taxa normally associated with estuaries were identified to genus or species level. This is a comparatively high number when one considers the generally unstable conditions of mobile, coarse sediments and low salinities punctuated by major flood events that characterise the Thukela estuary. The influence of these conditions does, however, show up in the structure of the benthic communities. Despite the above mentioned long list, more than 90% of individuals at most sampling sites were contributed by less than 10 species (loc.cit.). These in turn were dominated by “oligochaetes” by two to three orders of magnitude. Total individual densities peaked at 60-80, 000 per square metre at the richest sites during August-November 1997 but these represented a very limited area of the estuary. The variations recorded were seemingly driven by the physico-chemical environment rather than biotic interactions such as competition and predation.

The aquatic avifauna of the system consists of a summer group dominated by Palaearctic migrants, a winter group utilising the estuary for feeding and a third group which uses the system predominantly as a roosting site. A total of 54 species was recorded during the E.F.R. studies (Mackay & Cyrus 1998), with a maximum monthly count of 34 in September 1997 and a minimum of 20 in July. Total summer counts indicated *ca.* 2 000 birds using the estuary on a regular basis declining to *ca.* 200 in winter. Although records are few, it appears that the numbers of birds using the Thukela have not declined over the last 15 years and a strong argument in support of the significance of the area as a bird habitat is presented by the above authors.

Available data, which are not extensive, indicate that the Thukela, because of the limited and fluctuating estuarine habitat, does not support a rich nor diverse fish fauna. This appears to be a result of poor zooplankton and a highly localised benthic fauna development which is in turn an effect of unstable sediments, limited penetration of seawater and associated low salinities. Only 22 species, plus unidentified juvenile mullet, were recorded during winter surveys in 1986 and 1996. All save two were either estuarine residents or marine migrants; despite the generally low salinities only two freshwater species, *viz.* Mozambique tilapia and sharptooth catfish, were recorded. Both sets of samples were dominated by juvenile mullet. The suggested most important function of the Thukela estuary from a fish point of view is its significance as a conduit for migrating eel larvae (Quinn & Whitfield 1999). The estuary serves the same purpose for the migrating megalopa larvae of the grapsid crab *Varuna litterata.*

There is no legal commercial exploitation of any of the natural resources of the Thukela estuary. The small township and holiday cottages at the mouth presumably survive on the basis of the perceived natural attractions of the area which could, therefore, have an economic value attached to them.

5.2 Sandy Beaches

This habitat in KZN supports a specialised but not very abundant nor diverse fauna. The most obvious species are the ghost crabs and two species of mole crabs. The smaller species include isopod crustaceans and polychaete worms. Surveys during 1999-2000 of the areas that could possibly be affected showed that abundances of animals in this size range were typically low – densities greater than 20 per square metre were rare. 25% of samples at mid-tide levels produced no animals; the same situation occurred with 40% of samples at low and 50% at high tide levels. The interstitial fauna was more numerous and was dominated by nematodes and crustaceans in the form of ostracods and harpacticoid copepods.

Mole crabs and ghost crabs are used as bait by anglers. The area is not heavily fished, averaging about 2.3 rods/km of beach against a KZN coastal average of about 4.1. Limited access points tend to restrict beach users to those owning suitable vehicles. The diversity of fish species caught is relatively low, probably because of the lack of habitat diversity. Catches are dominated by sharks and rays followed by shad/elf, stumpnoses and garrick/leervis. There is no commercial shore-based angling activity.

There is relatively little infrastructure development close to the shoreline in the main impact area to the north of the Thukela mouth except possibly for the Amatikulu Prawn Farm to the north of the river of the same name. The prograding beaches and the backing dunes to the south of the Mlalazi River are unique features of the KZN coastline in that they support superb examples of coastal dune vegetation succession from beach pioneers to climax dune forest.

5.3 Rocky Shores

The nearest rocky shores north of the Thukela mouth are at Port Durnford, a distance of *ca.* 90 km, which virtually removes them from the ambit of the present study. There is approximately 11 km of rocky shores south of the mouth. A study site at Sinkwazi, which falls within this area, had the highest recorded density of redbait in KZN while a site at Seula Point, also within this area, had the highest density of brown mussels recorded in KZN.

Mussels, octopus and oysters are collected by recreational harvesters but only oysters are collected commercially. Oysters are harvested on a four yearly rotational basis and the value of the commercial catch during an open year is about R600 000.

5.4 Subtidal Reefs

Reefs are scattered throughout the area, becoming more extensive north of Mtunzini. The bulk of the available information on the biota of these areas relates to exploited species. The spiny lobster population in the area between Tinley Manor and Richards Bay has been estimated as being in excess of 750 000 but harvesting, particularly from any areas on the Banks, is limited by rough seas and turbid conditions

Fishes of inshore, relatively shallow reefs, particularly south of the mouth, are dominated by shad/elf, blacktail, stumpnoses, stonebream and strepie. Species of deeper, offshore reefs are best known from hook and line catches and these include the seabreams, kobs and rockcods. Smaller species doubtless occur but have not been documented.

Fisheries are recreational and commercial, both utilising hook and line techniques. An estimated 25%, or 7 000 of the total KZN recreational beach or ski-boat launches in 1995, occurred from sites which would have given access to the Thukela Bank reefs where recreational catch rates are higher than in the rest of the province. The average annual catch during the 90's has been estimated at 220 tonnes with a value at first sale of about R2 million. This figure is quoted because, despite the sale of recreationally caught fish being illegal, it is a common practice. Between 1991 and 1998 kobs contributed an average of 33% to the recreational catch as against 4% in the rest of the province.

Approximately 25% of the annual commercial ski-boat effort in KZN is expended in the Thukela area. Reported annual catches in the 90's ranged from *ca.* 100 to 200 tonnes with a value of about R1.7 m *p.a.* This estimate is less than the recreational catch but informed opinion suggests that the commercial catch may be under-estimated by as much as one third. Commercial fishermen target the same species as recreationals and the same species dominate the catch although over-exploitation has caused the kobs to decline in recent years.

5.5 Subtidal Soft Substrata

Despite research having been done on the benthic invertebrate communities off the KZN coast as far as the Mozambique border over the last century, little has been directed specifically at this component of the Thukela Banks. Information from other areas has, however, generated some general principles which would be applicable to the Banks.

A major feature of benthic invertebrate communities is apparent natural variation in space and time, even under apparently stable physico-chemical conditions, although there is always a strong relationship between sediment type and community structure. Physically more complex sediments, *i.e.* muddy sands or sandy muds, tend to be associated with greater species diversity than uniform sands and muds.

A major contributory factor in the KZN context is the decline in wave effects with depth. Deeper sediments are less disturbed and consequently tend to retain mud and detritus resulting in richer benthic communities. This trend is obviously not maintained indefinitely - proximity to the source of these materials is clearly a significant feature. There is no fixed depth at which the above change happens as it will depend on prevailing oceanographic conditions. Off Durban this threshold occurs at *ca.* 50-60 m. As a substantial proportion of the Thukela Banks lies within this depth range and as there are known mud depo-centres there are strong suggestions of a rich benthic fauna on the Banks. There is good evidence that sedimentologically stable areas off major rivers support significant benthic faunas.

Support for the above suggestion also derives from the existence of a prawn fishery on the Banks where the penaeid prawns are a major component of soft bottom communities. The life cycle of these organisms, which incorporates a juvenile estuarine phase and shallow water marine adult and planktonic larval phases, has been described in an accompanying report. This life style brings these animals into close contact with catchment events and it has been argued that population fluctuations are greatest in those species which are most dependent on estuarine nurseries. It is significant in the present context that the Thukela estuary, because of its particular characteristics, has minimal significance as a nursery ground. This function is to a large extent served by the Richards Bay complex and the St Lucia system which are by far the most important nursery grounds in KZN. The significance of the Thukela River to the KZN prawn population lies in the influence of the river on the Banks.

Three species are involved in the Thukela Bank fishery of which the Indian or white prawn *Penaeus indicus*, which is characteristic of muddy substrata, contributes, as it does elsewhere in the Western Indian Ocean, 70-90% of the catch. The other two species are the tiger prawn *P. monodon* and the brown prawn *Metapenaeus monoceros* which occupy the same habitat as the white prawn. This fishery is relatively recent having started in the mid-60's. It is globally small but locally significant. The small size of the fishery is arguably more strongly correlated with size of the juvenile estuarine nursery areas and the area of adult habitat on the Banks rather than any inherent net carrying capacity.

Catch data dating back to 1984 indicate an annual average of *ca.* 80 tonnes. In common with shallow water prawn fisheries worldwide, and with the earlier comments about the dynamics of shallow water benthic populations generally, there are wide variations in prawn abundance in space and time. Thukela bank catches have fluctuated between low's of 15 - 60 t to peaks of 85 – 160 t. As shown in the accompanying Specialist Report # 4, there is a highly significant correlation between prawn abundance as measured by catch per unit effort (*CPUE*) and flow levels in the Thukela River.

Beyond 100 m depth, the macro-invertebrates are dominated by scyllarid lobsters, pink prawns, deep water rock lobsters, langoustines, red crabs and spider crabs all of which represent economically significant resources. The average annual catch of pink prawns, deep water spiny lobsters, langoustines and red crabs is about 350 tonnes. There is a retained bycatch component, principally fish and cephalopods, of about 40 tonnes *p.a.* The total value of target and retained bycatch is about R 9 m *p.a.*

Most knowledge of the larger biota stems from fisheries although line fish operations tend to target reefs and much of the following information derives from trawler bycatches. The line fish groups include the kobs, mullet, stumpnoses, grunter, sharks and rays. Shad/elf are common in winter and sharks and rays during the summer breeding period. 132 fish species have been recorded in prawn trawler bycatches but, of these, six species contributed 80% of the total numbers. A feature of the fish community is the occurrence of juveniles of estuarine associated species, including blackhand sole, minikob and grunters as well as juveniles of various sharks and rays and five kob species. These factors indicate a localised nursery function on the Thukela Banks, probably associated with the frequently turbid conditions. Retained bycatch of the prawn trawl fishery includes a variety of fish, several species of crabs as well as squid or cuttle fish. The value of this bycatch in 1998 was about R200 000.

Information on fish of deeper soft substrata is sparse and the assumption is that the species composition will resemble that of adjacent similar areas at a comparable depth. Neither of the above habitats support any significant line fisheries.

5.6 The Pelagic Ecosystem

This is the least known and understood of the Thukela associated ecosystems. It is nevertheless one which could well be highly impacted because of the link between phytoplankton production and nutrient availability. Surface waters in the Agulhas Current are low in nutrients. Levels on the shelf are higher, increasing with depth and are derived by low levels of upwelling from the deeper waters of the Agulhas Current. Primary production is, nevertheless, still low with cell counts two orders of magnitude below those found in upwelling systems. The measurements of carbon fixation that do exist are scattered and contradictory. The zooplankton on the shelf is dominated by copepods and the total biomass, although greater than that in the Agulhas Current, can still only be described as moderate.

A potentially highly significant aspect of offshore zooplankton dynamics in the KZN coastal region relates to trends in the annual abundance of fish eggs. Data provided in accompanying specialist report # 3 suggest that there is a very strong correlation between peak flows from the Mkomazi River south of Durban and the abundance of fish eggs in the local inshore marine environment. The suggested mechanism is via increased river borne nutrient availability to phytoplankton, thereby enhancing zooplankton growth and culminating in improved condition in spawning planktivorous fish and greater egg production. As the Thukela provides about 40% of the KZN M.A.R. the potential effect in the Thukela Bank area is a serious consideration.

Pelagic gamefish, including mackerels and tunas, occur on the Banks in summer. It is assumed that all five species of turtle occur in the area but this requires verification. Birds include terns, albatrosses, skuas and Cape gannets.

Both humpback and bottlenose dolphins often occur off the Thukela Mouth. The former is a particularly endangered species in KZN because of its preference for shallow turbid areas, conditions which appeal to inshore sharks, and consequently is frequently caught and drowned in sharknets.

6 EFFECTS OF THE DAMS ON THE NATURAL COMMUNITIES – Biological and Economic Impacts

6.1 The Estuary

The most obvious effect of the dams on the estuarine environment will be a change in the pattern of mouth closure as a result of reduced river flow. This would reduce the diluting effect of the river water on any effluent entering the river such as still occurs from the paper mills at Mandini. A smaller water volume and less through flow would result in a greater retention time and more opportunity for any effects of pollutants to be manifested.

While the existing open mouth summer pattern is not expected to change, all scenarios indicate a drastic increase in the length of winter closure periods. Development of more extensive " tidal estuarine" conditions because of greater seawater intrusion as a result of reduced riverine input is unlikely because of mouth closure which would in turn result in lagoon formation behind the bar. Bar formation would restrict movement of any migratory species, such as fish, eels and invertebrates such as the megalopa larvae of the crab *Varuna litterata*, unless there was some overtopping of the bar at high tides. Most of these migratory species do have fairly extended recruitment periods lasting two to three months but clearly the longer the periods of closure and the more substantial the bar, the greater the negative impact will be.

Extended periods of closure would stabilise water levels and water movement. This would permit some settling of suspended material and thereby enhance water clarity and light penetration. If the patterns of nutrient input described earlier were maintained and water residence times increased, this would allow the development of phytoplankton and possibly marginal and emergent vegetation. Any fish trapped in the system following closure could benefit from the enlarged habitat although sustained low salinities would adversely affect marine migrants especially during low winter temperatures.

The effects of closure on the aquatic avifauna depends on the bird group concerned and the timing of closure. Piscivorous predators hunting from the air are unlikely to be affected unless closure results in a decrease in fish densities. Wading piscivorous species will be affected if shallow areas disappear. Swimming species such as cormorants and darters will probably be favoured unless fish populations decline. Benthic invertebrate feeders stand to be the most heavily impacted by mouth closure and the consequent raised water levels and loss of inter-tidal feeding areas. The bulk of these species are, however, summer migrants and therefore present when closure is least likely. Any closures during summer would, however, present a major obstacle to the use of these areas by this group. There was no clear indication of the nature of the impact of closure on species using the area for roosting purposes.

The economic impacts of mouth closure on the estuary and the lower reaches of the river relate largely to possible inundation of low lying, cultivated areas. There is no commercial exploitation of natural resources in the estuary and it is a moot point as to how extended periods of closure might be perceived by holiday makers or residents of the township at the mouth.

Effects are definite, long term, moderate to high magnitude and intensity, regional to national in extent, negative in that they will modify the existing situation, and of medium significance.

6.2 Sandy Beaches

The sandy beaches to the north of the Thukela are likely to become coarser due to erosion of finer particles, thereby favouring some benthic species. Climatic trends and effects of the dams appear likely to combine to cause, at best, stabilisation or, at worst, erosion of the beaches. There are no commercial operations based on the beaches and no, or minimal infrastructure on the dunes and immediate hinterland. The major exception is the prawn farm situated immediately north of the Amatigulu estuary which could be affected by long term beach and dune erosion. The vegetation succession on the prograding dunes, particularly in the Mlalazi Nature reserve south of the river, is a unique feature of the South African coastline which would be at risk under sustained eroding conditions.

> *Effects are definite, long term, moderate to high magnitude and intensity, regional to national in extent, negative and medium to high significance.*

6.3 Rocky shores

The only rocky shores in the possible impact area lie south of the Thukela mouth. High densities of brown mussels *Perna perna* occur in the vicinity and the concern is that a reduction in the detrital input could adversely affect inter-tidal filterfeeders. The dependence of rocky shore filter feeders on terrestrially derived detritus has been established elsewhere in the province. Both oysters and mussels are harvested but the extent of any impact and the possible economic consequences are uncertain.

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> *Effects are probable, long term, moderate in magnitude and intensity, local to regional in extent, negative and medium significance*

6.4 Subtidal Reef

Of potential significance to subtidal reef communities are the factors mentioned in the preceding section, plus possible reduced turbidity which could favour corals and greater primary productivity from fixed algae. Line fisheries are dependent largely on reef fish and are locally important at present. Changes in fish community composition are possible with a shift away from turbid water species to those favouring clearer water. Greater water clarity would also favour diving activities, especially spearfishing. The likelihood of turbidity changes, the area over which this would occur and the direction of change remain, however, as moot points.

A reduced sand supply to the shelf is expected to increase reef area and should result in an increased population of reef associated organisms. This could favour reef inhabitants but would not necessarily cause an increase in the fish populations which are already under heavy fishing pressure.

Effects are probable, long term, moderate, local to regional, positive for this particular environment which could increase in size, and low significance.

6.5 Subtidal Soft Substrata

The forecast increase in total area of soft sediments on the Bank would favour species associated with such habitats. The prawn trawl fishery is associated with muddy sediments and it might be expected that an increase in the area of this type of habitat would favour these species and ultimately the fishery. It is not certain, however, that a simple increase in the type of physical habitat favoured by the prawns would result in an increase in numbers.

The data and conclusions presented in the accompanying Specialist Report # 4 are the first indication of a cause and effect situation linking any component of the

Thukela Bank biota with river flow patterns. There was a clear positive correlation between river flow and prawn abundance and, when analysed in more detail, a strong suggestion that maximum prawn abundance was closely linked to high flow levels. Abundance declined generally during low flow years but the relationship was less distinct.

Catch data indicate a three- to four-fold variation in abundance linked to natural flow variations. It should, therefore, be possible to use this process to model the likely response of the prawn stocks to modifications in the Thukela flow regime and to obtain a more accurate estimation of the possible biological and economic impacts.

The potential for change is therefore, very real but the extent of many of the impacts are speculative at this stage. This is particularly the case in the deepwater trawl fishery where the lifestyles and habits of the species involved are less well known than the shallow water types.

Effects are probable to definite, long term, moderate to high magnitude and intensity, and regional to national in extent. Muddy substrata are expected to increase while sandy substrata are expected to shrink; one habitat would benefit while one would suffer. Significance is medium to high.

6.6 The Pelagic Ecosystem

Conditions would be altered by any change in turbidity. Decreased turbidity during mouth closure periods could enhance phytoplankton production by increasing light penetration, assuming that nutrient levels remain adequate. Changing turbidities would affect the distribution patterns of fish species favouring clear or turbid waters. Unfortunately there are no measures of the relative inputs of nutrients derived from the low levels of upwelling that occur in the region and that derived from riverine inputs. The Mkomazi data clearly suggest a major influence of freshwater runoff on the inshore environment which can be strongly argued to be acting via nutrient input and an enhancement of phyto- and zooplankton production. Confirmation and quantification of such an influence remains a major gap in our knowledge.

Effects are probable to definite, long term, moderate, regional to national, sign uncertain to negative and medium to high significance.

7 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

In drawing together all the above conclusions it is unequivocal that, disregarding any effects between the dams and the estuary, there will be impacts on the estuary, the inshore marine environment including the beaches and the Thukela Banks to an as yet unknown degree and extent. There is nothing heretical or revolutionary in this statement as the Thukela system will simply be added to an already long list of documented cases world-wide where large dams on major rivers have had effects ranging from minor to disastrous on the downstream, estuarine and local marine environments.

At this stage the levels of confidence for forecasts in the Thukela system are greatest for the anticipated physical effects on the estuarine and beach environments and slightly less for the shelf. It should be clearly noted that the changes predicted with the greatest confidence relate to changed water flow patterns in the river and estuary and the associated sediment transport and availability. While these are very significant driving forces, the points made above indicate clearly that they are not the only factors influencing the broader system. Historic variations in prawn abundance would not necessarily be linked to variations in sediment transport.

Biological effects in the short term will be most obvious in the estuary. Offshore effects will be less visible and longer term but potentially at least as significant. The estuarine biological response, in terms of the changes associated with a greater degree of environmental stability as already described, could be construed as positive. It will, however, represent a deviation from the pristine condition and will occur at the expense of some other component of the overall system.

The nature of biological responses to environmental changes at the population or community levels are never easy to forecast except in the extreme case where it involves total loss of habitat. In the present case we are dealing with several systems at increasing distances from the source of change. These increasing distances correspond with progressively less certainty about the extent of physical change and have not taken into account any of the possible other changes in inputs such as organic material, plant nutrients and the simple diluting or cueing effects of a large input of freshwater. At this stage we do not have any information on the magnitude of organic and nutrient input into the inshore and shelf environments.

A further problem is centred around the relative importance of major flood events, above average wet years and more normal, annual flow level variations. The contrast has been emphasised above and it is clear that one major flood can discharge more water and transport more sediments and potentially more organic material and dissolved nutrients than might be found in an average year. The correlation between Thukela River flow and prawn abundance on the Bank is statistically highly significant (Specialist Report # 4) while a similar pattern emerged from data on fish egg abundance off the Mkomazi River (Specialist Report # 3). The possible mechanisms are similar in that increased nutrient would benefit phytoplankton to the advantage of planktonic, larval prawns while enhanced phytoplankton production would also increase the zooplankton to the benefit of filter feeding fish resulting in improved spawning. These two examples indicate very strongly that attenuation of high flow levels will have a negative impact on the productivity of the inshore environment, particularly in the oligotrophic KZN situation where the Thukela River provides some 40% of the provincial M.A.R.

Depending on the component of the system and the degree of dependence on river flow, it could take several years to detect any effect. It is, however, our considered opinion that ultimately effects will be manifested and the questions then relate simply to speed and scale.

Recommendations

Recommendations for future monitoring and research fall into two categories, *viz.* physico-chemical and biological. There are obvious gaps in our knowledge in both areas.

Physico-chemical.

In terms of sedimentary processes, despite the amount of historical information available, ongoing monitoring is necessary to test the accuracy of the predictions. This includes:

- ongoing monitoring of coastline changes by aerial photography before and following dam construction. Water flow rates and sediment transport rates should be monitored in conjunction with beach sediment sampling and profiling. Coastal monitoring should initially be done six monthly for five years, after which the time frame could be reviewed;

- monitoring of changes in muddy and reef areas on the shelf using side scan sonar for surface changes and seismic profiles for sediment thickness. This should be repeated every five years.

The magnitude of organic and nutrient inputs into the coastal environment is as yet unknown.

Biological

Any existing long term data bases should be maintained and, if necessary, broadened in scope. In particular the existing monitoring of fisheries and most importantly the crustacean trawl fisheries on the Bank should be maintained as indices of conditions on the Banks.

In addition to the above recommendation that fisheries monitoring be maintained, non-harvested organisms should also be considered in terms of detection of community change. This could include coralline algae on rocky shores, tunicates and sponges on subtidal reefs and meiofauna in soft substrata. Information from dedicated biological, as opposed to fisheries research on virtually any component of the Banks ecosystem is sparse to non-existent and no attempts have been made to coincide investigations with major flood events and particularly their aftermath.

If there is going to be any forecasting or assessment of the effects of the dams it is vital that nutrient and carbon budgets be produced, and that basic biological information on the benthos, hyper-benthos and pelagic fauna and flora be obtained. The hyper-benthos refers to that component of the water column fauna which is generally small, 1-3 cm long, and which occurs immediately above the bottom. In this position it is not vulnerable to normal bottom sampling devices nor to plankton nets, which are generally towed well away from the bottom, but it can be a major component of inshore marine and estuarine systems. Changes in the benthos and hyperbenthos would provide indications of organic inputs while techniques such as the use of stable isotope ratios (e.g. $^{12}C/^{13}C$ analyses) could provide significant insight into the relative importance of different carbon and detrital sources. The source(s) of nutrients to the Banks and particularly the relative inputs from the marine and terrestrial environments need(s) to be quantified. The effects of high and low flows on nutrient inputs and any consequent effects on phytoplankton and zooplankton production and the possible links with the prawn populations needs to be clarified.

If a decision is taken to proceed with the dams it would be necessary to draw up a research and monitoring programme incorporating the above points, for implementation before construction began, in order to provide a before and after picture and to allow the assessment of any mitigatory actions.

8 REFERENCES

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Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT FEASIBILITY STUDY

WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK SYSTEM MODEL

MARCH 2000

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THUKELA WATER PROJECT FEASIBILITY STUDY WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK

WATER RESOURCES SYSTEM MODEL

Job No 2354/10
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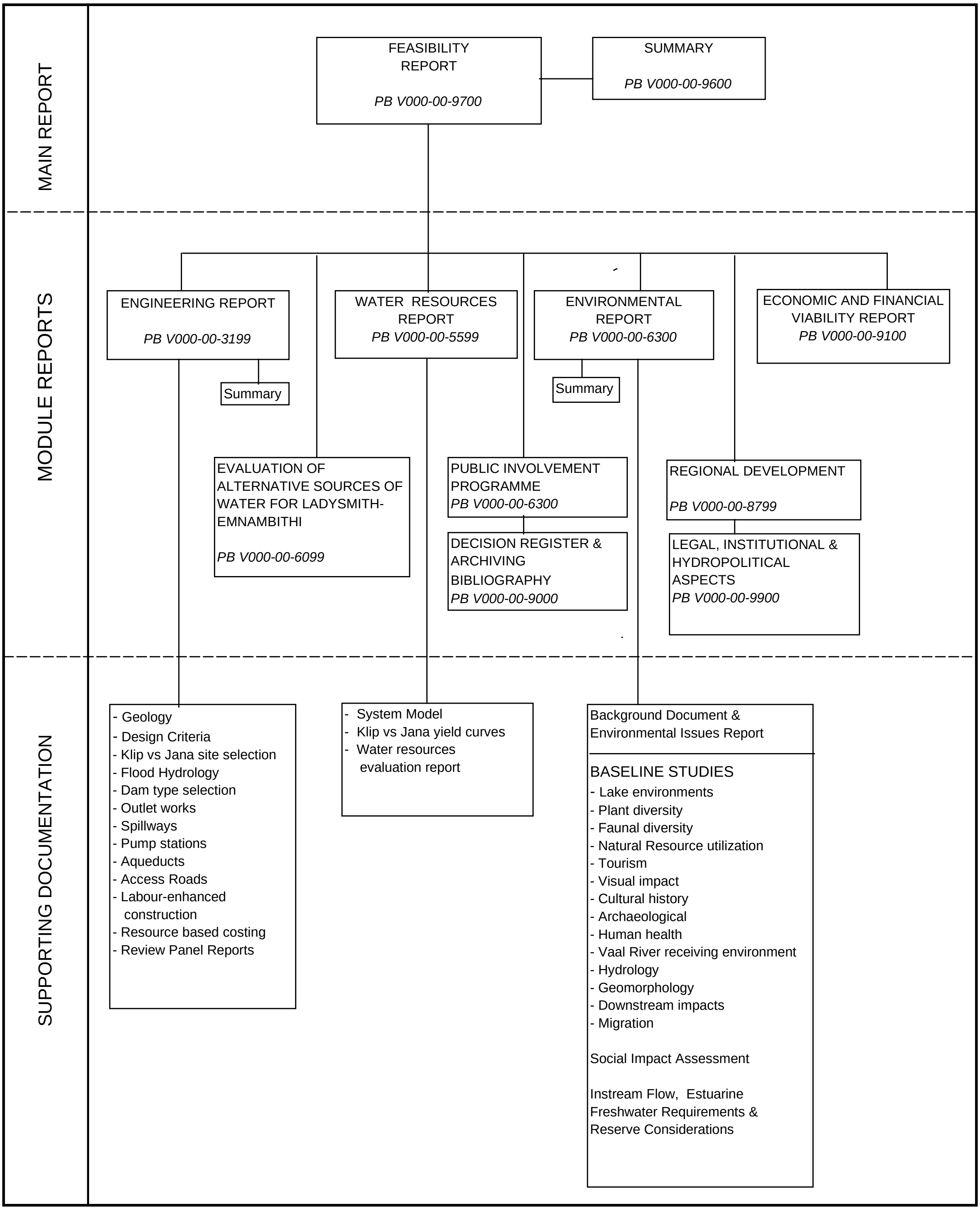
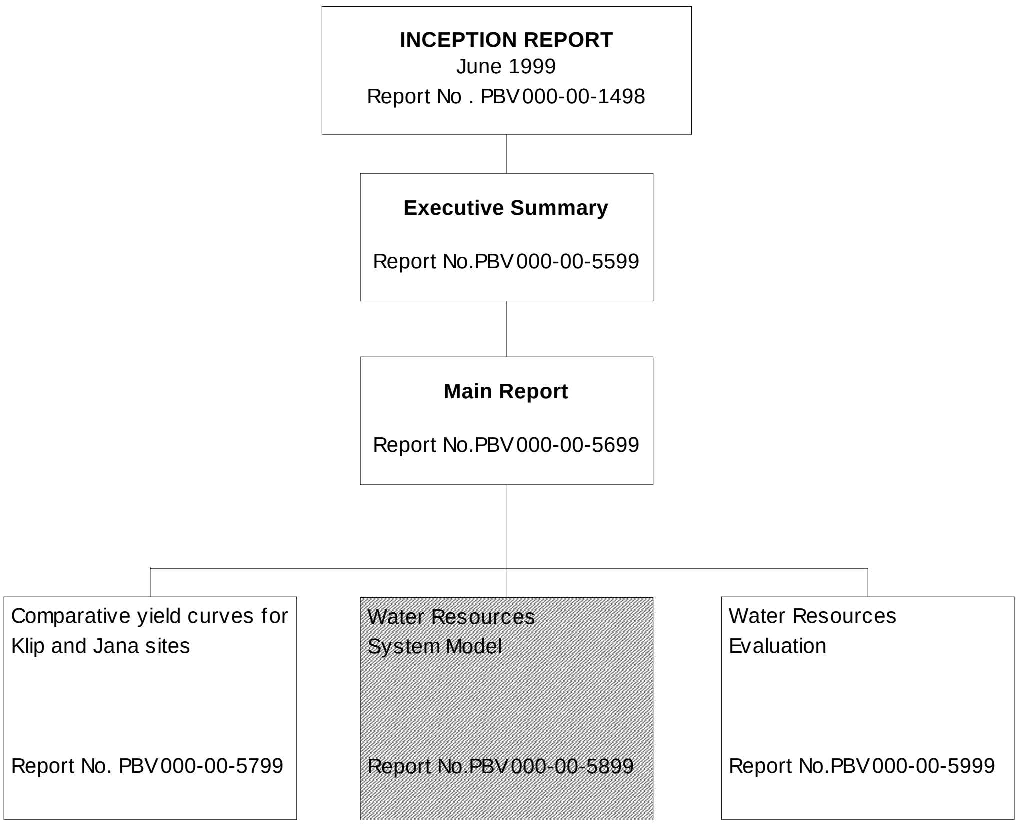


THUKELA WATER PROJECT : FEASIBILITY STUDY
WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK

WATER RESOURCES SYSTEM MODEL

The Water Resource Evaluation and Systems Analysis Task comprised a number of sub-tasks that are reported in a number of separate reports. This report describes the development and verification of the water resources system model. The diagram that follows shows how the various reports produced for the water resource evaluation and systems analysis task inter-relate:



THUKELA WATER PROJECT FEASIBILITY STUDY

TBC CONSORTIUM MARCH 2000

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THUKELA WATER PROJECT : FEASIBILITY STUDY

WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK

WATER RESOURCES SYSTEM MODEL

EXECUTIVE SUMMARY

This report describes the implementation of first, second and third phase revisions to the system model. These revisions included updating hydrology, improvements to the system model particularly in the areas of IFR's and increased system complexity, refinement of demands and elevation–area–storage data and revision of priorities for supplying demands. The Mooi River was modelled in more detail in a separate Mgeni River Augmentation Planning Study. This system was therefore included as an input channel to the Thukela system. The most recent natural runoff, demands, transfers, return flows and IFR details are given and compared to previous phases where relevant. The feasibility study WRYM system model is shown in Drawing W5.

THUKELA WATER PROJECT : FEASIBILITY STUDY
WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK

WATER RESOURCES SYSTEM MODEL

TABLE OF CONTENTS

List of Tables

List of Drawings

List of Appendices

THUKELA WATER PROJECT : FEASIBILITY STUDY
WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK

WATER RESOURCES SYSTEM MODEL

ABBREVIATIONS

DSL	Dead Storage Level
DWAF	Department of Water Affairs and Forestry
EFR	Estuarine Flow Requirement
FSL	Full Supply Level
IFR	Instream Flow Requirement
MAR	Mean Annual Runoff
PMT	Project Management Team
TOR	Terms of Reference
TVTS	Thukela-Vaal Transfer Scheme
TWP	Thukela Water Project
VAPS	Vaal Augmentation Planning Study
WRYM	Water Resources Yield Model

THUKELA WATER PROJECT: FEASIBILITY STUDY
WATER RESOURCE EVALUATION AND SYSTEMS ANALYSIS TASK

WATER RESOURCES SYSTEM MODEL

1 INTRODUCTION

The Thukela river rises in the Drakensberg from where it flows in an easterly direction through the province of KwaZulu-Natal to drain into the Indian Ocean. It is the third largest river in South Africa and the largest river that is not subject to water demands or rights from other countries. Accordingly, the Thukela represents an important and significant part of the water resources available to South Africa.

Compared to most other large rivers in South Africa the Thukela is still not well developed and there is scope to increase supply from the river to legitimate users. At present there are seven large dams in the Thukela as follows:

- *Woodstock Dam* in the upper Thukela river is the main regulating storage for the Drakensberg pumped storage hydro-electric and water transfer scheme to the Vaal river system.
- *Driel Barrage* in the upper Thukela river is the main abstraction point for the Drakensberg scheme.
- *Spioenkop Dam* in the upper Thukela river was built mainly to regulate flow in the Thukela downstream of the Drakensberg scheme. To date demand in the Thukela basin has not grown to the extent that Spioenkop Dam is heavily used and the dam is often close to full or spilling.
- *Wagendrift Dam* in the Bushmans river is used primarily for water supply to the town of Estcourt and surrounding developments. This dam is also not fully used at present.
- *Chelmsford Dam* in the Ngagane river is used primarily for water supply to the town of Newcastle and surrounding developments.
- *Zaaihoek Dam* in the Slang river is used primarily as the regulating storage for water transfer to Majuba power station in the Vaal river catchment.
- *Craigieburn Dam* in the Mnyamvubu river is used primarily for irrigation.

Other significant water infrastructure comprises the following:

- *The Drakensberg pumped storage scheme* which can generate up to 1000MW of peak power. At the time of commencing this study, Eskom indicated that this scheme could transfer 35m^3/s of water, on average[1], from the Thukela to Sterkfontein Dam in the Vaal river catchment without affecting the power generation function. Currently, the infrastructure is in place to transfer water from the upper Thukela system, consisting of Woodstock Dam and Driel Barrage, at a peak rate of 20 m^3/s. The *average* yield of this system is estimated at 527 million m^3/a . It follows that new developments in the Thukela, with peak transfer rates of up to 15m^3/s, could transfer additional water to the Vaal river catchment through the Drakensberg pumped storage scheme very cost effectively.
- *The Zaaihoek transfer scheme* comprises a pumped transfer from Zaaihoek Dam in the Thukela basin to Majuba power station in the Vaal river System. Water can also be transferred the East Vaal system.
- *The Mooi-Mgeni transfer scheme* was originally built as an emergency scheme to pump water from the Mooi river to the Mgeni river during the 1980's drought but was only used for one year to supply of domestic and industrial water demand to Durban and Pietermaritzburg. Subsequently the scheme was moth-balled when the drought broke but the intention is now to re-instate the scheme as a permanent transfer scheme and to enhance its yield by the construction of one or two dams in the Mooi river.
- *The Middledrift transfer scheme* transfers water from the Thukela river to Goedertrouw Dam in the Mhlatuze river at a rate of 34 million m^3/a to supply industrial and domestic users in Richards Bay. The scheme was implemented in the early 1990's and investigations are currently underway to investigate the feasibility of increasing the transfer rate. The systems analyses carried out as part of the Thukela Water Project assumed a maximum future transfer rate of 8m^3/s but it now appears unlikely that the transfer will escalate to this extent within the planning time frame of the Thukela Water Project.

The Thukela-Vaal Transfer Scheme (TVTS) pre-feasibility and interim studies served to eliminate a large number of potential dam sites in the Thukela and its tributaries and to narrow development proposals to two, one in the upper Thukela and the southern tributaries and one in the northern tributaries. The Thukela Water Project (TWP) Feasibility Study focuses primarily on the proposed development in the upper Thukela and the southern tributaries.

1 A more detailed analysis by Eskom, completed after the systems analyses carried out for the Thukela Water Project, indicated that the transfer possible via the Drakensberg pumped storage scheme was limited to a *peak* rate of 35m^3/s and not an *average* rate. The impact of this change needs to be investigated in further studies.

The interim study defined the project as one comprising Mielietuin Dam in the Bushmans river and either Klip or Jana Dam in the Thukela. The proposed location of the dams is shown in Drawing W1.

The Water Resources Yield Model (WRYM) was used to do the system analysis for the pre-feasibility study. After completion of this study a so-called interim study was undertaken. As part of the interim study an attempt was made to incorporate into the system analysis model flows for Instream Flow Requirements (IFR's). However, at that stage WRYM did not have a facility to model IFR releases properly and, consequently, the results of the analysis were basically inconclusive. These results did, however, indicate that considerable extra storage would be required to satisfy the IFR's. Channels to model IFR's and the estuarine flow requirement (EFR) have since been added to the WRYM model and are incorporated in the system model for the feasibility study.

During the interim study the Thukela basin was represented as a network extending from upstream of the Driel Barrage down to the mouth of the Thukela. The catchment was divided into 32 runoff sub-catchments each of which had a naturalised time series of runoff generated. The system consists of seven existing major dams, two proposed dams (Mielietuin and Jana), two dummy dams one in the Sundays river and one in the Buffalo river to allow for supply of IFRs and projected demands in these rivers, (Uitkyk and Buffelshoek) and seven dummy farm dams (refer to the system diagram in Drawing W5).

The more detailed Ninham-Shand system for the Mooi river catchment that was developed during the detailed feasibility study for the Mooi-Mgeni transfer Scheme has been used to replace the less detailed modelling done of this sub-system during the interim study. The Mooi sub system is shown separately in a corner of the final systems diagram (Drawing W5) as the sub-system was analysed separately and the output was used as input to the Thukela system.

All system diagrams show incremental flows in blue at certain nodes and reservoirs, urban demands in red, return flows in orange, transfers and IFR's in light green and irrigation demands in black. Penalty structures are shown for all channels and reservoirs.

Of key importance is the existing Thukela-Vaal transfer (Drakensberg pumped storage hydro-electric scheme), the Mooi-Mgeni transfer scheme as well as the Zaaihoek and Middledrift transfer schemes.

There are seven IFR's and one EFR included in the feasibility system model as follows:

IFRA	Downstream of Spioenkop Dam
IFRC	Downstream of Driel Barrage
IFR2	Downstream of Jana Dam
IFR3	Downstream of Mielietuin Dam
IFR5	Downstream of Sundays, Bushmans and Thukela confluence.
IFRBUF	Downstream of Buffelshoek dummy dam
IFRSUN	Downstream of Uitkyk dummy dam
EFR	Thukela river estuary

For the location of the IFRs the reader is referred to Drawing W5.

The upper Thukela system down to Spioenkop is complex. The existing abstraction of the Drakensberg pumped storage scheme is mainly from the Driel Barrage (which has a relatively small storage capacity) at a peak rate of 19 m^3/s. Run of river abstractions are also made at three separate points in the tributaries of the upper Thukela and diverted under gravity to the Jagersrus pumpstation forebay. The peak capacity of these diversion are 4 m^3/s. Together with the pumped abstractions from Driel, water is pumped through a minor vertical lift to Kilburn Dam at a peak rate of 20 m^3/s. The assumed operating rule of this system, for modelling purposes, is that abstractions from the upstream diversions are maximised to reduce puming costs from Driel.

Woodstock Dam, situated on the Thukela River just upstream of Driel Barrage, is the main storage for the Drakensberg scheme and releases water as required into Driel Barrage for transfer. The Mlambonja river flows into Driel Barrage downstream of the Driel Barrage but much of these flows spill as a result of the limited storage in Driel.

The hydrological database for the interim study covered the period 1920 to 1992 (hydrological years). Subsequently these time series of natural streamflow, afforestation usage and irrigation usage have been extended by two years to the end of the 1994 hydrological year (i.e. to September 1995). Other changes required that the record length be reduced by starting in year 1925 rather than 1920.

Section 3 of this report describes the amendments made to the system model subsequent to the interim study, with particular emphasis on the IFR and EFR channels.

Section 4 summarises the review of model input data including the extended and augmented hydrological database, which encompasses natural streamflow; afforestation; urban, rural and industrial demands; return flows; IFR's and the EFR.

The report concludes by presenting the final TWP feasibility study WRYM system model in section 5.

2 STUDY OBJECTIVES

The objectives of the Water Resources Evaluation and Systems Analysis task are as follows:

- to assess the storage-yield relationship of dams over a range of capacities at the selected sites for input to the Engineering Task for the purpose of optimisation of dam and other component sizes.
- to assess the quantities of water that can be transferred to the Vaal from each dam after due allowance has been made to meet all projected source-basin demands including environmental requirements and existing and planned inter-basin transfer schemes.
- to assess the long term yield of the TWP using stochastic inflows.

This report serves to record the several significant changes that were made to the TVTS interim study systems model to update it to be a comprehensive model to be used during the feasibility study.

3 REVISIONS TO THE SYSTEM MODEL

System analysis is a procedure for analysing the performance of a complex combination of activities and components – in this case a complicated water resource system. The Water Resources Yield Model (WRYM), developed by consultants for DWAF, was used in this study. Primary input to the model takes the form of either historical or stochastically generated time series of flow and water use at key points. The model requires the water resource system to be set up as a network of nodes connected by channels. Nodes are used to represent points where natural inflow enters the system, where demands are abstracted and return flows, if any, enter the system. Nodes can have storage to represent reservoirs. Channels are used to connect nodes and to represent demands on the system.

During the interim study, a WRYM system model was developed for the Thukela river catchment. The interim study network diagram is shown in Drawing W2. Constraints were placed on the amount of detail in this model due to limitations of the Mark 3 version of WRYM used for the interim study. The WRYM software was updated subsequent to the interim study (WRYM Mark 5 version), to include some new features as well as to expand existing features and decrease component limitations allowing more detail in the model. The interim Thukela river model was therefore updated to make use of the software improvements and availability of new and improved data as follows:

- The hydrology files and prescribed demand time series were extended to the end of the 1994 hydro-year and a new "paramk5.dat" file was generated.
- The elevation-area-storage relationships for the Mielietuin, Jana and Klip sites were updated.
- Minimum flow channels (that were used because of the Mark 3 restriction on the maximum number of general flow channels) were replaced with general flow channels.
- IFR channels, available in the Mark 5 version, were used to model supply of In-stream Flow Requirements (IFR) and Estuarine Flow Requirements (EFR).
- The nodes and channels were renumbered to be more ordered, thereby facilitating checking and addition of new nodes and channels.
- The penalty system and number of operating zones in the reservoirs were revised to introduce flexibility needed in implementing realistic operating rules and optimising system operation.
- The prioritisation of supplying demands was reviewed and revised.

Comparative elevation-yield curves for the proposed Klip and Jana Dam sites, for input into the selection of one of the sites, were required early in the TWP study programme, before the system model revisions could be fully implemented and the new model validated. However, as the catchments for the two sites are essentially the same, the effect of the rest of the system on the yields from the two dams would be the same. Therefore it was possible to derive comparative elevation-yield curves for Klip and Jana sites using the interim system model with only the extended hydrology and IFR channels implemented. This part of the work is recorded in a separate report titled "Comparative yield curves for Klip and Jana sites" (Report No. PBV000-00-5799).

This need for a usable system model early in the study period dictated that the revisions to the system model be made in two phases namely:-

- **first phase revisions**
  - ❑ update hydrology and time series demands
  - ❑ replace minimum flow channels with general flow channels
  - ❑ update elevation-area-storage data for the proposed reservoirs
  - ❑ initial implementation of IFR channels

- **second phase revisions**
  - ❑ renumber nodes and channels
  - ❑ revise penalties and reservoir storage zones

As work on the revised system model progressed according to the original TOR a number of issues pertaining to the project were identified for further investigation. Some of these were merely extensions of the original feasibility study TOR (either due to the new version of WRYM, or an improved understanding of the issue), but others were new issues. A revised TOR was drawn up in addition to the original TOR for the feasibility study. A copy of the revised TOR is included in Appendix A for reference purposes.

The resulting model revisions as required in the revised TOR are referred to as third phase revisions.

- **third phase revisions**
  - ❑ incorporating additional farm dams into the system network;
  - ❑ adjusting irrigation supply to provide water at an appropriate assurance of supply;

- replacing the Mooi river subsystem in the original feasibility study model with an inflow file obtained from the more detailed Mooi-Mgeni model obtained from Ninham Shand;
- revising the hydrology of Zaaihoek Dam;
- reviewing projected 2030 urban demands in the Buffalo river; and
- modelling the proposed Uitkyk and Buffelshoek Dams with corresponding IFR's on the Sundays and Buffalo rivers respectively.

In addition to the above-mentioned revisions, it was found necessary to implement various system changes including

- renumbering of the system;
- adjusting the Ladysmith demand in line with the Ladysmith Water Supply study;
- revision of some IFR's;
- revision of elevation-area-storage data for Jana and Mielietuin Dams;
- standardisation of full supply levels for proposed dams to allow for comparison of analysis results;
- revision of the order in which demands are supplied in the lower Thukela river; and
- inclusion of buffer levels on some existing dams to ensure supply to demands.

Implementation of the three phases of revisions as well as the additional revisions that proved to be necessary are described further in what follows:

3.1 Implementation of first phase revisions

The first phase revisions were implemented before the analyses to determine comparative yields from dams at the Jana and Klip sites were performed. These revisions were all straight forward and required minimal amounts of checking to ensure that errors were not being introduced into the system model.

Implementation of the four revisions described below and successful model verification resulted in the development of the first phase feasibility systems model shown in Drawing W3. This first phase feasibility model was used to derive the comparative storage-yield curves used in the Jana/Klip Dam selection process as described in the separate report entitled "Comparative Yield Curves for Klip and Jana sites" (Report No. PBV000-00-5799).

3.1.1 Hydrology and Time Series Demands Update

A WRYM system network depicts the system as nodes connected by channels. Nodes with incremental inflow are called reservoir nodes. A reservoir node need not have storage. Thirty two nodes with incremental inflow were used in the interim model. It was decided to use the same inflow nodes for the feasibility study.

Details on the update of hydrological inputs to WRYM are given in Section 4. This sub-section merely reports on the implications of these updates on WRYM.

A revised PARAMK5.DAT file was generated using ANNUAL and CROSSY software with the updated hydrology as input.

Limitations on the number of prescribed demand channels that could be used in the pre-feasibility and interim studies had necessitated some irrigation demands being modelled as min-max channels rather than prescribed demand channels. This limitation was improved in the latest version of WRYM so all irrigation demands were included as time series demands.

The model was run with the updated hydrology and extended prescribed demand channel time series and flow in selected channels were compared with results obtained before the changes were made. Analysis of the results showed no changes over the period of the interim hydrology and the model with the updated hydrology and prescribed demand channel time series was accepted.

3.1.2 Replacement of minimum flow channels

The Mark 3 version of WRYM limited the number of general flow channels to 50, whereas the Mark 5 version allows up to 100 general flow channels to be used. Minimum flow channels operate the same as a general flow channel when the minimum flow is set to zero. However, for the sake of neatness and consistency the minimum flow channels used in the interim model were changed to general flow channels.

This change did not affect the results obtained from the model.

3.1.3 Updating of elevation-area-storage data

In the interim model elevation-area-storage information for the proposed Mielietuin, Jana and Klip sites were obtained from 1:10000 and 1:50000 maps. Subsequently the dam basins have been surveyed and more accurate elevation–area–storage information was made available by DWAF. The

WRYM program allows up to 15 points in the elevation-area-storage curve to be specified. The points selected for the three proposed dams are shown in Tables 3.1 to 3.3

Table 3.1 : Jana site elevation-area-storage information

Elevation (m)	Area (km^2)	Storage (10^6m^3)
704	0.0	0.2
720	0.3	3.7
740	1.6	23.0
760	4.2	82.2
780	7.1	197.6
800	10.9	377.2
810	13.2	498.3
820	15.6	643.7
830	17.8	812.1
840	20.4	1004.3
850	23.9	1226.1
860	27.4	1482.6
870	31.3	1776.6
880	36.0	2190.0
890	41.3	2652.0

Note : Jana curves only accurate up to 870

Table 3.2 : Klip site elevation-area-storage information

Elevation (m)	Area (km^2)	Storage (10^6m^3)
766	0.0	0.0
780	0.3	1.6
790	0.8	6.7
800	1.9	20.1
820	4.4	83.0
840	6.5	192.2
860	8.4	341.6
870	9.4	430.6
880	10.6	530.0
890	12.4	644.21
900	14.7	779.5
910	17.1	938.1
916	19.0	1046.6
920	20.3	1125.1

Table 3.3 : Mielietuin site elevation-area-storage information

Elevation (m)	Area (km^2)	Storage (10^6m^3)
938	0.0	1.1
950	0.1	9.4
960	0.6	20.6
970	1.7	40.9
978	2.8	66.9
986	4.3	104.0
994	5.7	153.0
1002	6.8	213.3
1010	8.0	283.6
1018	9.6	365.5
1024	11.7	438.2
1030	14.6	527.2
1034	16.7	597.1
1040	20.3	720.4

The changes to the elevation-area-storage curves were checked by comparing yields from the reservoirs against yields obtained during the interim study. The results showed that the critical period still coincided with the drought of the latter sixties and early seventies, but that yields were not the same for the FSL's from the Interim Study. Comparisons of the elevation-storage curves from the interim study with the revised curves showed significant changes. However, the storage-yield curves agreed with the interim results confirming that changes in reported yield were as a direct result of the revised elevation-storage relationship and not the result of an error introduced in the system model.

3.1.4 Initial implementation of IFR channels

The IFR channel is a special case of the min-max channel. The flow requirements for the min-max channels, specified in the F12 data file, remain fixed and during simulations the program will supply the required flow depending on availability of water and relative penalties. The flow requirements for IFR channels are not fixed, as they depend on inflows. Flow requirements are specified both in the F12 and the F14 files (IFR data). In the F14 file the IFR requirement is specified as a function of the inflow at up to ten of the nodes with incremental inflow, called reference nodes. This function can be based on the inflow for the current month (lag =0) or the average of up to 12 preceding months (lag<>0). The value in the F12 file is only used when lag<>0 and the number of months simulated is less than the lag. For the TWP analyses IFR channels were set up with lag=0.

IFR's were specified by the specialist IFR team as a time series of streamflow at each IFR site. These time series were matched with the reference node time series by relating their duration curves to determine the relationship for input to the F14 file.

The in-house program RANKFLOW was written to rank and plot the twelve monthly IFR flow time series and to combine, rank and plot the reference node inflow time series. WRYM uses net inflow at the reference nodes therefore irrigation and afforestation usage is subtracted from inflow before the inflows are combined. In some months irrigation plus afforestation usage in the data files exceeds inflow. RANKFLOW reports the events and sets net inflow to zero for these months. Inflow factors for the node in the FO2 file are applied when the inflows are combined. Points on the IFR curves were selected and entered together with the corresponding points off the reference node curves in the F14 data files to define the twelve monthly relationships between reference node inflow and IFR requirement.

Flows were specified for five IFR sites and the EFR site. Site locations are as follows:-

IFR A Thukela river, downstream of Spioenkop Dam
IFR B Klip river, downstream of Qedusizi Dam
IFR 2 Thukela river, downstream of proposed Jana/Klip Dam
IFR 3 Bushmans river, downstream of proposed Mielietuin Dam
IFR 5 Thukela river, upstream of Mooi river confluence
EFR Thukela river estuary

The reference nodes selected for each site are listed in Table 3.4.

Table 3.4 : Reference nodes used for IFR channels

Site	Inflow files	Site	Inflow files
IFR A	TM01.INC	IFR 3	TM19.INC
	TM03.INC		TM18.INC
	TM04.INC		TM13.INC
	TM05.INC		TM17.INC
			TM09.INC
IFR B	TM07.INC	IFR 5 & EFR	TM05.INC
	TM11.INC		TM07.INC
IFR 2	TM01.INC		TM10.INC
	TM03.INC		TM16.INC
	TM04.INC		TM08.INC
	TM05.INC		TM11.INC
	TM07.INC		TM13.INC
	TM10.INC		TM09.INC
	TM08.INC		TM14.INC
	TM11.INC		TM15.INC

The IFR channel, being a variation on the min-max channel, will not pass more than the specified flow. A general flow channel is therefore required in parallel to the IFR channel to allow flow out of the upstream node to exceed the IFR requirement. This occurs when the reservoir spills or when releases in excess of the IFR requirement are required to supply downstream users. These releases also need to be included in the assessment of flow at the IFR site. Accordingly the IFR's were modelled with the IFR channel and a general flow channel from the upstream node. These channels were then routed to a new node connected to the node downstream of the IFR site by another general flow channel which can be used to check simulated flows at the IFR site. Thus implementation of IFR's in the system model required the addition of the IFR channel, a new node and a general flow channel at each of the IFR sites and the EFR site.

These changes were implemented and operation of the system was simulated with the IFR requirements set to zero so that the results could be checked without being affected by IFR releases. After the addition of the nodes and channels had been confirmed as not affecting the results, the appropriate IFR requirements were set in the F14 and F12 data files.

3.2 Implementation of second phase revisions

The interim system model (Drawing W2) had been revised a number of times to meet changing requirements during the pre-feasibility and interim studies and to incorporate IFR channels as part of the first phase feasibility revisions (Drawing W3). Introduction of new nodes and channels had resulted in the numbering becoming haphazard which made it difficult to find nodes and channels and to select unused numbers for new nodes or channels. Accordingly it became necessary to renumber the model nodes and channels.

Similarly, the penalty system became complex and lacked the flexibility that would be required to meet the requirements of the feasibility study analyses. Accordingly it was decided to revise the penalty system and review supply priorities.

Implementation of the two sets of revisions described below and successful model verification resulted in the development of the second phase feasibility systems model shown in Drawing W4.

3.2.1 Renumbering of nodes and channels

The system diagram was updated to include the IFR channels and EFR channel as well as Mielietuin, Jana/Klip and Qedusizi Dams. The nodes and channels were numbered from upstream to downstream, first along the main river and then the tributaries and the data files were updated. The revised system was checked by comparing simulation results from the renumbered system with results from the previous system to ensure that no numbering errors had been introduced.

3.2.2 Review and revision of priorities and penalties for supplying demands

In-basin demands and existing and planned transfers must be supplied in preference to the new transfers to the Vaal. In accordance with this rule the following priority for supplying users was adopted:-

- primary demands – industry, urban and rural,
- inter basin transfers, within KwaZulu-Natal, both existing and planned,
- irrigation,
- IFR's and the EFR,
- proposed Thukela Vaal transfer (overall yield).

Although the above list of priorities indicate that IFRs and the EFR only get supplied after full supply of the primary demands, inter-basin transfers and irrigation, it should be understood that the reported yields for the proposed Thukela Vaal transfer were determined by increasing the transfer demand to the point of first failure of transfer yield subject to no-failures in IFR supply. The selected priority list thus enabled supply of IFRs to be checked rigorously in the knowledge that if IFRs are supplied all other in-basin transfer demands would have been supplied fully.

There was also the following priority for supply from the reservoirs.

- Chelmsford
- Craigieburn
- Zaaihoek
- Mearns - (dummy dam in the Mooi system that was included to model the Mooi-Mgeni transfer before the system was modified to utilise an inflow time series from the Mooi-Mgeni system model).
- Jana
- Spioenkop
- Mielietuin
- Wagendrift

Operation of the system model upstream of Spioenkop Dam was thoroughly tested during the interim study. This part of the system model is particularly sensitive to changes in penalties because of the operation of the diversion channel used to simulate diversion of water to downstream of Driel Barrage. To ensure that water, other than spills, is not supplied to downstream users a penalty of 2500 was placed on the general flow channel into Spioenkop Dam. At this stage of model development, IFR A was specified at a level at which

Spioenkop Dam could comfortably supply the IFR. Accordingly, the upstream plug did not influence supply of the IFR.

Demands upstream of reservoirs were given penalties for under supply of the order of 1500 (with the exception of the urban demand on the Klip - DEM5 which was given a penalty 2510) because they would have first access to the water and it would be difficult to control abstractions. Demands along tributaries but downstream of reservoirs were given penalties for under supply in the range 1405 to 1450 so that their penalty would be higher than the cumulative penalty for supplying water through a series of IFR channels. Other demands (on the Thukela) were allocated penalties from 390 to 310. IFR channels were given a penalty of 350 (with the exception of IFR 3 that is discussed later). Penalties were set so that demands competing for the same water would not have the same penalty. Urban demands were allocated penalties first, with penalties decreasing downstream but always higher than 350. Irrigation penalties were set below 350. The penalty for under supply on the transfer channels from Mielietuin and Jana Dams was set to 310.

Reservoirs were set up with provision for seven storage zones. The value of water in the four central zones were however set equal so that reservoirs were effectively operated with four zones. The value of water in the dead storage zone and the cost of holding water above FSL were both set to 10000. The five working storage zones were divided into two groups. The value of water in the lower group was set high (of the order of 1400) so that the water would be available only to users along the tributary that could not be supplied from other storage in the system. This was done to avoid a tributary reservoir drawing empty because of supplying demands on the main Thukela River when they could have been supplied from other sources.

IFR 3 in the Bushmans river should have preferential access to the water stored in this tributary. Accordingly the penalty for under supply on the IFR channel must be high enough for water to be drawn from all zones in the reservoirs in the Bushmans river. This high penalty on the IFR channel will work well as long as cumulative penalties further downstream does not lead to preferential supply of downstream users via the IFR channels. To avoid this situation a penalty of 900 was placed on the general flow channel. downstream of the IFR channel. This penalty serves as a plug to prevent Thukela demands drawing water from Mielietuin through the IFR channel.

3.3 Implementation of third phase revisions

As work progressed using the second phase feasibility systems model to test the effect on yield of various IFR scenarios, it became apparent that further revisions would greatly enhance the performance of the model and the reliability of results. These third phase model revisions are described in what follows.

Implementation of the revisions described below and successful model verification resulted in the development of the final feasibility systems model shown in Drawing W5. A primary check was done on how demands are supplied and can be found in Appendix B.

3.3.1 Farm Dams

Many farm dams have been built in the tributaries of the Thukela River. Water stored in the farm dams is not available for downstream demands as these dams have no outlets and therefore can't release water. These dams are all fairly small but have a total cumulative storage of approximately $338x10^6m^3$ which is large enough to have a significant impact on water availability in the system. Therefore it is important to include as many of these dams in the model as possible. As they are small relative to the DWAF dams (e.g. Spioenkop Dam), a number of them can be lumped together such that a dummy farm dam modelled in the Thukela model represents storage in a number of smaller dams in reality. The total storage in dummy dams that was included in the system is approximately $240x10^6m^3$.

The storage provided in dummy dams ($240x10^6m^3$) versus the estimated cumulative storage in all farm dams in the catchment ($338x10^6m^3$) appears to be low at first sight. However, the storage not provided in the model (98 $x10^6m^3$) exists in a myriad of small dams scattered over the entire catchment which would make representing them by grouped or dummy dams unrealistic. It is therefore considered that the omission of this storage in the model would affect reported yields less than the distortions that would be introduced by additional dummy dams.

The original Mark 3 version of WRYM used in the interim study limited the number of dams that could be modelled in a system. Thus, at that stage, after modelling all the proposed and existing large dams, only two dummy farm dams could be included in the model. These were situated, on tributaries , one upstream of Woodstock Dam, and the other between Driel Barrage and Spioenkop Dam. Details of these dummy farm dams are given as farm dams 1 and 2 in Table 3.5.

The current Mark 5 version of WRYM allows a greater number of dams to be included in the system model. Five additional dummy farm dams were identified as being necessary to more realistically portray farm dam storage in the Thukela catchment, and were therefore included in the system model. The size and location of the five additional dummy farm dams is shown in Table 3.5 as dams 3 to 7.

Surface areas of farm dams were obtained from satellite imagery and inspection of 1: 50 000 topographical maps. Volumes were then determined by multiplying the areas by an average depth depending on which tertiary catchment they were in. Average depths were obtained from the dam safety register database. This average depth ranged from 2.4 m for certain quaternaries in the V2 secondary catchment to 3.7 m for the V1, V4, V5, V6 and V7 secondary catchments. The 1:50 000 topographical maps were used to determine the catchment areas commanded by farm dams.

The storage capacity of each dummy farm dam (representing the total storage of a number of lumped farm dams) can be found in Table 3.5, and the storage-elevation-area curves and data used for each dummy farm dam can be found in Appendix C.

Table 3.5 : Total storage capacity and location of system model dams representing lumped farm dams

Farm Dam	Location	Total Storage Capacity (10^6 m^3)
1	Upstream of Woodstock Dam	14.4
2	Between Driel barrage and Spioenkop Dam	32.38
3	Upper reaches of the Little Tugela river	36.16
4	Upper reaches of the Klip river	48.86
5	Between the confluence of the Klip with the Thukela rivers, and Jana Dam, but not on the Thukela river	41.75
6	Upper reaches of the Sundays river	28.19
7	Between V3 and Rork irrigation of the Buffels river, but not on the Buffels river	38.18
	Total	240.19

The five additional dummy farm dams (dams 3 to 7 in Table 3.5) were incorporated into the model at nodes where catchment runoff enters the system. However, not all of the catchment runoff at these nodes flows into the farm dams. Thus catchment runoffs were split between the dummy farm dams and the original inflow nodes in the ratios shown in
Table 3.6. These ratios were based on the total catchment area commanded by farm dams divided by the total catchment area i.e. it was assumed that the percentage runoff is the same as the percentage of catchment area commanded by the farm dams.

Table 3.6 : Split of catchment runoff between original node and additional dummy farm dams

Farm Dam	Runoff File	Percentage of Runoff Flowing Into Farm Dam	Percentage of Runoff Flowing Into Original Node
3	TM08	16%	84%
4	TM11	16%	84%
5	TM10	15%	85%
6	TM14	30%	70%
7	TM28	13%	87%

The farm dams supply some of the irrigation demands. Water in farm dams is not available to downstream demands as the farm dams do not have outlet structures. The penalty structures established for the dummy farm dams were therefore set to enforce this restriction.

This effectively means that the catchment runoff that flows into the system is reduced by the amount of runoff that gets stored in the dummy farm dams. This impacts on transferable yield from Jana in two ways:

1. Storage of catchment runoff in farm dams upstream of Jana Dam reduces flow into Jana Dam; and
2. Storage of catchment runoff in farm dams downstream of Jana Dam reduces the amount of water available for demands downstream of Jana Dam, requiring Jana Dam to make up the shortfall in supply to these demands.

Both of these factors result in a decrease in transferable yield from Jana Dam.

3.3.2 Irrigation Demands

In times of drought, supply to irrigators will be restricted before restrictions are applied to any other users. To cater for the low assurance of supply to irrigators, it was agreed to reduce average irrigation demands, for the purpose of modelling, to 75 percent of the full demand.

One method of modelling irrigation demands in WRYM is by means of an input file with extension .irr. These irrigation demands can only be modelled at nodes with catchment runoff inflows, and their file names must be the same as that of the runoff inflow file at that node. This type of irrigation demand file contains the demand for every month of the simulation for that specific irrigation demand. Afforestation demands are modelled in the same way, with a file extension .aff. The model calculates net monthly inflow at those nodes by subtracting the afforestation and irrigation demands from the catchment runoff for each month in the simulation. A methodology for ensuring that net inflows remain positive or zero is presented in section 4.3 of this report. The method involves changing the irrigation demand (in the irrigation demand file) in those months with negative net inflow so that net inflow is zero.

For the purposes of this task, the original, and not the changed, irrigation demand files were adjusted. The new irrigation demand files were created simply by multiplying the original monthly demands by a factor of 0.75.

Irrigation can also be modelled using a prescribed demand channel. Each prescribed demand channel has an associated file with monthly demands.

The monthly demands in these files were multiplied by a factor of 0.75 to allow for reduced supply to irrigators.

Where irrigation demand can be supplied from more than one inflow source the .irr files cannot be used. The prescribed demand channel utilises similar time series files. Thus to enable the variation in irrigation requirement to be preserved, prescribed demand channels were selected to model irrigation usage. However, because of WRYM constraints, in the interim study all irrigation demands could not be modelled using prescribed demand channels and the surplus were modelled using min-max channels with average monthly irrigation requirements. In the Mark 5 Version of WRYM, the maximum permissible number of prescribed demand channels has been increased and all irrigation demands were changed to prescribed demand channels.

Where an irrigation demand was partially supplied by a new farm dam (see section 3.3.1), supply of the irrigation demand was split between the farm dam and the original node inflow, but not in the same ratio that the inflow was split. The split was determined by dividing the ratio of the area irrigated by farm dams by the total irrigated area. The area irrigated from farm dams was determined by inspection of 1:50 000 topographical maps and is therefore an approximation. The affected demands, as named in the final feasibility system model shown in Figure 3.4, are as follows:

- TM0875 split into TM0875A (27% - supply from farm dams) and TM0875B (73% - supply from run of river)
- TM1175 split into TM1175A (34% - supply from farm dams) and TM1175B (66% - supply from run of river)
- Klip75 split into Klip75A (18% - supply from farm dams) and Klip75B (82% - supply from run of river)
- TM1475 and Mungu75 combined, and then split into TM14_MUN (37.1% - supply from farm dams), TM1475B (42.2% - supply from run of river) and Mungu75B (20.7% - supply from run of river)
- V375 and Rork75 combined, and then split into V375B (57% - supply from run of river), V3_Rork (16% - supply from farm dams) and Rork75B (27% - supply from run of river).

Demands that were to be supplied from farm dams were given penalties such that they would have access to the water in the farm dam.

Table 3.7 lists the irrigation demands, their reduced average requirements and their full requirements.

Table 3.7 : Comparison of projected 2030 full irrigation demands and average demands taking a more realistic level of assurance of supply into account (based on a 75 year time series)

Demand Name	Average Demand 75% of full demand (m^3/s)	Full Demand (m^3/s)
TM0275	0.053	0.071
Thwood75	0.119	0.158
Thdrie75	0.056	0.075
Thskop75	1.068	1.424
TM0675	0.265	0.353
Thskds75	0.095	0.127
TM08		0.432[1]
TM0875A	0.087[1]	
TM0875B	0.237[1]	
Thltug75	0.728	0.971
TM11		0.458[2]
TM1175A	0.117[2]	
TM1175B	0.227[2]	
Klip		0.893[3]
Klip75B	0.549[3]	
Klip75A	0.121[3]	
Tm1275	0.051	0.067
TM14		0.620[4]
TM14_MUN	0.237[4]	
TM1475B	0.270[4]	
Mungu75		0.231[4]
Mungu75B	0.132[4]	
Wag75	0.040	0.054
Lochs75	0.379	0.505
Mgwen75	0.561	0.748
Non75	0.143	0.191
TM2475	0.205	0.274
Cheld75	0.059	0.079
TM2675	0.073	0.098
Zaaid75	0.241	0.322
V375B	0.570[5]	0.775[5]
V3_Rork	0.159[5]	
Rork75		0.562[5]
Rork75B	0.274[5]	
Mhlathuze	0.443	0.590
Mand75	0.352	0.470

[1] TM08 split into TM0875A (27%) and TM0875B (73%)

[2] TM11 split into TM1175A (34%) and TM1175B (66%)

[3] Klip split into Klip75A (18%) and Klip75B (82%)

[4] TM14 and Mungu75 combined and then split into TM14_MUN (37.1%), TM1475B (42.2%) and Mungu5B (20.7%)

[5] V3 and Rork75 combined and then split into V375B (57%), V3_Rork (16%) and Rork75B (27%).

The obvious effect of reducing the irrigation demands would be to increase transferable yield from Jana Dam.

3.3.3 Mooi River System

In keeping with the rest of the Thukela model, the Mooi river tributary was not modelled in great detail in the interim study model. The Mooi river is however, modelled in great detail in the Mooi-Mgeni model developed for the Mgeni river augmentation planning study. It was decided to incorporate the more detailed Mooi sub-system in the Thukela model for consistency between the two studies.

It was, however, not possible to include the whole of the Mooi river sub-system from the Mooi-Mgeni model into the Thukela river model due to constraints on the number of model elements allowed by the WRYM software. Accordingly the Mooi-Mgeni model was run to obtain an outflow file from the Mooi river, that could be used as an inflow for the Thukela river. This inflow file replaced the Mooi river sub-system in the Thukela model.

Hydrological data used in the Mooi-Mgeni model was limited to the period 1925 to 1995. This limits output data, including the Mooi river outflow file, to the same period. The original Thukela feasibility model used data from 1920 to 1994. WRYM does not permit time series in data files to be of different durations or periods in the model. Data files for the Thukela model were therefore shortened to accommodate the Mooi river inflow file. Thus all hydrological, input and demand time series were reduced to the period 1925 to 1994.

The Mooi-Mgeni model has demand data for 1995 and 2040. It is expected that the area will be fully developed by 2010, allowing the 2040 scenario to represent all post-2010 scenarios. Two Mooi river outflow files were generated by running the Mooi-Mgeni system – one each for the 1995 and 2040 scenarios. The 1995 scenario flow file would be used for the Thukela present-day analyses, and the 2040 scenario flow file would be used for the Thukela 2010, 2020, and 2030 analyses of the Thukela catchment.

Using the inflow file for the Mooi river, obtained from the Ninham Shand Mooi-Mgeni model, and all the associated alterations in the Thukela model was found to have no effect on transferable yield from Jana Dam. The two flow files can be found in Appendix D.

3.3.4 Zaaihoek Hydrology

The hydrology for the Zaaihoek Dam area was revised to incorporate flow based on records for Zaaihoek Dam not previously available. Less reliable streamflow gauges downstream of Zaaihoek Dam were previously used.

The revision of the hydrology resulted in catchment runoff for two inflow nodes being revised – TM26 and TM31, upstream and downstream of Zaaihoek Dam respectively. New inflow files for these two catchments were generated. The mean annual runoffs for the revised inflow time series are lower than for the original inflow time series as shown in Table 3.8.

Table 3.8: Revised and original Zaaihoek hydrology for the period 1925 to 1994

Catchment name	Revised MAR (10^6 m^3/a)	Original MAR (10^6 m^3/a)
TM26	97.1	115.1
TM31	140.8	160.8

Analysis using the revised inflow time series resulted in a reduction in transferable yield from Jana Dam.

The Zaaihoek Dam transfer to Majuba Power Station was also reduced (see Table 3.9) in keeping with the most recent available data from Eskom (refer to Draft report from BKS (1999)“Annual Operating Analysis for the Total Integrated Vaal River System (1999/2000)”).

Table 3.9 : Revised and original Majuba demand (Zaaihoek transfer)

Year	Revised Demand ($10^6m^3/a$)	Original Demand ($10^6m^3/a$)
1995	0.060	1.99
2010	16.708	47.34
2020	18.582	47.34
2030	27.543	47.34

The lower Majuba transfer resulted in an increase in transferable yield from Jana Dam, but this is more than offset by the revised hydrology. The net effect is a reduction in yield from Jana Dam.

3.3.5 Buffalo Urban Demands

The combined projected urban demand from Newcastle, Madedeni and Osizweni in the Buffalo Catchment was considered too high and therefore adjusted according to recent data (see Table 3.9). This is by far the largest urban demand (mainly for Newcastle) and was revised following graphical analysis of recent (and post interim) trends in water use. The other urban demands were also reviewed but found to be acceptable.

Table 3.10 : Revised original projected urban demand from Newcastle, Modedeni and Osizweni

Year	Revised Demand ($10^6 m^3/a$)	Original Demand ($10^6 m^3/a$)
1995	22.69	27.43
2010	42.92	64.98
2020	61.79	102.37
2030	95.68	151.19

The decrease in this demand results in an increase in transferable yield from Jana Dam.

3.3.6 Uitkyk and Buffelshoek Dams

The original TOR for the feasibility study of the TWP focussed on developing the southern tributaries of the Thukela river. The client would review development of the northern tributaries as a separate assignment. As the northern tributaries would in any event have to be developed in the future to meet the growing demands in their catchments, it would be unreasonable to assume that the TWP scheme would supply demands in these tributaries in the long term. Therefore the greater Thukela river catchment should be analysed as a whole instead of different teams analysing different components separately. It was therefore decided that proposed future developments of the northern tributaries would be incorporated into the Thukela river model.

Uitkyk and Buffelshoek Dams were included as dummy dams in the Sundays and Buffalo rivers respectively. Both dams are situated on the reach of river between the most downstream demands on the river and its confluence with the Thukela river. The storage-elevation-area curves and data for these two dams can be found in Appendix E.

IFR's were included on the section of river downstream of each dam. IFR data was obtained from the IFR team at a workshop held in November 1998. IFR curves and data for both dams can be found in Appendix F.

Including these two dams together with their IFR's in the system increased transferable yield from Jana Dam by almost 47 million m^3/a. It must be borne in mind that this increase in transferable yield is wholly dependent on the development of the Uitkyk and Buffelshoek Dams and implementation of the IFR's for the Sundays and Buffalo rivers. Should development of these dams be delayed, transferable yield from Jana Dam may have to be decreased until such time as they are built.

3.4 Miscellaneous System Changes

The following miscellaneous changes were found to be necessary:

3.4.1 System Renumbering

Numbering of elements in the second phase feasibility model became haphazard due to additions and alterations to the model. When adding a new element into a haphazardly numbered system, it is easy to assign the new element a number that is already used for an existing element. This will result in errors in the output when the model is run. These errors are difficult to detect, and can significantly distort results.

Nodes and channels in the model were therefore renumbered in a logical order to facilitate easy location of model elements. The model was run after renumbering to ensure that output was consistent with that obtained before the renumbering.

3.4.2 Ladysmith Demand

In keeping with the report titled “An evaluation of alternative sources of water for the Ladysmith/Emnambathi area – Executive summary” (report number PB V000-00-6099), it was decided to incorporate in the model an existing pipeline supply to Ladysmith from Spioenkop Dam with a capacity of 0.25 m^3/s. The original Ladysmith demand in the model, abstracting water from the Thukela river at the point where the Klip river flows into the Thukela river, was decreased by the same amount. The Ladysmith demand abstracting water from Spioenkop Dam is supplied in preference to the existing Drakensberg scheme and other in-basin demands i.e. it is permitted to draw water from Woodstock Dam if the need arises.

3.4.3 Revised Instream Flow Requirements

Qedusizi Dam is a flood attenuation and not a storage dam, and it was excluded from the original feasibility model. IFR B site is located just downstream of Qedusizi Dam in the original feasibility model, and therefore there was no storage from which it could draw water. For this reason, IFR B was removed from the final feasibility model.

IFR 2 and IFR 5 flows were revised at the November 1998 IFR workshop, to take account of refined hydraulics and a re-evaluation of the period of daily record used for IFR 5. A new IFR A was generated at the same workshop to replace the IFR A used in the original feasibility model.

IFR A is discussed in detail in the report entitled “Water Resources Evaluation” (Report No. PBV000-00-5999). It is important to note that the IFR determined at the workshop resulted in a change in operation of the system. IFR A is now able to draw on Driel Barrage and Woodstock Dam in preference to all else in the system including the existing Drakensberg Transfer.

The rating curve for the IFR 2 site was re-evaluated and found to be inaccurate at higher discharges. Using the revised rating curve, flood discharges for the IFR were adjusted. The impact of this change to the IFR is negligible.

IFR 5 flows obtained from the IFR team in July 1998 were based on the daily flows for the period 1951 to 1993. However, after 1971 the record is not stationary due to the construction of Spioenkop Dam and the IFR flows generated using the 1951 to 1993 record would be affected by the non-stationarity. The period 1951 to 1971, however, does not include adequate periods of low flow and this would result in the IFR flows being too high. Including the period 1972 to 1981 gives a more representative range of high and low flows. Thus, even though Spioenkop Dam affects flow at IFR 5 after 1971, the daily flows from 1951 to 1981 were used to generate the IFR flow time series. The revised IFR 5 is significantly higher than the July 1998 IFR 5. With the revised IFR the yield from Jana Dam is reduced by about $12x10^6m^3/a$.

The EFR was also revised. The modified requirement was issued by the EFR team on the 19 July 1999. The small changes affected drought and maintenance flows in a few of the months only and resulted in no impact on transferable yield from Jana Dam.

In the original feasibility study model, all IFR’s were modelled using nine data points, and the EFR was modelled using four data points. These points were chosen at different percentage probabilities of exceedence for each IFR. The number of points defining the IFR’s and the EFR in the data has been increased to 12, and the percentage probabilities of exceedence have been standardised for all IFR’s and the EFR. The 12 data points include two points for 100 percent probability of exceedence, and one point each for 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 percent probability of exceedence.

The original IFR and EFR curves used to determine the data points used in the model were revised according to alterations made at the workshop, and data files updated. The new curves and data for the IFR’s and the EFR can be found in Appendix G.

3.4.4 Elevation-Area-Storage Data Revision

DWAF revised the elevation-area-storage data for Mielietuin and Jana Dams.

The new data for Jana Dam were very similar to the original data, and differences in output using the new and old data are negligible. The new elevation-area-storage curves and data for Jana can be found in Appendix H.

Accurate topographical surveys at the Jana site are available only up to 870 masl (the limit of the aerial photography). Values for storage and area above an elevation of 870 masl were extrapolated using available data. If a dam at Jana in excess of 870 masl is ever recommended, the survey will have to be extended to above this contour to obtain more accurate estimates of the storage and surface area.

The new elevation-area-storage curves and data for Mielietuin Dam can be found in Appendix H. The new Mielietuin Dam data are considerably different to the original data, and result in a reduction in assessed transferable yield from Mielietuin Dam for the full range of FSL's. Table 3.11 shows transferable yield from Mielietuin Dam using the revised and original elevation-area-storage data for a range of full supply levels.

Table 3.11 : Transferable Yield From Mielietuin Dam Using Original and Revised Elevation-Area-Storage Data

Full Supply Level (masl)	Original Elevation Area-Storage Transferable Yield ($10^6 m^3/a$)	Revised Elevation-Area-Storage Transferable Yield ($10^6 m^3/a$)
985	65	50
1005	108	97
1025	139	129
1039	149	146

3.4.5 General Changes

Reservoir Full Supply Levels

As full supply levels for proposed dams have not been finalised, realistic levels within the ranges being considered by the designers were selected and retained for analyses to ensure that results remained comparable. These full supply levels are by no means set and probably will be altered in the future.

Jana Dam was modelled in the pre-feasibility study with a full supply level of 846 masl. This was changed to a full supply level of 860 masl (storage of 1482.6 x 10^6 m^3). At this full supply level for Jana, total storage upstream of Jana is approximately 1.5 MAR (includes storage in Woodstock, Driel and Spioenkop reservoirs).

Mielietuin Dam was originally modelled with a full supply level of 1033 masl (storage of 335 x 10^6 m^3). It was changed to a full supply level of 1015 masl corresponding to a total storage in Mielietuin and Wagendrift of 1.4 times the MAR at Mielietuin.

The source of supply to urban/rural demand and non irrigation demands in the Klip river catchment was moved from the Thukela River to a dummy dam at Uitkyk in the Sundays River. The required storage in Uitkyk Dam to supply these demands was determined as 166.5 x $10^6 m^3$. Assuming a dead storage level of 815 masl the full supply level to provide this storage is 860 masl.

Penalties

All IFR/EFR penalties with the exception of IFR A, were changed to 1650 to ensure that IFR's/EFR are supplied first in the system. The penalty for IFR A is 2655, allowing it to draw water from Woodstock Dam and Driel Barrage.

The penalty placed on the Bushmans River just upstream of its confluence with the Thukela River to prevent downstream demands from drawing on the water in Mielietuin and Wagendrift Dams was changed from 2500 to 900. This means that supply to the IFR occurs unimpeded, and is not blocked as was occurring when the downstream channel penalty was higher than the penalty for under supply of the IFR. This ensures that the maximum possible Mielietuin transfer, for a particular size of Mielietuin Dam, is maintained.

A penalty was placed on the Sundays river just upstream of its confluence with the Thukela river to ensure that downstream demands first draw their water from the Buffalo river and Jana Dam before drawing water from the Sundays river. An existing penalty downstream of Jana Dam ensures that demands first draw on the Buffalo river.

The penalties for Thwood75.ird and for Dem2 were found to be the same. As it is possible for them to compete for water, it was decided to change the penalty for Thwood75.ird from 159 to 158.

Buffer Levels

A buffer level was included in Woodstock Dam at 1156 masl (18 m above DSL with approximately 50 x 10^6 m^3 storage) to reserve water for IFR A, the Ladysmith demand abstracting from Spioenkop Dam, and demands between Woodstock and Spioenkop Dams so that they would be supplied over the entire simulation period. The Drakensberg Transfer Scheme penalty was set so that water from the buffer zone would not be available. This buffer level is specific to the IFR A determined at the workshop in November 1998, and the scenario where IFR A can draw water from Woodstock Dam.

4 REVIEW OF MODEL INPUT DATA

All the primary model input data, compiled during the TVTS pre-feasibility and interim studies, were reviewed and if necessary extended and/or updated during the feasibility study. The various data sets are discussed in what follows.

4.1 Streamflow data

The TVTS interim study consultants undertook detailed assessments of runoff from the Thukela basin, summarised in DWAF Report No. PC 000/00/12894 & PV 000/00/0894 “Tugela-Vaal Transfer Scheme – Streamflow Hydrology : Volumes 1 & 2”, September 1994. For the system analysis the Thukela basin was divided into 32 sub-catchments, for each of which naturalised time series of runoff were generated by the rainfall-runoff model WRSM90, with model parameters obtained from the above-mentioned report.

Subsequently as part of the Vaal System Analysis Update study the natural streamflow database for the Thukela Basin was extended by two years, viz. from September 1993 to September 1995, which is just before the nineties drought was broken. These two additional years were neither exceptionally dry nor wet, so the effect on long-term MAR (i.e. 1920 to 1994 hydro years) was minimal. Total MAR was reduced from 3865 to 3837 x 10^6m^3 – a reduction of about 0.7%. Details of the runoff time series are presented in Table 4.1. The full time series are listed in Appendix I.

Table 4.1 : Sub-catchment runoff time series used in first and second phase system analysis (based on a 75 year time series)

Catchment Name	Natural MAR (10^6m^3)	Quaternary catchments (and portions thereof)
TM01	73.63	0.17*(V11A+V11B+V11C+V11D+V11E)
TM02	359.50	0.83*(V11A+V11B+V11C+V11D+V11E)
TM03	19.43	0.27*V11H+0.42*V11J
TM04	219.40	V11G+0.73*V11H
TM05	88.34	0.74*(V11F+0.58*V11J+V11K+V11L)
TM06	31.01	0.26*(V11F+0.58*V11J+V11K+V11L)
TM07	15.69	0.161*(V11M+0.19*V12F+V12G+0.05*V13E+V14A+V14B+0.13*V14E)
TM08	305.54	V13A+V13B+V13C+V13D+0.95*V13E
TM09	7.10	0.32*V70G
TM10	91.60	0.839*(V11M+0.19*V12F+V12G+0.05*V13E+V14A+V14B+0.13*V14E)+0.43*V14E
TM11	231.30	V12A+V12B+V12C+V12D+V12E+0.81*V12F
TM12	37.27	V14C+0.47*V14D
TM13	20.05	0.65*V70D

Catchment Name	Natural MAR ($10^6 m^3$)	Quaternary catchments (and portions thereof)
TM14	85.52	V60A+V60B

Table 4.1 (Continued)

Catchment Name	Natural MAR ($10^6 m^3$)	Quaternary catchments (and portions thereof)
TM15	114.78	V60C+V60D+V60E+0.35*V60F
TM16	83.12	0.53*V14D+0.44*V14E+0.65*V60F+0.60*V60G+0.17*V70F+0.68 *V70G
TM17	33.55	0.35*V70D+V70E+0.83*V70F
TM18	26.25	0.49*V70C
TM19	207.10	V70A+V70B+0.51*V70C
TM20	98.85	V20B+V20C+0.01*V20D
TM21	81.68	0.77*V20A
TM22	100.43	0.23*V20A+0.99*V20D+0.74*V20E
TM23	23.62	V20F
TM24	110.83	V31E
TM25	140.39	V31F+V31G+V31H+V31J+V31K
TM26	117.68	V31A
TM27	164.72	V32A+V32B+V32C+V32D
TM28	224.61	V32E+V32F+V32G+V32H+V33A+V33B+0.16*V33C
TM29	197.53	0.26*V20E+V20G+V20H+V20J+0.40*V60G+V60H+0.71*V60J+0.84*V33C+V33D+0.15*V40A+0.29*V60J+V60K
TM30	196.31	V50A+V50B+V50C+V50D
TM31	168.16	V31B+V31C+V31D
TM32	161.74	0.85*V40A+V40B+V40C+V40D+V40E
TOTAL	3836.73	

Third phase revisions included decreasing the length of the time series from 75 years (1920-1994) to 70 years (1925-1994). The hydrology for TM26.INC and TM31.INC was revised (section 3.3.4). The revised MAR's are presented in Table 4.2. The revised full time series for TM26 and TM31 can also be found in Appendix I.

Table 4.2 : Sub-catchment runoff time series used in third phase analysis (based on 70 year time series)

Catchment name	Natural MAR ($10^6 m^3$)
TM01.INC	73.24
TM02.INC	357.59
TM03.INC	19.24
TM04.INC	217.90
TM05.INC	87.40
TM06.INC	30.68
TM07.INC	15.07
TM08.INC	300.83
TM09.INC	6.77
TM10.INC	87.95
TM11.INC	226.63

Catchment name	Natural MAR ($10^6 m^3$)
TM12.INC	35.33
TM13.INC	19.63
TM14.INC	82.84
TM15.INC	110.47

Table 4.2 : (Continued)

TM16.INC	79.82
TM17.INC	32.42
TM18.INC	25.64
TM19.INC	203.75
TM20.INC	96.97
TM21.INC	80.38
TM22.INC	97.76
TM23.INC	23.11
TM24.INC	106.97
TM25.INC	133.88
TM26.inc	97.07
TM27.INC	151.21
TM28.INC	214.14
TM29.INC	191.50
TM30.INC	195.54
TM31.INC	140.78
TM32.INC	157.91
Total	3700.42

4.2 Afforestation water usage (including dryland sugar cane)

Afforestation water use was calculated for each sub-catchment by subtracting, from the streamflow time series generated by WRSM90 with zero afforestation area, the corresponding time series with afforestation included. Areas planted to dryland sugar cane were treated as afforested on the assumption that the effect on runoff would be similar.

Details of afforestation water usage are summarised in Table 4.3. As is the case for the streamflow time series, the addition of 1993 and 1994 hydro years has very little impact on the long – term means. The full time series are listed in Appendix J.

Table 4.3 : Average annual afforestation and dryland sugar cane water use used in first and second phase analyses (based on 75 year time series)

Catchment Name	Afforestation and dryland sugar cane usage for 2030 ($10^6m^3/a$)
TM01	0
TM02	0
TM03	0
TM04	2.85
TM05	0
TM06	0
TM07	0
TM08	0
TM09	0
TM10	0
TM11	0
TM12	5.98
TM13	5.28
TM14	0
TM15	0
TM16	0
TM17	0
TM18	4.88
TM19	0
TM20	0.94
TM21	0
TM22	1.22
TM23	4.47
TM24	2.04
TM25	4.90
TM26	0
TM27	6.51
TM28	6.54
TM29	2.54
TM30	2.92
TM31	5.38
TM32	2.87
TOTAL	59.32

Table 4.4 : Average annual afforestation and dryland sugar cane water used in third phase analysis (based on 70 year time series)

Catchment Name	Afforestation and dryland sugar usage ($10^6m^3/a$)	
	1995	2030
TM01.AFF	0	0
TM02.AFF	0	0
TM03.AFF	0	0
TM04.AFF	1.19	2.86
TM05.AFF	0	0
TM06.AFF	0	0
TM07.AFF	0	0
TM08.AFF	0	0
TM09.AFF	0	0
TM10.AFF	0	0
TM11.AFF	0	0
TM12.AFF	3.08	5.89
TM13.AFF	2.89	5.23
TM14.AFF	0	0
TM15.AFF	0	0
TM16.AFF	0	0
TM17.AFF	0	0
TM18.AFF	2.66	4.80

Table 4.4 : (Continued)

Catchment Name	Afforestation and dryland sugar usage ($10^6 m^3/a$)	
	1995	2030
TM19.AFF	0	0
TM20.AFF	0.54	0.94
TM21.AFF	0	0
TM22.AFF	0.67	1.20
TM23.AFF	2.57	4.46
TM24.AFF	0.34	2.00
TM25.AFF	0.84	4.86
TM26.AFF	0	0
TM27.AFF	1.74	6.38
TM28.AFF	1.74	6.38
TM29.AFF	1.46	2.54
TM30.AFF	2.54	2.94
TM31.AFF	0.95	5.41
TM32.AFF	2.47	2.87
Total	25.69	58.78

4.3 Irrigation demand

The WRSM90 model was used to generate, for each sub-catchment, monthly time series of irrigation demand based on average monthly evapotranspiration, historical rainfall and area under irrigation. The results indicated slightly lower average annual demands than were reflected in the interim demands report (DWAF Report No. PC 000/00/12894 & PV 000/00/0894 “Tugela Transfer Scheme – Water Demands”, September 1994), in which it was assumed that the irrigation requirement was constant for all the years.

After the time series of natural streamflow, afforestation and irrigation demands were generated it was necessary to check the irrigation demands as expressed in the .irr files against the availability of water. This was done by first subtracting the afforestation usage from the natural streamflow and then comparing the adjusted flows with the irrigation demands. If, in any month, the demand exceeded the inflow it was set equal to the inflow. The adjusted irrigation time series thus reflect irrigation *usage*, rather than irrigation *demand*. These adjustments were deemed necessary to provide appropriate input to WRYM for modelling the IFR releases.

Table 4.5 contains a summary of irrigation usage in each sub-catchment. Two types of time series based irrigation demand were used in the WRYM model. Demand names with a .IRR extension have no penalties as they are situated upstream of any dams and rely solely on run-of-river. Demand names with a .IRD extension have a penalty structure so that the supply can be curtailed in times of shortage. Also shown in the table are details of where the demands have been adjusted to reflect actual usage. The adjusted figures are shown in brackets.

Table 4.5 : First and second phase mean annual irrigation demands – based on 75 year time series (full development assumed by 2010)

Demand	Annual demand ($10^6 m^3/a$	
Name	1995	2030
HARL.IRD	5.50	7.57
CHELD.IRD	1.76	2.58
KLIP.IRD	17.78	28.18
LOCHS.IRD	10.32	15.95
MAND.IRD	6.32	14.82
MEARNS.IRD	3.37	4.65
MFUN.IRD	27.38	39.94
MHL.IRD	6.00	18.63
MNGENYA.IRD	15.27	23.6
MUNGU.IRD	4.15	7.29
NON.IRD	3.73	6.04
RORK.IRD	9.46	17.72
THDRIEL.IRD	1.87	2.35
THLTUG.IRD	26.45	30.65
THSKOP.IRD	35.73	44.93
THSKOPDS.IRD	3.19	4.01
THWOOD.IRD	3.97	5.00
TM02.IRD	1.78	2.24
TM06.IRD	9.00	11.14
TM08.IRD	11.75	13.63
TM14.IRR	11.14	19.56 (12.56)
TM11.IRR	7.36	14.46 (13.02)
TM20.IRR	3.47	5.06 (4.79)
TM21.IRR	0.43	0.62
TM23.IRR	0.29	0.42 (0.41)
TM24.IRR	6.09	8.64 (7.12)
TM26.IRR	2.17	3.08 (2.30)
TM12.IRD	1.35	2.13
V3.IRD	13.39	24.47
WAG.IRD	1.10	1.70
ZAAID.I.IRD	7.16	10.16
GRAND TOTAL	258.73	391.22 (380.20)

Third phase revisions, detailed in section 3.3.2, included:

- Changing all irrigation demands to time series demands with a .IRD extension. The original, and not adjusted, .IRR files were used for this.
- The irrigation demands were reduced by 25%.
- Some irrigation demands were split due to the inclusion of farm dams.

The first 5 years of each record was removed to comply with the Mooi-Mgeni hydrology. Irrigation demands in the Mooi river sub-catchment were removed due to the use of a single outflow file from the Mooi-Mgeni model (section 3.3.3.).

The resultant third phase mean annual irrigation demands are presented in Table 4.6. The full time series of third phase irrigation usage are listed in Appendix K.

Table 4.6 : Third phase mean annual irrigation demands (full development assumed by 2010) (based on a 70 year time series)

Irrigation demand name	Annual demand ($10^6 m^3$)	
	1995	2030
CHELD75.IRD	1.28	1.88
KLIP75A.IRD	2.40	3.80
KLIP75B.IRD	10.94	17.33
LOCHS75.IRD	7.79	12.02
MAND75.IRD	4.70	11.03
MHL75.IRD	4.49	13.94
MNGWEN75.IRD	11.51	17.80
MUNGU75B.IRD	2.38	4.18
NON75.IRD	2.81	4.54
RORK75B.IRD	4.64	8.70
THDRIE75.IRD	1.40	1.76
THLTUG75.IRD	19.85	23.00
THSKDS75.IRD	2.40	3.01
THSKOP75.IRD	26.81	33.71
THWOOD75.IRD	2.96	3.73
TM0275.IRD	1.32	1.67
TM0675.IRD	6.76	8.35
TM0875A.IRD	2.38	2.76
TM0875B.IRD	6.44	7.48
TM1175A.IRD	2.09	3.70
TM1175B.IRD	4.07	7.19
TM1275.IRD	1.02	1.60
TM1475B.IRD	7.57	8.53
TM14_MUN.IRD	6.23	7.49
TM2475.IRD	5.58	6.53
TM2675.IRD	2.16	2.29
V375B.IRD	9.89	18.06
V3_RORK.IRD	2.70	5.05
WAG75.IRD	0.83	1.28
ZAAID75.IRD	5.38	7.62
Total	170.77*	250.03*

*These totals are less than 75% of the total in Table 4.5 as the irrigation in the Mooi river catchment has been left out of the third phase and therefore this table.

4.4 Urban, rural and industrial demands

Table 4.7 lists, for each sub-catchment, the urban, rural and industrial demands for various time horizons up to the year 2030. These demands were taken directly from the interim report on demands.

Table 4.7 : Average annual urban, rural and industrial water demands (first and second phase)

Demand Name	Demand Type	Annual demand ($10^6 m^3/a$)				Description
		1995	2010	2020	2030	
DEM1	Urban	0.23	2.37	4.29	4.39	Bergville, Emmaus
DEM2	Rural	0.83	8.87	12.02	12.24	
DEM3	Urban	1.38	6.25	10.16	14.10	Ladysmith (part)
DEM4	Urban	6.23	28.15	45.19	62.77	Ezhakeni, Pieters industry
DEM5	Urban/rural	0.54	2.43	3.16	4.39	Driefontein, Peacetown
DEM6	Urban	0.54	9.63	14.23	14.55	Winterton, Loskop
DEM7	Urban/rural	0.89	1.96	2.78	3.50	Colenso, Nkanyezi
DEM8	Urban	0.32	0.88	1.17	1.61	Mooi river, Bruntville, Rosetta
DEM9	Rural	0.91	2.56	4.17	5.78	
DEM10	Urban	27.43	64.98	102.37	151.19	Newcastle, Madedeni, Osizweni
DEM11	Urban	5.26	8.77	12.56	23.32	Dundee, Glencoe, Utrecht
DEM12	Rural	2.83	12.18	21.46	32.63	
DEM13	Urban/ind.	9.85	12.81	19.28	25.25	Mandini etc.
DEM14	Urban/rural	7.05	20.58	32.69	46.33	Klipriver etc.
DEM15	Urban/ind.	2.27	6.628	10.26	14.52	Tugela Ferry
DEM16	Urban	22.11	24.93	28.81	35.19	Estcourt etc.
DEM17	Urban	1.48	1.67	3.79	4.61	Weenen, Noodkamp
DEM18	Urban/rural	2.66	3.00	3.95	4.83	Kwadamini, KwaMazel, Sobabili
DEM19	Urban	0.14	0.32	0.73	1.07	Wakkerstroom, Esizamelani
DEM20	Urban	1.04	2.46	4.20	6.22	Volksrust, Charlestown
DEM21	Urban/ind.	1.06	2.53	4.61	6.82	Durnacol, Dannhauser
TOTAL		95.05	223.93	341.86	475.31	

Dem 8 and Dem 9 were removed from the system with the inclusion of the outflow file from the Mooi-Mgeni model (section 3.3.3). The Buffalo urban demands were revised (section 3.3.5), and the Ladysmith demand was changed so that some of it was supplied from Spioenkop Dam (Section 3.4.2). The third phase demands are presented in Table 4.8.

Table 4.8 : Average annual urban, rural and industrial water demands (third phase)

Demand Name	Demand Type	Annual demand ($10^6 m^3/a$)				Description
		1995	2010	2020	2030	
DEM1	Urban	0.23	2.37	4.29	4.39	Bergville, Emmaus
DEM2	Rural	0.83	8.87	12.02	12.24	
DEM3	Urban	0.00	0.00	2.27	6.22	Ladysmith (part)
DEM3b	Urban	1.38	6.25	7.89	7.89	Ladysmith (drawing from Spioenkop Dam)
DEM4	Urban	6.23	28.15	45.19	62.77	Ezhakeni, Pieters industry
DEM5	Urban/rural	0.54	2.43	3.16	4.39	Driefontein, Peacetown
DEM6	Urban	0.54	9.63	14.23	14.55	Winterton, Loskop
DEM7	Urban/rural	0.89	1.96	2.78	3.50	Colenso, Nkanyezi
DEM10	Urban	22.69	42.92	61.79	95.68	Newcastle, Madedeni, Osizweni
DEM11	Urban	5.26	8.77	12.56	23.32	Dundee, Glencoe, Utrecht
DEM12	Rural	2.83	12.18	21.46	32.63	
DEM13	Urban/ind.	9.85	12.81	19.28	25.25	Mandini etc.
DEM14	Urban/rural	7.05	20.58	32.69	46.33	Klipriver etc.
DEM15	Urban/ind.	2.27	6.628	10.26	14.52	Tugela Ferry
DEM16	Urban	22.11	24.93	28.81	35.19	Estcourt etc.
DEM17	Urban	1.48	1.67	3.79	4.61	Weenen, Noodkamp
DEM18	Urban/rural	2.66	3.00	3.95	4.83	Kwadamini, KwaMazel, Sobabili
DEM19	Urban	0.14	0.32	0.73	1.07	Wakkerstroom, Esizamelani
DEM20	Urban	1.04	2.46	4.20	6.22	Volksrust, Charlestown
DEM21	Urban/ind.	1.06	2.53	4.61	6.82	Durnacol, Dannhauser
TOTAL		89.08	258.11	295.96	412.42	

4.5 Return flows

Return flows were not covered in the pre-feasibility report on demands, although data on return flows was assembled as part of the pre-feasibility study. The assembled data was used to estimate return flows as proportions of the water supplied. These proportions were applied to the projected demands presented in Table 4.7 to derive estimates of future return flows from the various urban centres. Table 4.9 lists average annual return flows for various time horizons.

Return flows from irrigation are usually of the order of 10 percent but were not included in the system analysis. This is because the irrigation demands, as calculated using WRSM90, are in effect net demands, i.e. gross supply less return flow.

Table 4.9 : Average annual return flows for all phases

Return flow name	Annual return flow ($10^6m^3/a$)				Description
	1995	2010	2020	2030	
MOOI[1]	0.16	0.43	0.58	0.77	Mooi river
LADY	3.15	14.22	22.20	30.57	Ladysmith
UTREC	0.74	1.23	1.73	2.24	Utrecht
DUND	1.77	2.95	4.55	5.87	Dundee
VOLKS	16.42	38.89	53.29	78.92	Newcastle, Volksrust
DURN	0.61	1.46	2.30	3.42	Durnacol
ESCRT	8.07	9.10	14.41	17.74	Estcourt
TOTAL	30.92	68.28	99.06	139.53	

[1] Not included in third phase feasibility system as this is in the Mooi river sub-catchment

4.6 Inter-basin transfers

There are two schemes which transfer water from the Thukela basin to the Vaal currently in operation, the Drakensberg pumped storage scheme and the Zaaihoek transfer scheme.

The larger of the two is the Drakensberg pumped storage hydro-electric scheme. Run-of-river flows are diverted from the upper tributaries of the Thukela and conveyed by gravity, at a peak rate of 4 m^3/s, to the main canal leading to Jagersrust pumping station, from where the water is pumped to Kilburn Dam, the lower reservoir of the pumped storage scheme. The major feed to Jagersrust pumping station is from Driel Barrage where water is pumped at a peak rate of $19m^3/s$ into the main feeder canal. Woodstock Dam provides the storage to regulate the flow into Driel. The peak pumping capacity of the Jagersrust pumping station is $23m^3/s$ but it is normally operated at a peak rate of $20m^3/s$. However, water is not always available for transfer at this peak rate and the theoretical average transfer rate, limited by availability, is estimated at 527 million m^3/a.

The smaller of the two schemes consist of the Zaaihoek Dam and pumping station located on the Slang river – an upper tributary of the Buffalo river. The main purpose of this scheme is to supply water to the Majuba power station. However, this power station is running well below capacity and using only a small fraction of the water it projected to use in the future. Surplus yield in the Zaaihoek Dam is therefore transferred to the eastern Vaal system via the Grootdraai Dam.

Water can also be diverted from the Mooi tributary for transfer to the Mgeni system. The Mooi-Mgeni emergency scheme was implemented during the 1983 drought and mothballed after the drought broke in 1984. The scheme has since been commissioned and can pump up to 4 m^3/s when available in the Mooi river. Proposals by Umgeni Water to provide storage in the Mooi

(Mearns Dam) to sustain an average transfer of 4 m^3/s to the Mgeni are being studied and implementation is expected in the near future.

The Middledrift transfer scheme transfers water from the Thukela river to Goedertrouw Dam in the Mhlatuze river at a rate of 34 million m^3/a to supply industrial and domestic users in Richards Bay. The scheme was implemented in the early 1990's and investigations are currently underway to investigate the feasibility of increasing the transfer rate. The systems analyses carried out as part of the Thukela Water Project assumed a maximum future transfer rate of 8m^3/s but it now appears unlikely that the transfer will escalate to this extent within the planning time frame of the Thukela Water Project.

The inter-basin transfers allowed for in the first and second phase system models are summarised in Table 4.10. It was assumed that the transfers would be operating at full capacity by 2010. This does not imply that no further transfer schemes can take place, but merely that the merits of any such proposals would have to be weighed against those of the proposals under consideration in this study.

Table 4.10 : Mean annual inter-basin transfers from the Thukela system (first and second phases)

Transfer Name	Transfer ($10^6m^3/a$)		Description
	1995	2010, 2020, 2030	
Thukela-Vaal	545.95	527.01	Existing Drakensberg transfer to Vaal
Zaaihoek	1.99	47	Existing Zaaihoek transfer to Vaal
Mooi-Mgeni	0.00	126	Proposed Mooi transfer to Mgeni
Mhlatuze	0.00	250	Proposed Middledrift transfer to Mhlatuze
TOTAL	633.14	1 057.18	

The third phase feasibility model does not include the Mooi-Mgeni transfer as this is part of the Mooi river system. The Zaaihoek transfer to Majuba power station was amended as explained in section 3.3.4. The inter basin transfers used in the third phase system model are presented in Table 4.11.

Table 4.11 : Mean annual inter-basin transfers from the Thukela system (third phase)

Transfer Name	Transfer ($10^6m^3/a$)				Description
	1995	2010	2020	2030	
Thukela-Vaal	545.95	527.01	527.01	527.01	Existing Drakensberg transfer to Vaal
Zaaihoek	1.89	16.708	18.582	27.543	Existing Zaaihoek transfer to Vaal
Mhlatuze	34.00	252.46	252.46	252.46	Proposed Middledrift transfer to Mhlatuze
TOTAL	633.14	900.318	902.192	911.153	

4.7 Instream and estuarine flow requirements

After workshops during 1997 and 1998, the teams of IFR and EFR specialists proposed environmental flow requirements at three sites in the Thukela River and at the estuary. These flow requirements were specified for maintenance and drought years and included both the base flow and flood recommendations for each calendar month. What was not clear from their reports is the frequency with which drought and maintenance flows should be provided. This information is required to prepare the IFR input data for WRYM.

Preliminary system modelling was done with IFR channels in the Thukela system to prepare output for comment by the IFR specialists at a meeting held in July 1998. To prepare the IFR input files it was assumed, after consultation with the EFR specialists, that drought flow would occur 10% of the time, the transition between drought and maintenance would be approximately 15% of the time and maintenance flows would occur or be exceeded the rest of the time. The percentage of time that maintenance flows would be exceeded was not defined in the input data for these preliminary analyses. Drought and maintenance flows used in these analyses are shown in Table 4.12. At that stage IFR's for sites A and B had not been defined.

Presentation of the WRYM model input data and results prompted the IFR specialist to offer the IFR requirements in the form of duration curves for each calendar month. The IFR duration curves were derived from IFR time series generated by running a specialist IFR model using the prescribed maintenance, drought and flood discharges as input. These curves were then matched with the reference node inflow duration curve to extract flows for the IFR data files. At the meeting in July 1998 the IFR requirements for sites A and B located downstream of Spioenkop Dam and Qedusizi Dam respectively were made available. The IFR information is included in Appendix L.

In November 1998 a workshop was held to determine the IFR requirement for the Thukela River downstream of Spioenkop dam. An IFR was no longer required for the Klip River downstream of Qedusizi Dam as the possibility of utilizing this flood attenuation dam for water supply had been discarded. At the workshop IFR's 2, 3 and 5 were also revised. The revised IFR information was supplied as flow duration curves. This information is included in Appendix G.

Table 4.12 : Environmental drought and maintenance flow requirements

Month	IFR 2 (m^3/s)		IFR 3 (m^3/s		IFR5 (m^3/s)		EFR (m^3/s)	
	Drought	Maint	Drought	Maint	Drought	Maint	Drought	Maint
October	1.3	3.0	0.5	1.0	1.9	4.3	2.0	5.0
November	2.0	5.0	0.8	1.8	3.1	7.7	5.0	10.0
December	3.0	7.0	1.0	2.2	4.6	10.7	10.0	10.0
January	3.5	8.0	1.2	2.5	5.6	12.8	10.0	10.0
February	4.0	9.0	1.3	3.0	6.4	15.3	10.0	10.0
March	3.5	8.0	1.2	2.5	5.6	13.0	5.0	5.0
April	3.0	7.0	0.9	2.0	4.4	10.2	2.0	5.0
May	2.0	5.0	0.7	1.5	2.8	7.3	1.0	2.0
June	1.5	3.5	0.5	1.0	2.0	5.0	1.0	2.0
July	1.0	2.5	0.4	0.7	1.4	3.6	1.0	2.0
August	1.0	2.0	0.4	0.7	1.4	3.1	1.0	2.0
September	1.0	2.0	0.4	0.7	1.4	3.0	2.0	2.0

Towards the end of the study, an IFR was introduced downstream of the Driel Barrage to cater for the ecological flow requirements of the river reach between Driel Barrage and Spioenkop Dam. Note that no IFR is deemed necessary between Woodstock Dam and Driel Barrage because the tailwater from Driel Barrage backs up almost to the toe of Woostock Dam and there is no riverine ecology as such to protect.

The flow requirements for the IFR downstream of the Driel Barrage were determined by DWAF using the rapid assessment method. Because of uncertainty in selecting the appropriate class of river for this IFR two scenarios referred to as the "low" and "high" IFR scenarios were selected. These scenarios were based on a class D river below Driel and Spioenkop. The IFR flow requirements for these two IFR sites used in the final feasibility system analysis model are listed in Appendix M. Small changes were also made to the other IFRs so the full set has been listed in Appendix M. Introducing these IFRs required a few modifications to the system model in addition to the IFR channels. Initial analyses showed that these IFRs were not fully supplied because the penalty system prevented them being supplied when the downstream dams (Spioenkop and Jana) were full. This situation was rectified by including a bypass channel around these dams.

The final system diagram is shown in Drawing W5

5 FINAL WRYM SYSTEM MODEL

A schematic diagram of the final WRYM system model to be used in the TWP feasibility study is shown in Drawing W5. The diagram is in colour to highlight certain groupings of IFR, domestic and industrial water requirements, return flows, transfers and irrigation requirements. All penalty structures have been shown including those in the reservoir storage zones.

For final results of the water resources evaluation for the TWP feasibility study the reader is referred to a separate report entitled “Thukela Water Project : Feasibility Study. Water resource evaluation and systems analysis task. Water Resources Evaluation.” Report no. PBV000-00-5999.

APPENDIX A

REVISED TOR

THUKELA WATER PROJECT

STRATEGIC WATER RESOURCES ASSESSMENT OF THE THUKELA BASIN

1. Introduction

During the course of the water resources and system analysis task for the feasibility study a number of issues have been identified for further investigation. Although some of these issues are directly related to the tasks set out in the original terms of reference (ToR), many of them go beyond the ToR of the feasibility study. In the following section, sub-tasks covering all major issues are described. The sub-tasks are divided into three groups, firstly depending on whether they are covered in the original ToR and secondly depending on whether they need to be completed by the end of January 1999. The latter grouping is important because it relates to the tasks that must be done in order to re-assess the transferable yield from Jana Dam.

The main task groupings are as follows:

(A) Tasks considered to be part of the original ToR
(B) Tasks specific to the Strategic Water Resources Assessment that need to be completed by end January 1999, to enable revised yield curves to be obtained for Jana Dam.
(C) Tasks specific to the Strategic Water Resources Assessment that do not need to be completed by end January 1999.

2. Description of tasks

(A) Tasks considered to be part of original ToR (Nos. 1 to 4)

Task no. 1 — The version of WRYM used in the pre-feasibility had a restriction on the number of dams in a system, which limited the number of farm dams to two. As this limitation has fallen away the impact of farm dams can now be modelled more realistically than before.

Task no. 2 — At the PMT meeting on 12 November 1998 it was agreed to reduce the full irrigation requirements throughout the system by applying a factor of 0.75 (75%). It was considered that this adjustment would cater for the restrictions imposed during times of water shortage.

Task no.3 — The PMT has also decided that the Mooi sub-system, as set up by Ninham Shand, should be incorporated into the Thukela system for reasons of consistency between the two studies. This will entail the introduction of a further IFR site on the Mooi River. It has also been decided to adopt a consistent transfer of 4 m^3/s, notwithstanding the fact that the transfer would be stopped when Midmar Dam spills.

Task no.4 — The hydrology of Zaaihoek Dam has been revised recently. It is necessary to adopt the new hydrology in the Thukela system analysis to ensure consistency with the Vaal system analysis. It will also be necessary to obtain consistency in the operation of Zaaihoek Dam with regard to the transfers to the Vaal.

(B) *Tasks specific to the Strategic Water Resources Assessment that need to be completed by end January 1999, to enable revised yield curves to be obtained for Jana Dam (Task nos. 5 to 9)*

Task no.5 Concern has been expressed by the PMT that the projected urban demands in the Buffalo could be too high. Accordingly, these projections will be reviewed in the light of recent (post pre-feasibility study) trends in water use. However, it is considered that KwaZulu Natal Water Resources Assessment Study will eventually provide the more reliable estimates of future water requirements.

Task no. 6 The inclusion of Uikyk Dam on the Sundays and Buffelshoek Dam on the Buffalo will require IFRs to be established downstream of the dam sites. The system model will need to be updated to include IFR channels at these two points.

Task no.7 In the ToR for the pre-feasibility study it was assumed that the system analysis team would be provided with finalised IFR information. However, analyses to date have shown the IFRs (and EFR) to have a major impact on the transferable yields from Jana and Mielietuin. It has been decided, therefore, to perform sensitivity analyses on the IFRs to assist the environmental team in selecting IFRs that are environmentally acceptable and have the least unfavourable impact on transferable yields.

Task no.8 The present (1998) water resources situation in the Thukela constitutes a useful baseline for assessing the viability of providing IFRs at current levels of development. Accordingly, a base scenario will be analysed, taking into account all existing in-basin demands and transfers but without imposing any IFRs on the system. For purposes of comparison, the present day scenario will also be analysed with all IFRs imposed on the system. This analysis will illustrate the degree to which the present system is able to meet IFRs.

Task no. 9 Future water resources situations will be assessed for the Thukela appropriate to envisaged levels of development in the years 2010, 2020 and 2030. The analyses will include all IFRs and currently planned transfers out of the Thukela basin (i.e. Mooi and Mhlatuze transfers). These future scenarios will also incorporate Uitkyk and Buffelshoek dams, suitably sized to meet in-basin requirements and IFRs.

(C) *Tasks specific to the Strategic Water Resources Assessment that do not need to be completed by end January 1999 (Task nos. 10 to 16)*

Task no.10 There is a degree of uncertainty surrounding the proposed Mooi and Mhlatuze transfers. These transfers could also have a significant impact on the available yield for transfer to the Vaal basin. Accordingly, six analyses will be undertaken with varying transfer rates for the two schemes. The transfer rates to be tested are as follows:

Mhlatuze: 1.2, 2.7 and 8.1 m^3/s
Mooi: zero and 4.3 m^3/s

In the analyses Buffelshoek Dam will be sized in order to support the Mhlatuze transfer.

Task no. 11 If the Mhlatuze transfer is shown to have a significant impact on transferable yield it may be desirable to develop alternative sources for augmentation of supplies to the Richards Bay region. Accordingly, alternative sources will be assessed by referring to existing reports.

Task no.12 The Mooi transfer is planned as a bridging scheme, in conjunction with the much larger transfer that is proposed from the Mkomaas River. There will thus be times when the Mooi scheme would be available to augment supply within the Thukela basin. The proposed phasing of the Mooi and Mkomaas transfers will therefore be analysed to ascertain their influence on the Thukela system.

Task no. 13 The system analyses to date indicate that only about 10 m^3/s can be transferred from Jana and Mielietuin dams on a firm basis, as against the required 15 m^3/s. The situation is expected to improve with the provision of Uitkyk and Buffelshoek dams on the Sundays and Buffalo rivers but it is unlikely that the full 15 m^3/s can be met from Jana and Mielietuin. If this is the case both Uitkyk and Buffelshoek dams will be sized to make up the shortfall. (An additional analysis will be undertaken by the Vaal System Analysis team to ascertain the benefits – if any – of transferring at higher rates but on a non-firm basis.)

Task no. 14 Uitkyk and Buffelshoek dams were identified in the interim study as the most economical combination to transfer water via the northern tributaries, referred to as the NTTS (Northern Tributaries Transfer Scheme). As the system model will include these dams, which will be sized for meeting in-basin requirements and IFRs, the potential transfer from these dams can be established by making these dams as large as is practical. Transferable yield for a range of dam sizes will also be determined to help assess the possibility of a phased extension of the NTTS.

Task no. 15 The results of the strategic water resources assessment of the Thukela basin will be presented in a stand-alone report, which will be an extension to the reporting envisaged for the original feasibility study.

Task no. 16 The additional work for the strategic assessment will require extra time for project management and meetings with DWAF, PMT and other task teams.

3. Summary of tasks and budget estimates

Task No.	Task description	Cost (Rand)	Included in Original ToR
1	Add farm dams in tributary catchments	-	Y
2	Adjust irrigation requirements to 75% of full	-	Y
3	Incorporate NSI Mooi sub-system	-	Y
4	Incorporate new Zaaihoek hydrology and operation	-	Y
5	Review projected demands in Buffalo catchment	5300	N
6	Incorporate IFRs in Sundays and Buffalo rivers	5300	N
7	Perform sensitivity tests on IFRs	26400	N
8	Analyse present-day situation (with and without IFRs)	13200	N
9	Analyse 2010, 2020 and 2030 situation	39600	N
10	Perform sensitivity on Mooi and Mhlatuze transfers	26400	N
11	Evaluate alternative sources for Mhlatuze augmentation	13200	N
12	Evaluate conjunctive use of Mooi River	13200	N
13	Size Utkyk and Buffelshoek dams to transfer 15 m^3/s total	10600	N
14	Analyse NTTS	10600	N
15	Report on strategic water resources assessment	52800	N
16	Additional project management and meetings	26400	N
	SUB-TOTAL	243000	
	Disbursements and recoverable expenses	17000	
	TOTAL	260000	
	VAT @ 14%	36400	
	TOTAL (including VAT)	296400	

4. Work programme

Task	Description	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99	Apr-99	May-99	Jun-99	Jul-99	Aug-99	Sep-99
1	Add farm dams	■										
2	Adjust irrigation	■										
3	Incorporate Mooi		■									
4	Zaaihoek Dam	■										
5	Buffalo demands		■									
6	Sundays, Buffalo IFRs		■									
7	IFR sensitivity	■										
8	Present-day analysis		■									
9	2010,2020,2030 analyses			■								
10	Mooi/Mhlatuze sensitivity				■	■						
11	Alternatives for Mhlatuze				■	■						
12	Conjunctive use of Mooi				■	■						
13	Size Uitkyk, Buffelshoek				■	■						
14	Analyse NTTS						■	■				
15	Report								■	■	■	

5. Manpower and professional fees

Staff	Position	Hourly rate (R)	Daily rate (R)	Budget (Days)	Budget (Rand)
EFA Snell	Project Director	400.00	3200	2	6400
L Furstenburg	Project Director	400.00	3200	2	6400
WV Pitman	Task Leader	375.00	3000	12	36000
AK Bailey	System analyst	270.19	2162	22	47553
PG Blom	Assistant system analyst	115.30	922	6	5534
JR Hansford	Specialist (system analyst)	330.00	2640	25	66000
EG Stevens	System analyst	178.95	1432	25	35790
WA Lloyd	Assistant system analyst	275.00	2200	5	11000
B Gernet	CAD services	163.95	1312	2	2623
AL Privett	CAD services	153.25	1226	3	3678
Trainee	Assistant system analyst	110.00	880	25	22000
			Totals	129	242979

APPENDIX B

SUPPLY OF DEMANDS

Supply of Demands in 2030 in m^3/s

Description of demands	Current			Comment
	Required	Supply	%	
Drakensburg transfer	20.000	14.375	72	demands and IFR A supplied first
Dem 2	0.388	0.388	100	
Dem 1	0.139	0.139	100	
Dem 6	0.461	0.460	100	storage at node 16 (farm dam 3) not available
Dem 7	0.111	0.111	100	
Ladysmith return flow	0.969	0.969	100	
Dem 3	0.197	0.197	100	
Dem 4	1.989	1.989	100	
Dem 5	0.139	0.139	100	
Dem 15	0.460	0.456	99	insufficient run of river, no storage to draw from
Dem 18	0.153	0.153	100	
Dem 16	1.115	1.115	100	
Estcourt return flow	0.562	0.562	100	
Mielietuin transfer	3.612	3.611	100	Mielietuin transfer operating at yield
Dem 17	0.146	0.146	100	
Dem 14	1.468	1.468	100	
Durnacol return flow	0.108	0.108	100	
Dem 21	0.216	0.215	100	
Dem 19	0.034	0.029	85	insufficient run of river, no storage to draw from
Zaaihoek transfer	0.873	0.873	100	
Dem 20	0.197	0.197	100	
Dem 10	3.032	3.032	100	
Volksrust return flow	2.501	2.501	100	
Utrecht return flow	0.071	0.071	100	

Supply of Demands in 2030 in m^3/s (continued)

Description of demands	Current			Comment
	Required	Supply	%	
Dem 11	0.739	0.739	100	
Dundee return flow	0.186	0.186	100	
Dem 12	1.034	1.034	100	
Mhlathuze transfer	8.000	8.000	100	
Dem 13	0.800	0.800	100	
Dem 3b	0.250	0.250	100	

Supply of Irrigation Demands in 2030 in m^3/s

Description of demands	Current			Comment
	Required	Supply	%	
TM02 irrigation	0.053	0.053	100	
Thwood irrigation	0.118	0.118	100	
Thdriel irrigation	0.056	0.056	100	
Thskop irrigation	1.068	1.068	100	
TM06 irrigation	0.265	0.265	100	
Thskopds irrigation	0.095	0.095	100	
TM08A irrigation	0.087	0.088	101	
TM08B irrigation	0.237	0.187	79	storage at node 16 (farm dam 3) not available
Thltug irrigation	0.729	0.466	64	storage at node 16 (farm dam 3) not available
TM11A irrigation	0.117	0.117	100	
TM11B irrigation	0.228	0.204	90	storage at node 21 (farm dam 4) not available
KlipB irrigation	0.549	0.533	97	IFR A depletes Spioenkop
KlipA irrigation	0.121	0.121	100	
Tm12 irrigation	0.051	0.047	93	insufficient run of river, no storage to draw from
TM14_MUN	0.237	0.237	100	
TM14B	0.270	0.181	67	storage at node 32 (farm dam 6) not available
Mungu irrigation	0.132	0.097	73	storage at node 32 (farm dam 6) not available
Wag irrigation	0.041	0.041	101	
Lochsloy irrigation	0.381	0.381	100	
Mgwenya irrigation	0.564	0.564	100	
Non irrigation	0.144	0.144	100	
TM24 irrigation	0.207	0.179	87	insufficient run of river, no storage to draw from
Cheld irrigation	0.060	0.058	97	chelmsford runs empty in yr 4
TM26 irrigation	0.073	0.057	78	insufficient run of river, no storage to draw from

Supply of Irrigation Demands in 2030 in m^3/s (continued)

Description of demands	Current			Comment
	Required	Supply	%	
Zaaid irrigation	0.241	0.242	100	
V3 irrigation	0.572	0.572	100	
V3_Rork	0.160	0.160	100	
Rorkes irrigation	0.276	0.276	100	
Mhlathuze irrigation	0.442	0.442	100	
Mandini irrigation	0.349	0.349	100	

APPENDIX C

DUMMY FARM DAM STORAGE-ELEVATION-AREA CURVES AND DATA

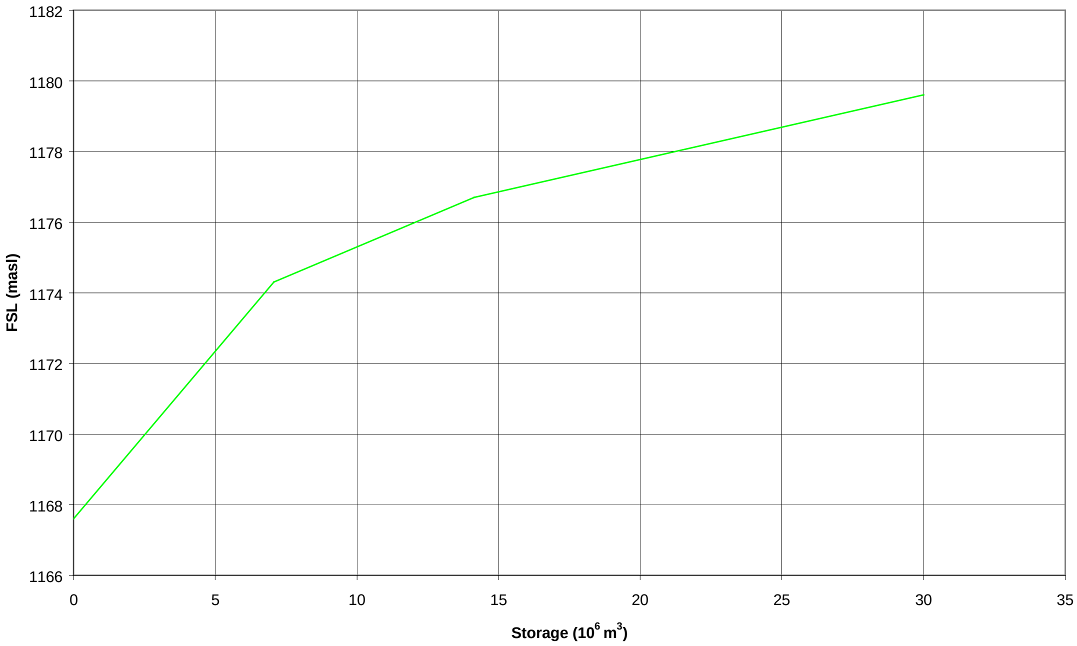


Figure C.1: Storage – Elevation Curve for Farm Dam 1

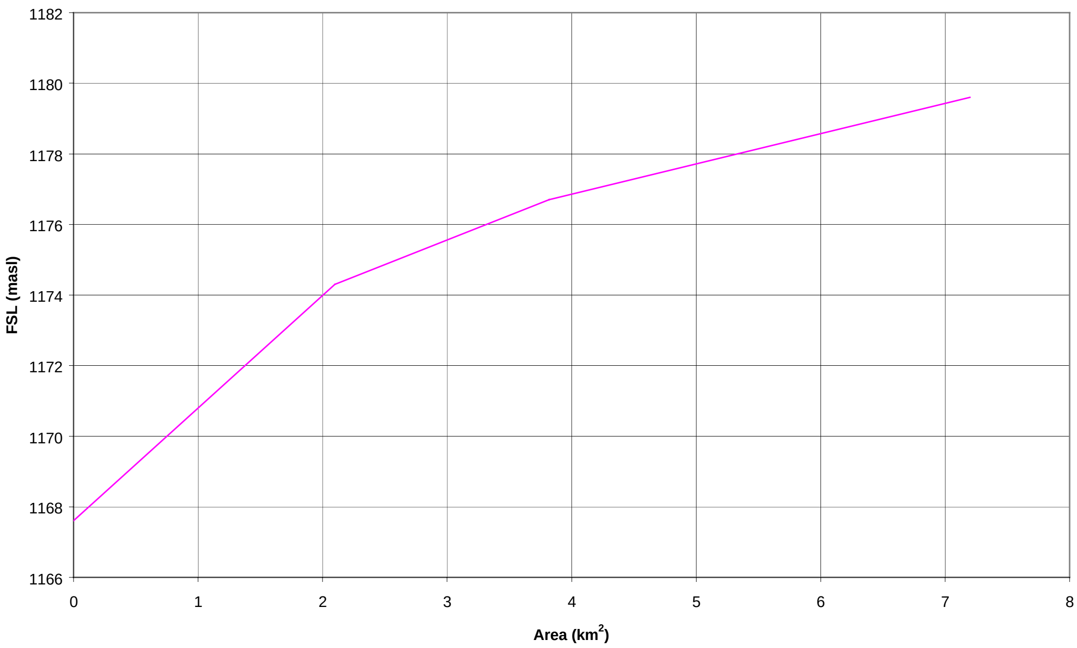


Figure C.2: Area – Elevation Curve for Farm Dam 1

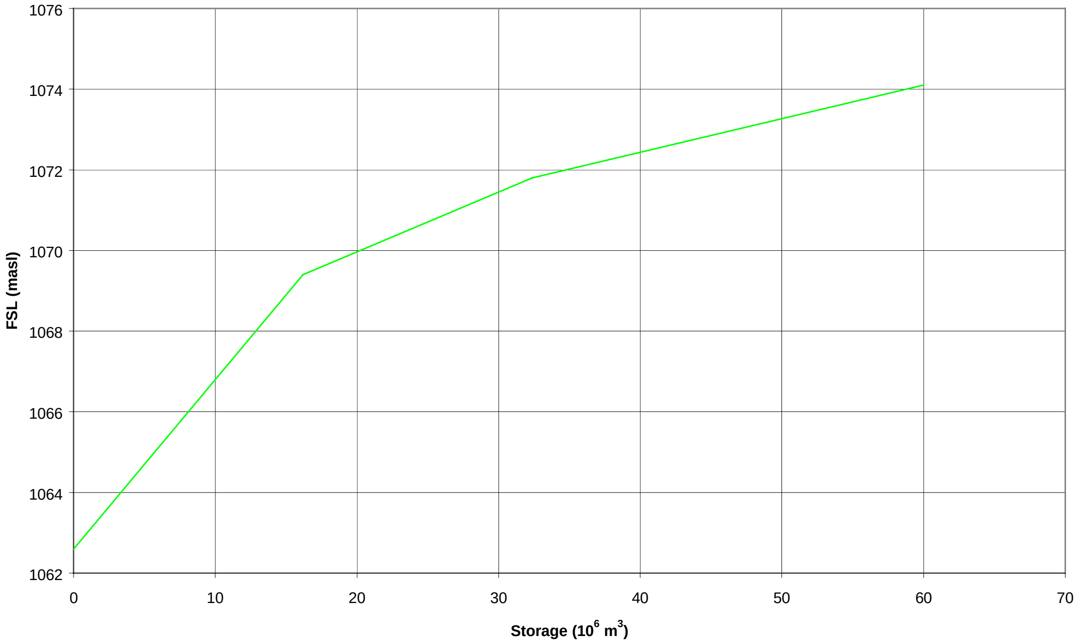


Figure C.3: Storage – Elevation Curve for Farm Dam 2

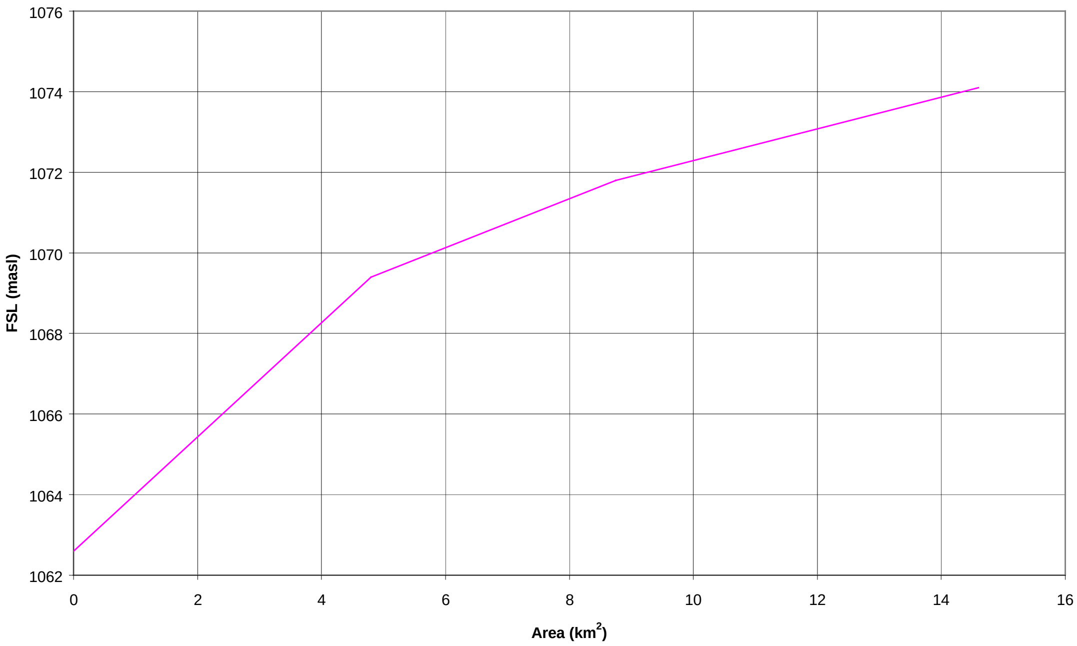


Figure C.4: Area – Elevation Curve for Farm Dam 2

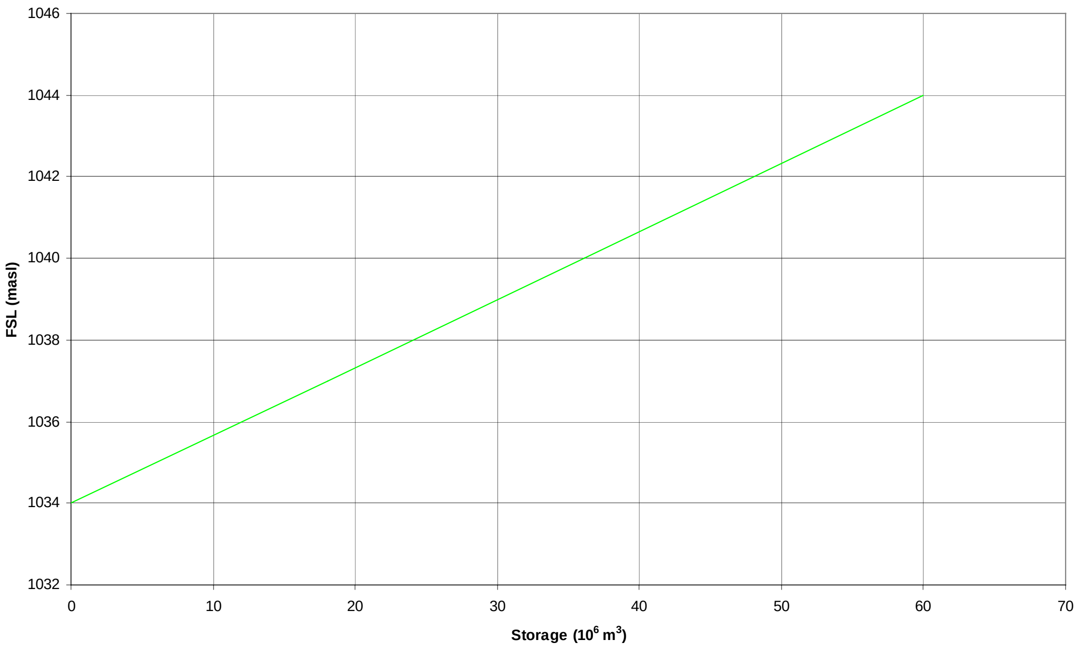


Figure C.5: Storage – Elevation Curve for Farm Dam 3

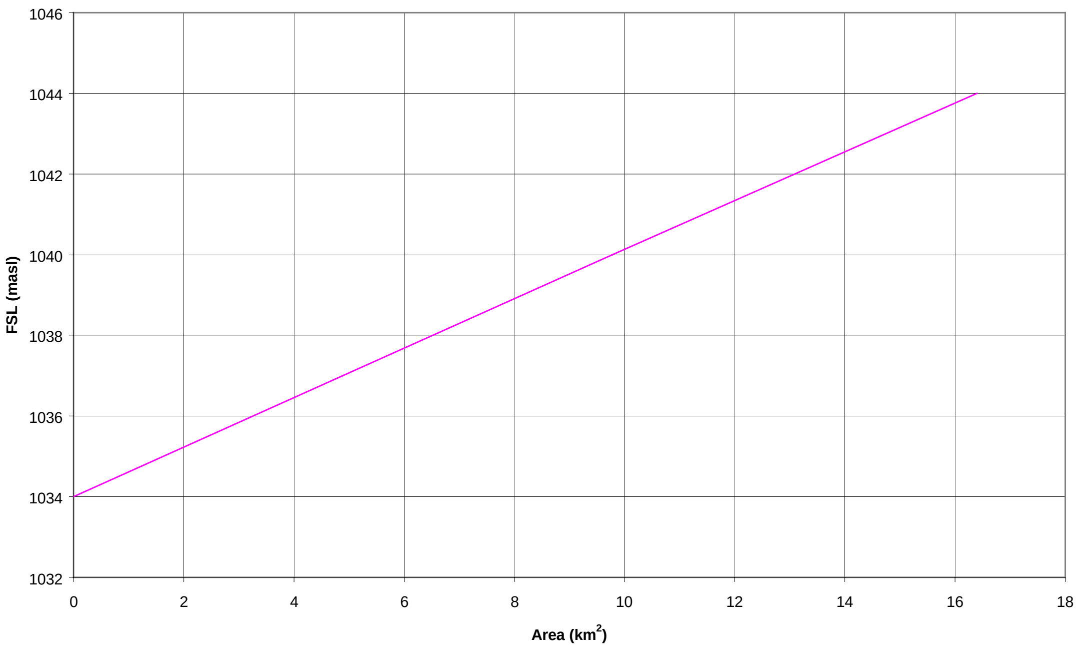


Figure C.6: Area – Elevation Curve for Farm Dam 3

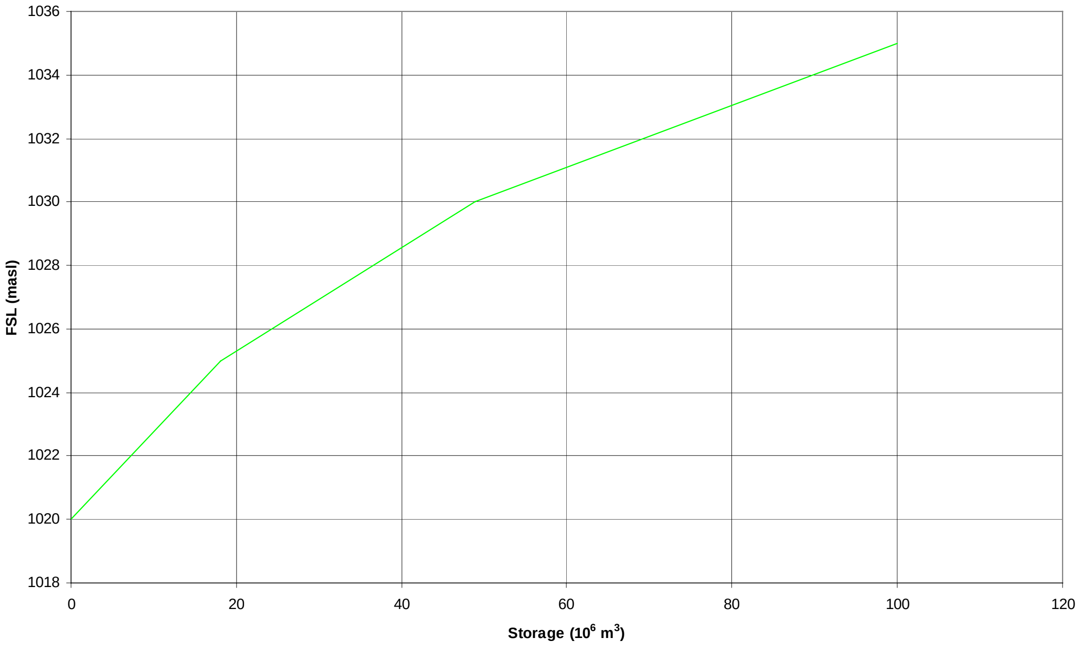


Figure C.7: Storage – Elevation Curve for Farm Dam 4

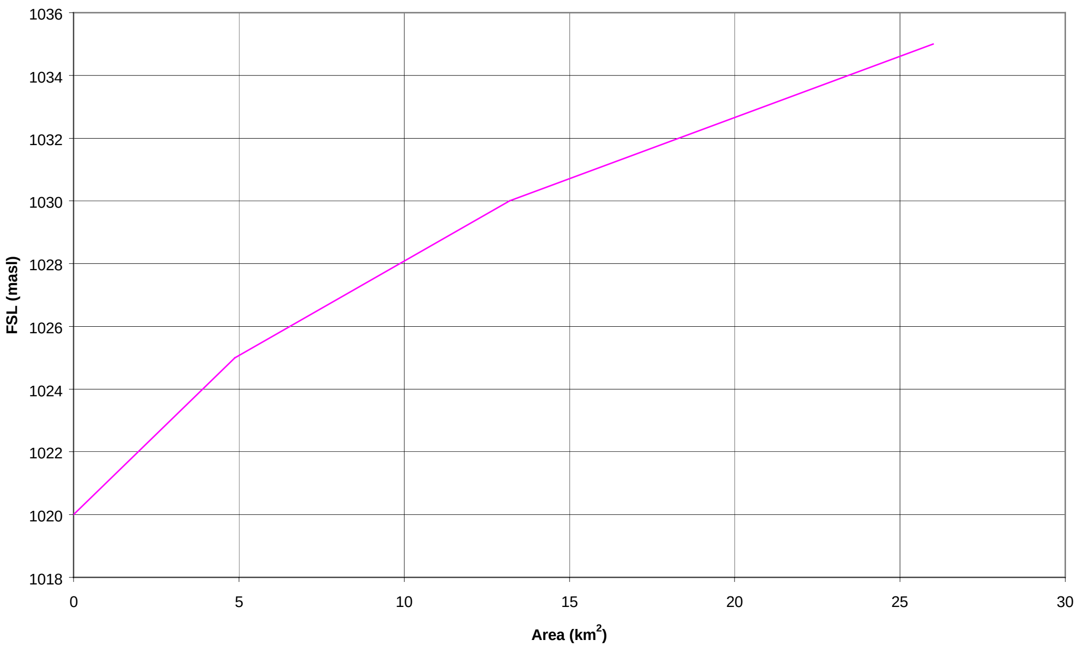


Figure C.8: Area – Elevation Curve for Farm Dam 4

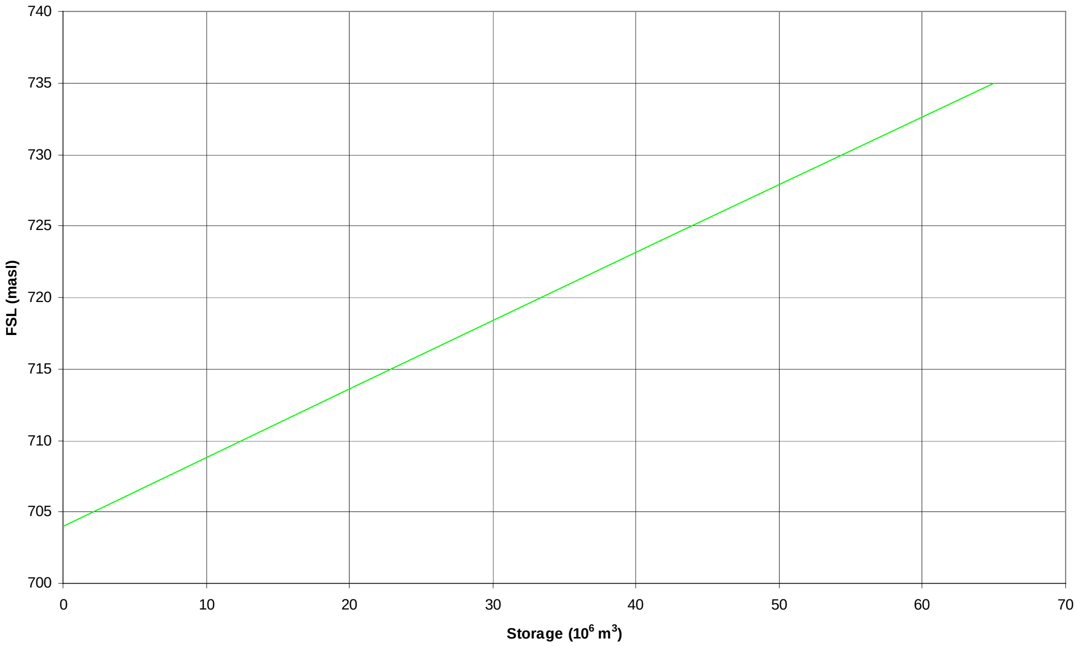


Figure C.9: Storage – Elevation Curve for Farm Dams 5 and 6

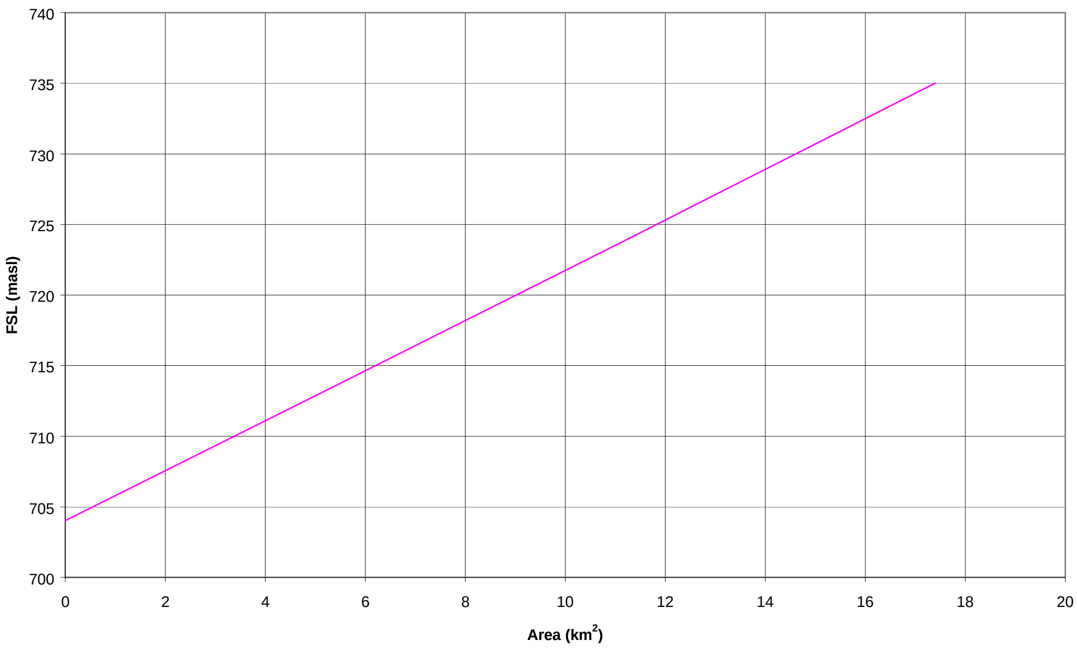


Figure C.10: Area – Elevation Curve for Farm Dams 5 and 6

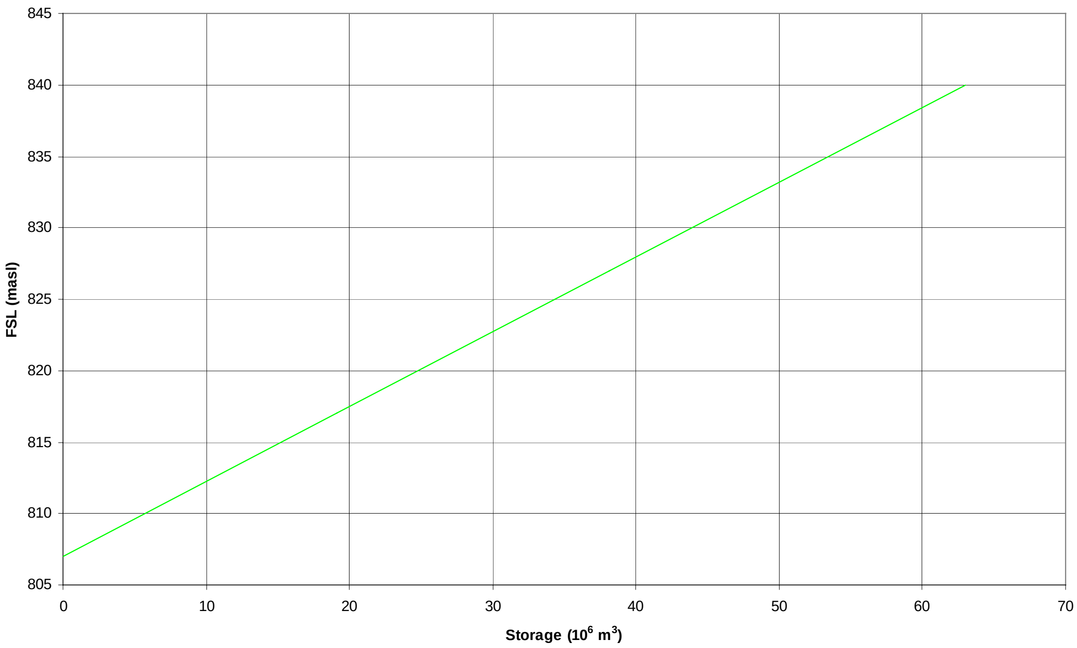


Figure C.11: Storage – Elevation Curve for Farm Dam 7

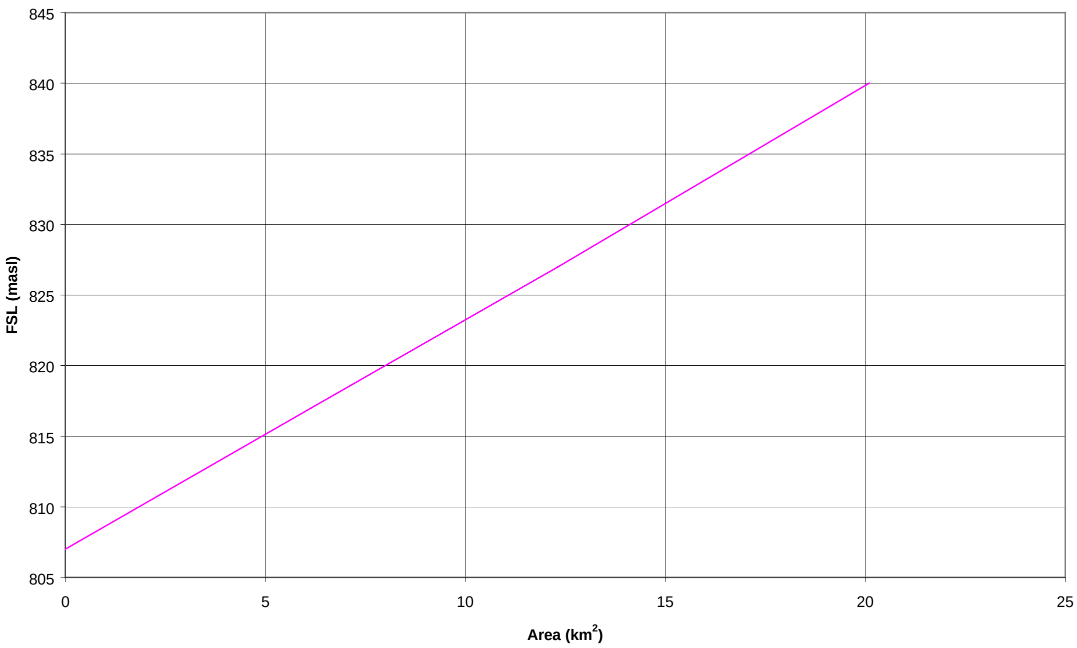


Figure C.12: Area – Elevation Curve for Farm Dam 7

STORAGE – AREA – ELEVATION DATA FOR FARM DAM 1

Elevation (masl)	1167.6	1174.3	1176.7	1179.6
Storage($x10^6$ m^3)	0.000	7.070	14.140	30.000
Area (km^2)	0.000	2.100	3.820	7.200

STORAGE – AREA – ELEVATION DATA FOR FARM DAM 2

Elevation (masl)	1062.6	1069.4	1071.8	1074.1
Storage($x10^6$ m^3)	0.000	16.200	32.380	60.000
Area (km^2)	0.000	4.800	8.750	14.600

STORAGE – AREA – ELEVATION DATA FOR FARM DAM 3

Elevation (masl)	1034	1037	1040	1044
Storage($x10^6$ m^3)	0.000	18.080	36.160	60.000
Area (km^2)	0.000	4.885	9.770	16.400

STORAGE – AREA – ELEVATION DATA FOR FARM DAM 4

Elevation (masl)	1020	1025	1030	1035
Storage($x10^6$ m^3)	0.000	18.080	48.860	100.000
Area (km^2)	0.000	4.885	13.200	26.000

STORAGE – AREA – ELEVATION DATA FOR FARM DAM 5 AND 6

Elevation (masl)	704	714	724	735
Storage($x10^6$ m^3)	0.000	20.875	41.750	65.000
Area (km^2)	0.000	5.640	11.280	17.400

STORAGE – AREA – ELEVATION DATA FOR FARM DAM 7

Elevation (masl)	807	817	827	840
Storage($x10^6$ m^3)	0.000	19.090	38.180	63.000
Area (km^2)	0.000	6.160	12.320	20.100

APPENDIX D

MOOI RIVER INFLOW FILES

Mooi River inflow file for 2030 – Mooi.inf Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	2.189	3.208	1.674	18.991	20.042	8.485	4.417	2.487	1.680	1.320	1.665	2.209
1926	2.170	2.891	4.092	8.548	5.298	10.005	5.915	2.462	1.523	1.145	1.665	2.209
1927	2.151	3.160	3.658	14.515	9.272	9.846	5.188	2.599	1.803	1.320	1.314	1.697
1928	2.144	3.223	4.433	11.555	3.998	9.504	5.614	2.950	2.082	1.752	1.665	2.213
1929	2.189	7.013	4.813	13.342	18.040	26.263	12.802	2.955	2.163	1.341	1.437	1.751
1930	1.334	1.167	5.902	10.519	4.870	4.617	4.417	2.704	1.680	1.472	1.665	2.209
1931	1.232	0.394	1.129	4.827	29.893	19.948	5.300	3.675	2.813	1.979	1.131	2.209
1932	1.667	3.551	6.094	6.183	4.972	5.706	2.833	1.665	1.048	1.320	1.665	1.542
1933	1.093	9.838	20.048	45.843	24.695	13.566	12.985	11.777	3.788	2.873	2.505	2.365
1934	2.378	12.145	38.277	15.275	13.880	13.631	6.702	2.978	3.004	2.150	1.665	2.209
1935	1.114	0.844	1.135	1.567	17.525	12.390	4.199	4.120	3.235	2.155	1.521	1.363
1936	1.398	5.766	5.354	9.632	12.358	8.764	4.225	1.564	1.193	0.941	0.861	0.700
1937	0.994	0.968	2.418	11.549	9.811	6.529	6.682	3.562	2.494	2.371	2.111	2.209
1938	2.169	3.705	14.303	11.336	42.897	22.910	7.489	4.717	2.994	2.205	1.665	2.209
1939	2.079	4.681	6.116	10.137	8.311	8.498	5.381	17.185	15.037	4.963	3.072	2.643
1940	2.201	4.059	31.350	32.901	65.529	37.927	11.924	4.766	3.064	2.101	1.665	2.209
1941	1.281	1.324	3.067	12.251	23.879	32.471	17.563	5.083	3.383	2.436	2.092	2.209
1942	2.016	11.350	32.409	55.270	37.126	17.558	71.796	44.808	16.600	15.504	37.728	18.411
1943	45.685	40.851	32.954	26.194	34.751	28.788	10.516	3.305	2.576	1.742	1.665	2.209
1944	2.188	2.270	1.304	2.825	2.556	14.687	9.641	3.627	2.242	1.431	1.287	0.890
1945	0.932	0.804	1.108	2.677	2.628	7.732	4.474	2.661	1.418	1.030	0.868	0.698
1946	0.941	3.191	3.096	2.834	10.522	12.992	6.353	3.279	2.691	2.137	1.665	2.209
1947	1.980	9.908	8.634	10.711	6.547	9.253	6.702	3.949	2.701	1.726	1.540	1.152
1948	1.097	1.267	3.324	11.713	9.322	12.546	6.207	4.335	2.766	1.917	1.665	2.209
1949	1.400	3.062	11.103	7.911	2.780	19.175	10.476	3.530	2.247	1.774	1.712	2.209
1950	1.801	1.937	4.809	12.677	5.722	6.433	4.417	2.149	1.119	0.929	1.665	2.209
1951	2.071	1.057	4.214	50.872	58.944	20.603	4.902	3.253	2.212	1.612	1.665	2.209
1952	1.259	3.462	5.396	8.678	18.161	5.242	3.978	1.903	1.421	1.005	1.665	2.209
1953	1.986	1.861	5.719	10.414	14.558	7.088	4.417	3.405	2.415	1.587	1.343	2.209
1954	2.558	5.020	8.810	21.849	37.028	15.733	4.633	4.107	2.645	1.777	0.865	0.707
1955	1.488	0.887	6.055	3.260	6.500	14.229	4.856	2.612	1.465	0.998	0.878	1.212
1956	1.262	3.595	53.312	45.603	21.020	24.136	10.430	5.052	3.272	2.569	2.233	25.779
1957	32.418	18.555	12.090	21.591	21.121	11.981	10.786	4.141	2.532	1.527	1.334	2.209
1958	1.079	3.251	7.654	13.692	28.140	18.256	5.263	24.956	7.814	3.576	2.241	2.209
1959	1.830	3.205	4.179	5.177	8.594	7.799	6.792	3.890	2.368	1.593	1.558	1.651
1960	1.710	2.029	9.169	6.987	5.711	8.879	11.319	4.210	2.439	1.724	1.364	0.887
1961	1.474	2.110	5.142	17.081	11.240	11.035	5.233	3.884	2.176	1.320	1.664	2.209
1962	1.196	3.231	4.547	10.920	3.314	20.122	7.959	3.805	2.830	2.917	1.808	1.775
1963	2.073	3.797	3.393	21.646	9.971	4.892	4.160	2.838	2.434	1.618	1.558	2.209
1964	2.193	12.034	6.591	11.069	6.653	1.447	1.171	0.954	2.030	1.637	1.774	2.209
1965	2.029	2.082	1.684	22.917	15.352	3.909	3.005	2.512	1.631	0.930	0.813	0.895
1966	1.146	3.722	5.201	19.135	59.614	28.611	26.093	6.513	4.198	2.974	2.059	1.983
1967	1.547	3.314	3.450	6.769	1.716	2.914	2.785	1.582	1.137	0.817	0.776	0.728
1968	0.930	1.411	2.309	2.215	1.649	12.316	7.732	4.065	2.764	2.054	1.665	2.209
1969	2.179	2.687	5.987	9.175	4.342	3.110	1.549	1.150	0.767	0.593	1.665	2.209
1970	2.193	3.532	2.181	5.126	3.883	3.070	2.564	5.395	3.433	2.247	2.670	2.209
1971	2.350	4.250	7.414	7.951	7.053	18.831	5.421	2.218	1.403	1.245	0.961	0.773
1972	1.705	2.804	2.053	1.996	28.357	18.788	15.301	5.984	3.573	2.185	2.410	2.209
1973	2.202	3.587	3.747	19.901	34.646	20.204	13.531	4.712	2.722	1.878	1.665	2.209
1974	1.335	2.641	4.759	22.580	35.199	18.511	9.543	2.622	1.680	1.272	1.549	3.241
1975	2.105	3.619	24.118	57.313	63.766	98.268	33.167	11.968	5.564	3.472	2.508	2.209
1976	5.901	4.668	3.150	5.646	8.716	16.126	12.209	3.577	1.778	1.172	1.002	2.209
1977	2.067	3.453	3.527	34.076	20.892	13.233	14.117	4.629	2.962	1.984	1.665	2.209
1978	2.805	5.151	22.143	22.353	17.733	13.349	3.510	3.941	2.368	1.932	1.837	2.209
1979	2.096	1.786	1.930	5.832	3.337	5.880	1.891	1.190	0.788	0.889	0.913	2.209
1980	2.112	2.555	5.740	7.766	27.301	8.762	2.083	2.600	1.680	1.320	1.665	2.209
1981	2.051	2.759	3.299	5.988	1.373	7.236	4.417	2.593	1.680	1.320	0.487	0.273
1982	3.012	2.376	1.682	5.410	1.685	3.140	3.391	1.663	1.238	0.951	1.594	2.209
1983	0.489	5.316	6.565	9.532	2.255	4.082	4.671	2.845	1.551	1.625	1.665	2.209
1984	2.014	1.364	1.391	10.188	29.815	9.885	3.749	2.568	1.733	1.030	0.981	1.298
1985	2.067	3.876	13.436	25.314	19.940	32.306	16.716	7.284	5.076	3.319	2.290	2.338
1986	2.146	3.766	6.012	13.291	10.605	33.132	12.423	3.894	2.746	1.707	3.251	100.431
1987	50.111	20.451	19.530	20.533	55.932	66.856	18.974	5.660	5.728	4.987	1.862	2.209
1988	2.125	3.362	22.859	35.030	38.537	22.888	4.489	3.056	1.967	1.483	1.665	2.209
1989	1.775	6.439	32.840	18.910	15.664	36.115	19.389	4.596	2.966	2.043	1.824	2.209
1990	1.989	1.272	3.395	33.794	44.932	15.082	6.240	2.642	1.797	1.320	1.277	2.156
1991	4.542	7.249	6.084	3.938	32.500	12.373	2.353	1.713	1.243	0.900	0.836	0.770
1992	0.912	40.600	123.960	39.473	23.678	9.610	3.366	2.419	1.696	1.264	1.105	0.922
1993	2.426	3.508	4.612	21.862	13.045	7.399	3.289	3.144	1.703	1.764	1.805	2.209
1994	1.745	1.213	1.296	5.013	2.017	2.308	4.417	2.653	1.967	1.320	1.665	2.209

Mooi River inflow file for 1995 – Mooipd.inf Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	2.263	3.273	1.720	20.018	20.884	8.030	4.417	2.550	1.680	1.320	1.665	2.209
1926	2.179	3.164	4.110	8.589	4.946	7.224	4.876	2.453	1.473	1.096	1.665	2.209
1927	2.164	3.220	3.672	12.077	6.920	8.180	6.825	2.604	1.714	1.320	1.336	1.746
1928	2.163	3.288	4.461	11.573	4.096	7.448	4.944	2.868	2.065	1.730	1.665	2.385
1929	2.193	9.278	5.715	16.806	15.665	27.409	13.850	2.962	2.163	1.320	1.466	1.800
1930	1.486	1.174	5.909	10.570	4.191	4.666	4.417	2.710	1.680	1.436	1.665	2.209
1931	1.380	0.886	1.153	4.870	29.157	15.818	5.433	3.745	2.748	1.904	1.155	2.209
1932	1.835	3.623	6.097	6.235	5.157	5.768	2.916	1.749	1.073	1.320	1.665	1.576
1933	1.218	12.649	21.484	43.439	26.600	18.270	21.662	13.926	3.758	2.862	2.497	2.286
1934	2.403	18.800	41.350	15.920	14.579	14.819	7.980	3.025	3.058	2.122	1.665	2.209
1935	1.245	0.846	1.138	1.582	16.105	13.917	4.581	4.493	3.325	2.259	1.542	1.385
1936	1.579	5.459	5.741	9.669	13.463	9.720	4.415	1.485	1.122	0.954	0.867	0.747
1937	1.032	0.971	2.431	11.566	7.517	7.025	7.562	3.504	2.509	2.389	2.024	2.209
1938	2.182	3.759	12.265	11.355	48.735	36.998	12.737	4.742	2.937	2.198	1.665	2.209
1939	2.117	4.273	7.921	10.477	12.204	13.284	7.801	22.547	19.570	6.060	2.951	2.629
1940	2.306	4.376	33.792	39.972	67.525	37.922	11.412	4.744	3.025	2.039	1.665	2.209
1941	1.432	1.333	3.089	12.255	23.513	35.490	18.609	5.764	3.348	2.362	1.997	2.209
1942	2.094	8.538	34.737	61.617	38.452	18.205	73.947	45.461	17.430	16.529	39.885	20.215
1943	48.390	42.669	33.758	26.803	35.425	29.910	10.281	3.283	2.585	1.650	1.665	2.209
1944	2.193	2.526	1.308	2.849	2.662	12.223	10.044	3.669	2.204	1.351	1.313	0.897
1945	0.936	0.809	1.112	2.695	2.639	7.744	4.530	2.668	1.514	1.041	0.874	0.746
1946	0.947	3.253	3.121	2.989	10.504	9.899	5.879	3.254	2.709	2.092	1.665	2.209
1947	2.061	10.450	10.431	10.773	6.024	10.582	8.724	4.487	2.664	1.651	1.555	1.161
1948	1.229	1.274	3.399	11.724	9.805	13.794	6.738	4.364	2.738	1.885	1.665	2.209
1949	1.578	3.192	11.706	8.320	3.133	16.062	9.762	5.476	2.274	1.803	1.665	2.209
1950	1.931	1.953	4.843	12.154	9.563	8.728	4.417	2.308	1.158	0.949	1.746	2.209
1951	2.115	1.066	4.230	53.159	61.601	26.659	6.104	3.529	2.264	1.620	1.665	2.209
1952	1.412	3.517	5.415	8.720	18.004	6.911	4.404	2.228	1.538	0.936	1.665	2.209
1953	2.067	1.876	5.726	10.467	11.123	7.332	4.417	3.416	2.382	1.533	1.372	2.209
1954	2.583	4.689	6.575	21.922	49.310	22.025	7.326	4.158	2.633	1.701	0.877	0.748
1955	1.737	0.889	6.059	3.282	5.615	16.145	7.971	2.812	1.722	0.985	0.888	1.235
1956	1.418	3.667	56.288	51.770	30.277	30.775	15.374	5.018	3.227	2.585	2.156	24.166
1957	37.874	22.027	16.117	32.076	21.857	13.144	11.808	4.132	2.508	1.452	1.352	2.209
1958	1.189	3.320	8.027	14.112	28.673	20.433	5.312	32.310	10.977	3.770	2.142	2.209
1959	1.973	3.271	4.195	5.232	6.049	6.965	6.384	3.874	2.328	1.525	1.575	1.700
1960	1.853	2.048	6.167	7.061	6.628	9.854	11.761	4.262	2.463	1.682	1.386	0.903
1961	1.728	2.125	5.180	14.184	12.113	12.062	5.400	3.888	2.131	1.320	1.665	2.209
1962	1.347	3.300	4.587	10.940	3.736	21.584	11.093	3.792	2.825	2.943	1.717	1.872
1963	2.115	3.957	3.414	22.629	17.976	5.767	4.252	2.791	2.424	1.578	1.583	2.209
1964	2.193	10.801	5.871	12.151	7.720	1.824	1.248	0.954	2.038	1.608	1.744	2.209
1965	2.099	2.268	2.338	21.361	13.615	4.172	3.082	2.504	1.567	0.848	0.826	0.915
1966	1.284	3.767	5.217	19.934	60.354	39.231	35.088	8.268	4.224	2.979	1.916	2.032
1967	1.790	3.390	3.471	6.816	2.081	2.645	2.223	1.503	1.045	0.721	0.780	0.759
1968	0.934	1.417	2.325	2.240	1.655	12.814	8.855	4.859	3.152	2.211	1.665	2.209
1969	2.189	3.035	5.996	9.209	3.966	3.139	1.623	1.210	0.830	0.601	1.665	2.209
1970	2.511	3.842	2.871	5.223	4.318	3.353	2.672	5.651	3.461	2.263	2.693	2.209
1971	2.728	4.476	7.964	8.982	7.228	19.260	5.569	2.238	1.370	1.265	0.981	0.789
1972	1.849	3.131	2.057	2.020	30.449	16.321	16.491	5.945	3.468	2.035	2.399	2.209
1973	2.297	3.660	3.760	21.200	47.581	35.698	22.106	6.956	2.756	1.842	1.665	2.209
1974	1.483	2.992	4.788	20.250	47.229	19.075	10.656	2.628	1.680	1.287	1.560	3.141
1975	2.138	3.692	22.288	67.014	65.848	100.786	34.082	13.559	5.790	3.520	2.359	2.209
1976	4.618	5.796	3.633	5.386	13.890	16.429	13.483	3.586	1.735	1.154	1.022	2.209
1977	2.113	3.664	3.543	36.128	21.959	14.350	19.236	5.168	2.899	1.893	1.665	2.209
1978	2.775	4.568	27.816	26.590	18.525	13.653	3.675	3.965	2.325	1.935	1.785	2.209
1979	2.128	1.798	1.934	5.876	3.359	5.921	1.927	1.195	0.792	0.895	0.924	2.209
1980	2.145	2.913	5.748	7.822	27.614	9.361	2.121	2.605	1.680	1.320	1.665	2.209
1981	2.107	3.094	3.318	6.027	1.457	7.255	4.417	2.598	1.680	1.320	1.665	1.762
1982	2.727	2.735	1.748	5.463	1.690	3.002	3.540	1.558	1.074	0.865	1.625	2.209
1983	2.121	5.333	7.269	9.607	2.648	4.226	5.311	2.798	1.510	1.625	1.665	2.209
1984	2.093	1.374	1.873	11.691	33.131	10.558	4.171	2.701	1.773	0.912	0.986	1.323
1985	2.113	4.031	16.563	24.523	17.574	31.880	17.385	7.132	4.995	3.201	2.118	2.232
1986	2.216	3.873	6.364	12.152	10.691	30.965	9.767	4.076	2.852	1.585	3.611	106.483
1987	59.292	28.283	24.775	20.833	56.872	68.670	20.484	6.457	6.520	5.057	1.717	2.209
1988	2.159	3.441	29.585	35.878	40.069	24.507	4.417	3.001	1.884	1.402	1.665	2.209
1989	1.872	5.807	35.795	19.402	16.876	41.336	20.621	4.595	2.875	1.949	1.802	2.209
1990	2.071	1.279	3.418	34.716	54.819	15.471	7.670	2.643	1.787	1.320	1.298	2.209
1991	2.321	7.014	6.881	3.979	33.960	13.877	2.455	1.630	1.154	0.817	0.845	0.786
1992	0.917	42.241	128.974	41.246	24.660	10.094	3.488	2.408	1.626	1.183	1.128	0.934
1993	2.429	3.571	4.903	18.986	10.479	4.874	3.445	3.130	1.680	1.780	1.770	2.209
1994	1.864	1.219	1.470	5.262	2.433	2.539	4.417	2.658	1.920	1.320	1.665	2.209

APPENDIX E

UITKYK AND BUFFELSHOEK STORAGE-ELEVATION-AREA CURVES AND DATA

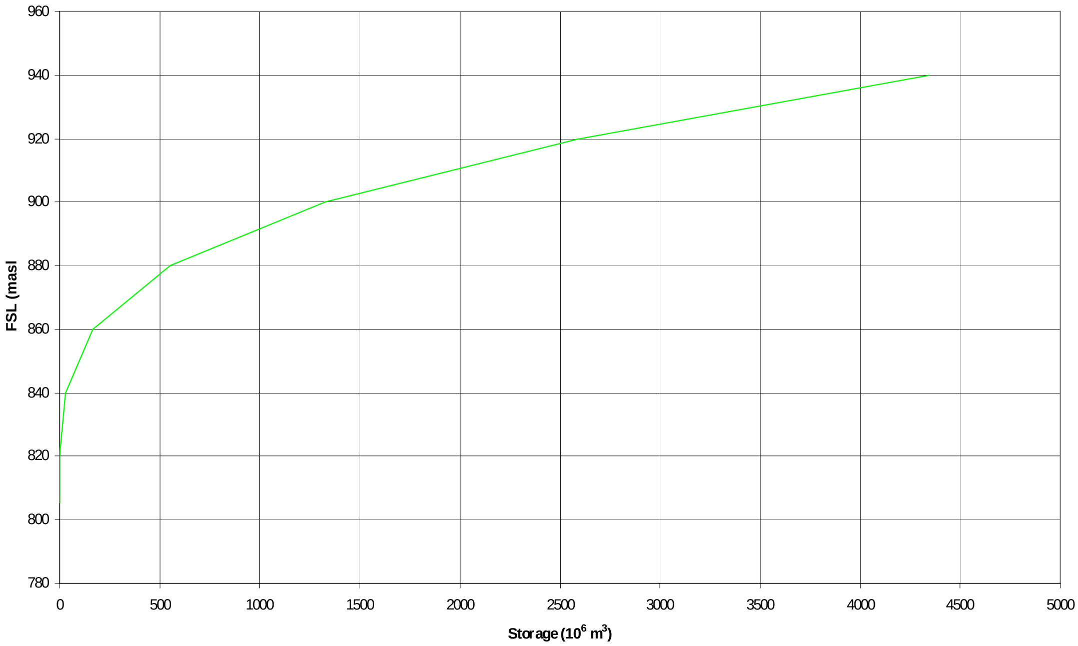


Figure E.1: Storage – Elevation Curve for Uitkyk Dam

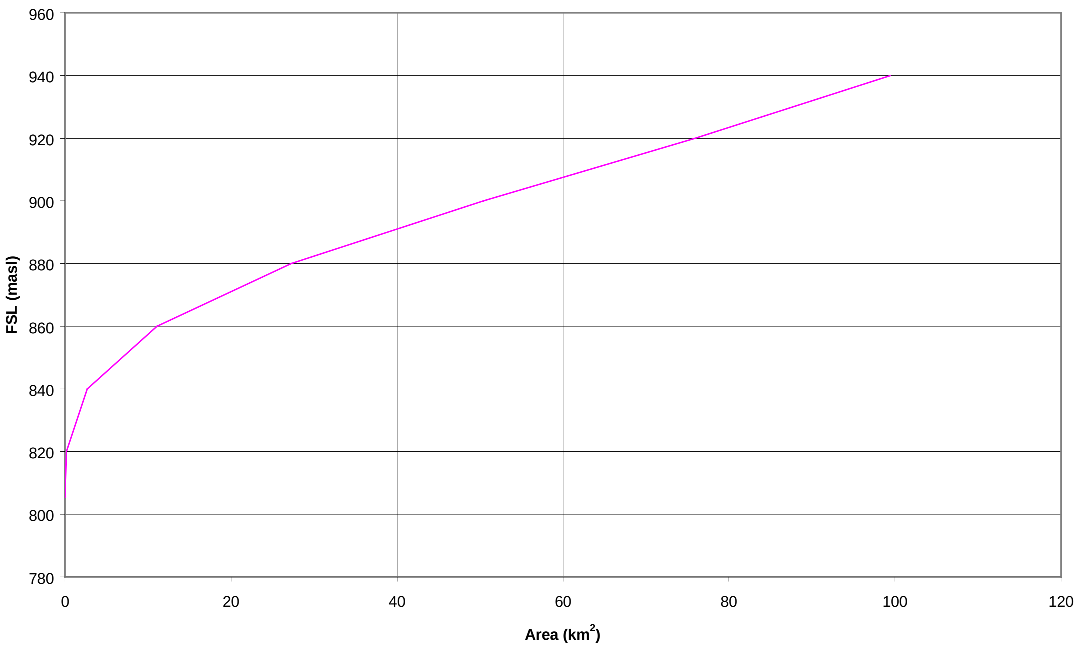


Figure E.2: Area – Elevation Curve for Uitkyk Dam

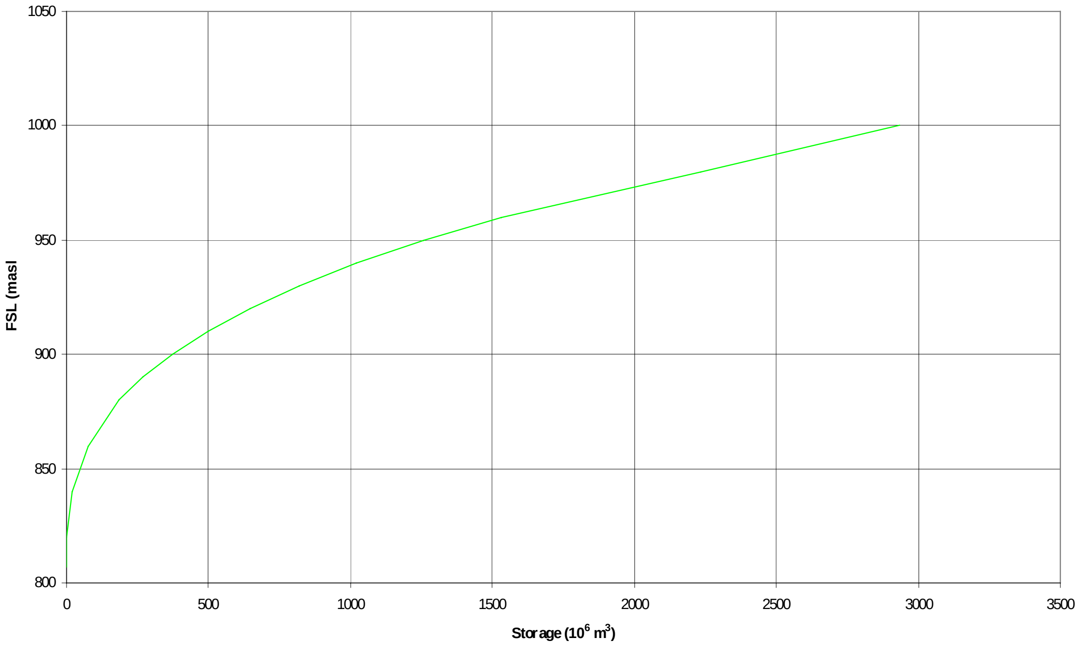


Figure E.3: Storage – Elevation Curve for Buffelshoek Dam

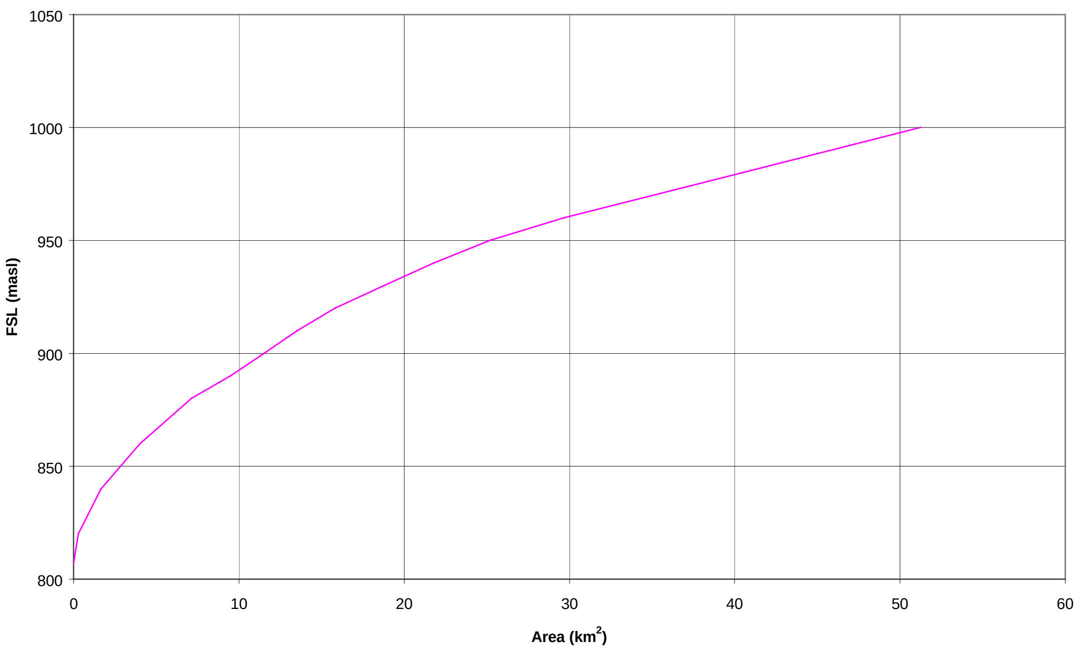


Figure E.4: Area – Elevation Curve for Buffelshoek Dam

STORAGE – AREA – ELEVATION DATA FOR UITKYK DAM

Elevation (masl)	805.5	820	840	860	880	900	920	940
Storage($x10^6$ m^3)	0.000	1.259	30.005	167.835	551.255	1328.065	2590.995	4344.168
Area (km^2)	0.000	0.174	2.701	11.082	27.260	50.421	75.872	99.445

STORAGE – AREA – ELEVATION DATA FOR BUFFELSHOEK DAM

Elevation (masl)	807	820	840	860	880	890	900	910	920	930	940	950	960	980	1000
Storage($x10^6$ m^3)	0.000	2.000	20.500	75.800	186.800	269.900	374.900	500.000	646.600	819.600	1022.400	1257.400	1531.700	2232.500	2933.300
Area (km^2)	0.000	0.293	1.647	4.011	7.139	9.485	11.510	13.511	15.808	18.787	21.790	25.206	29.640	40.440	51.240

APPENDIX F

UITKYK AND BUFFELSHOEK IFR CURVES AND DATA

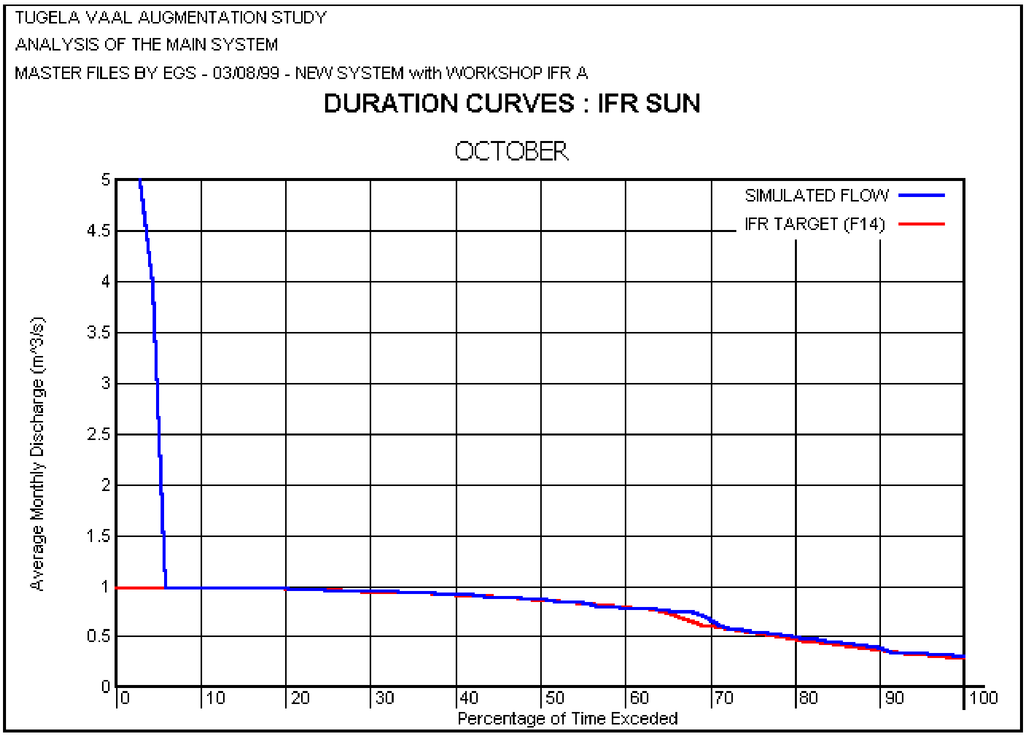


Figure F.1: Supply of IFR SUN

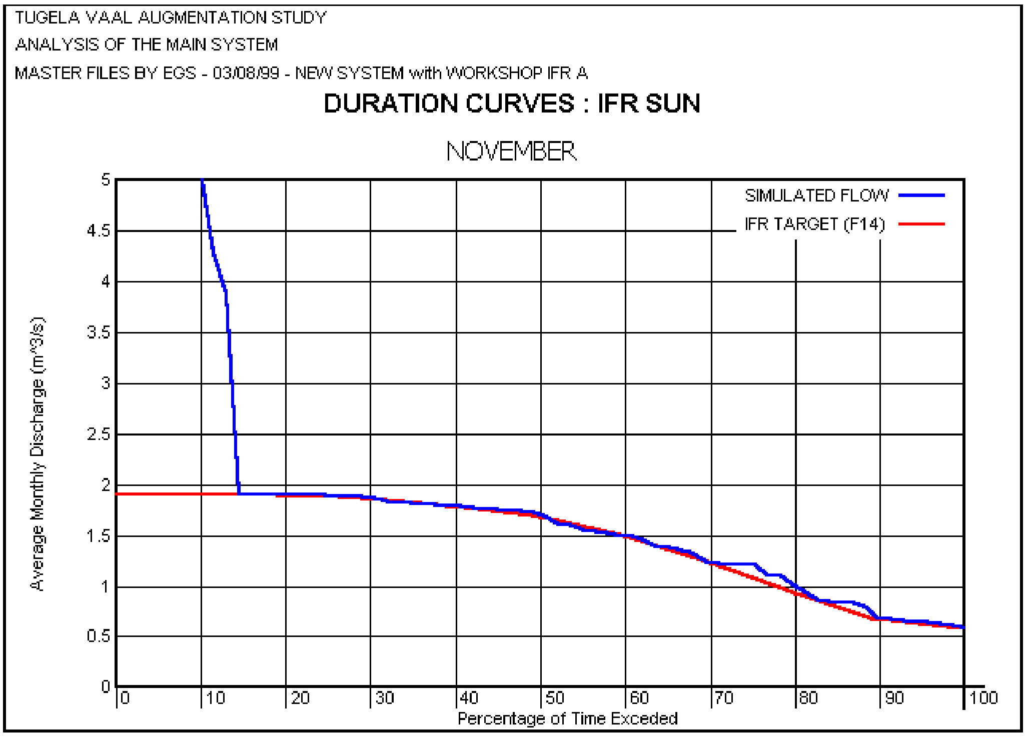


Figure F.2: Supply of IFR SUN

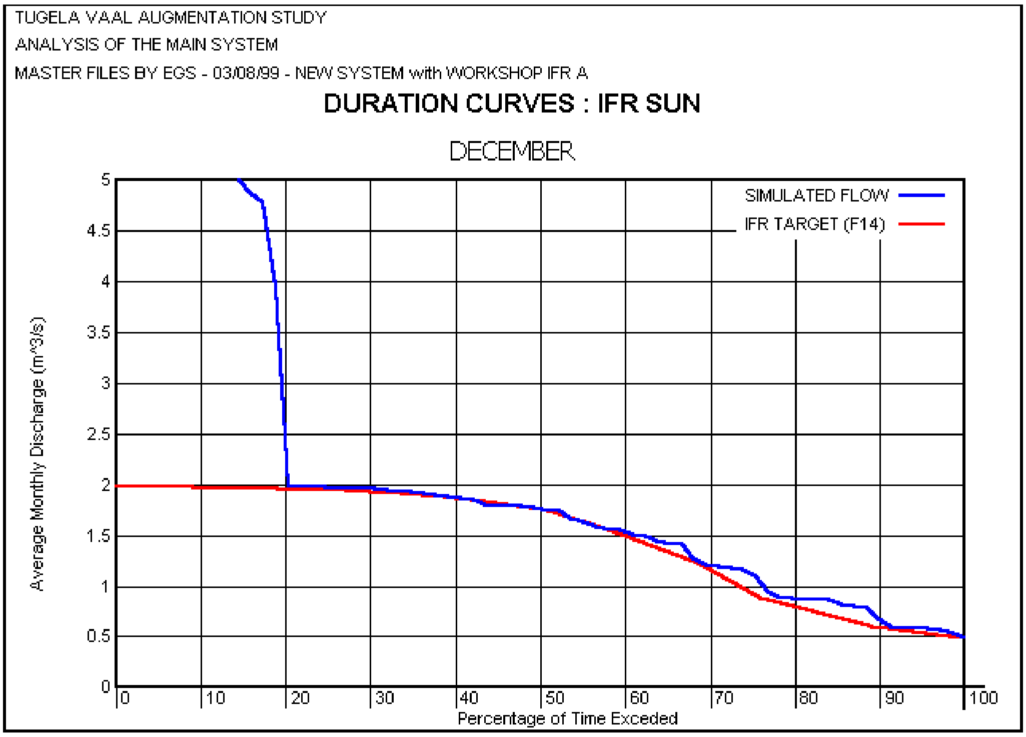


Figure F.3: Supply of IFR SUN

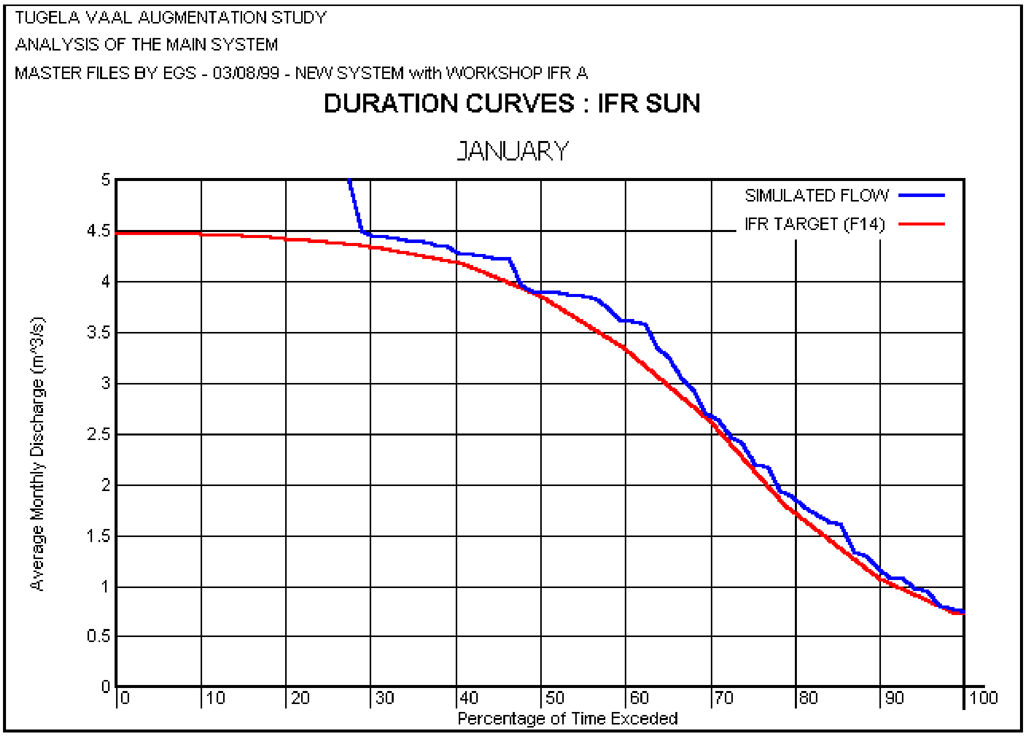


Figure F.4: Supply of IFR SUN

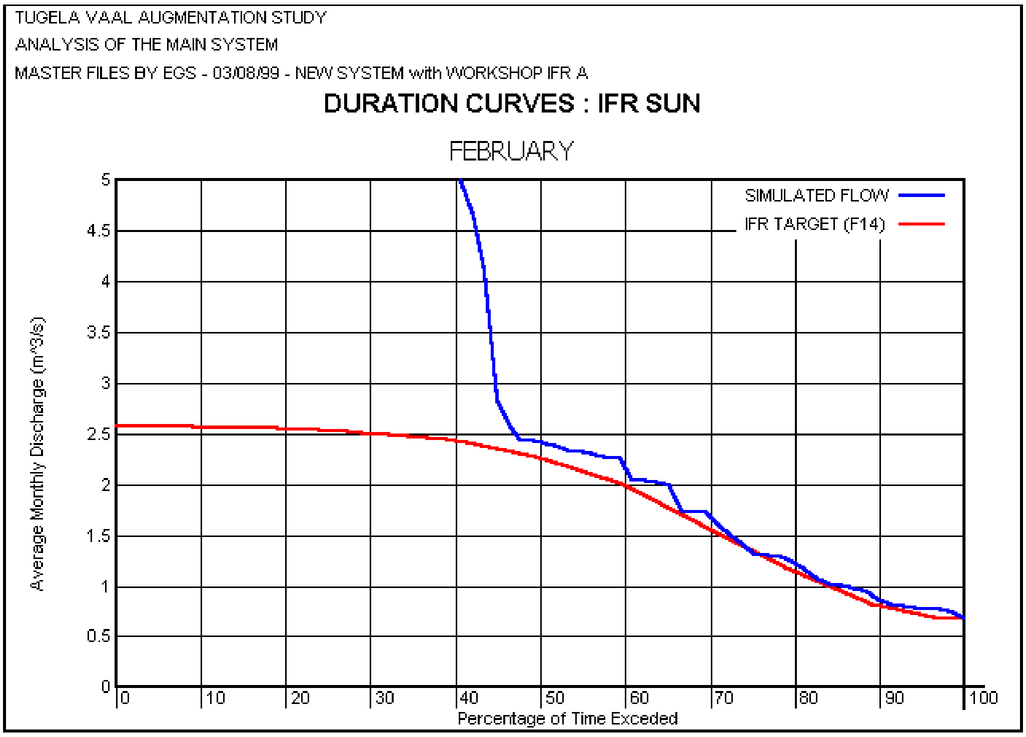


Figure F.5: Supply of IFR SUN

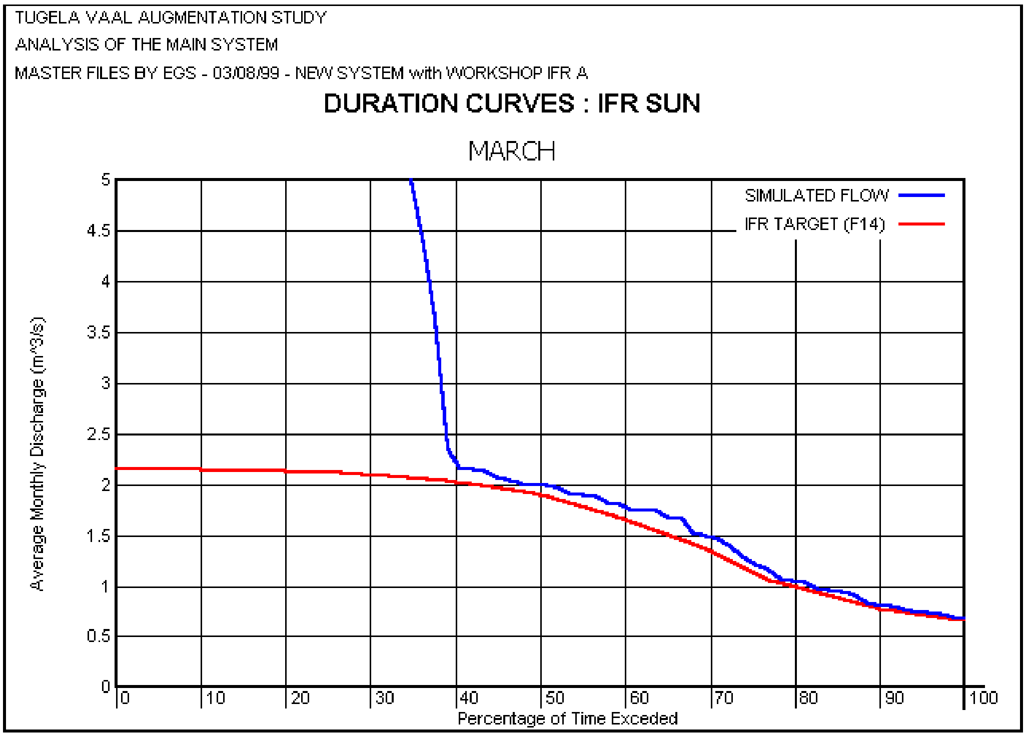


Figure F.6: Supply of IFR SUN

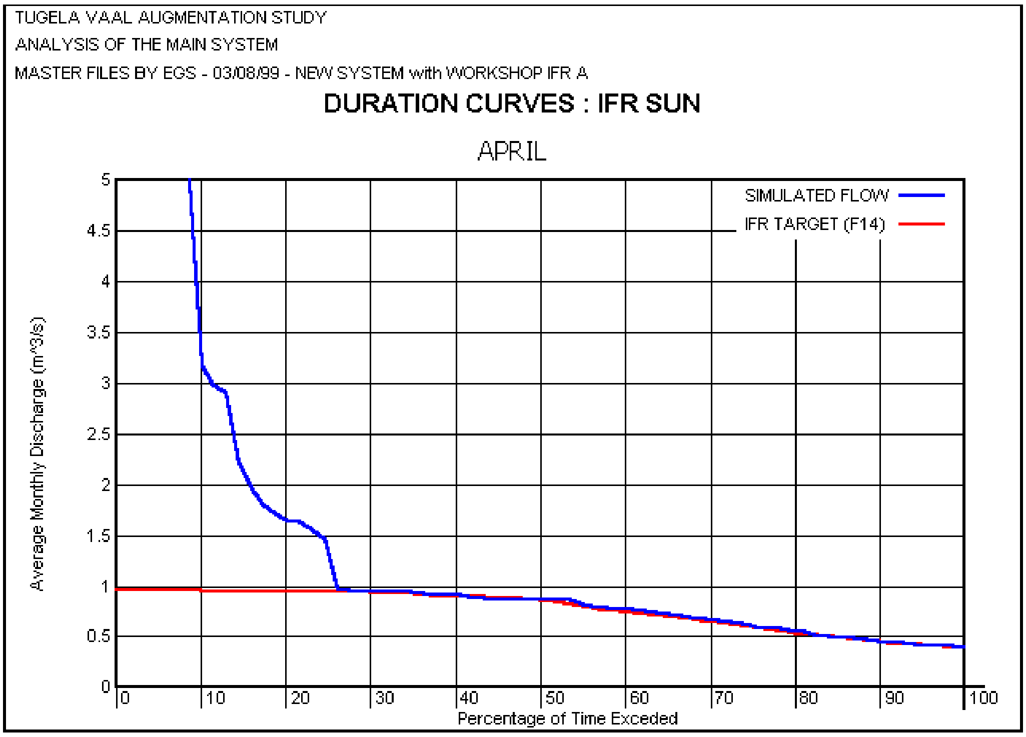


Figure F.7: Supply of IFR SUN

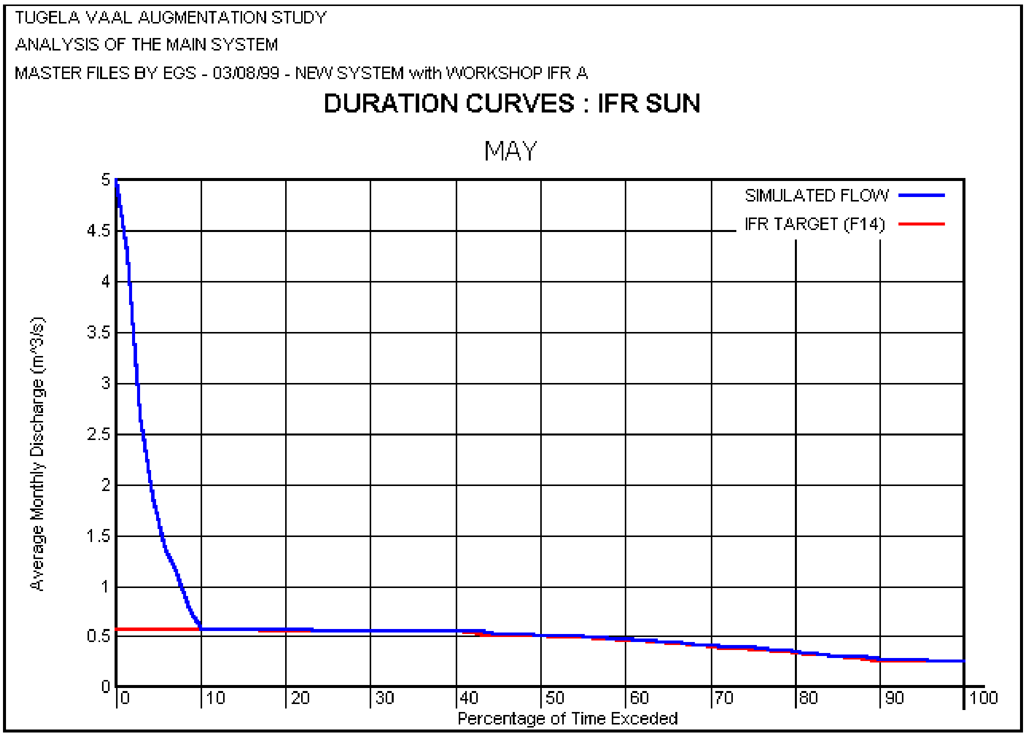


Figure F.8: Supply of IFR SUN

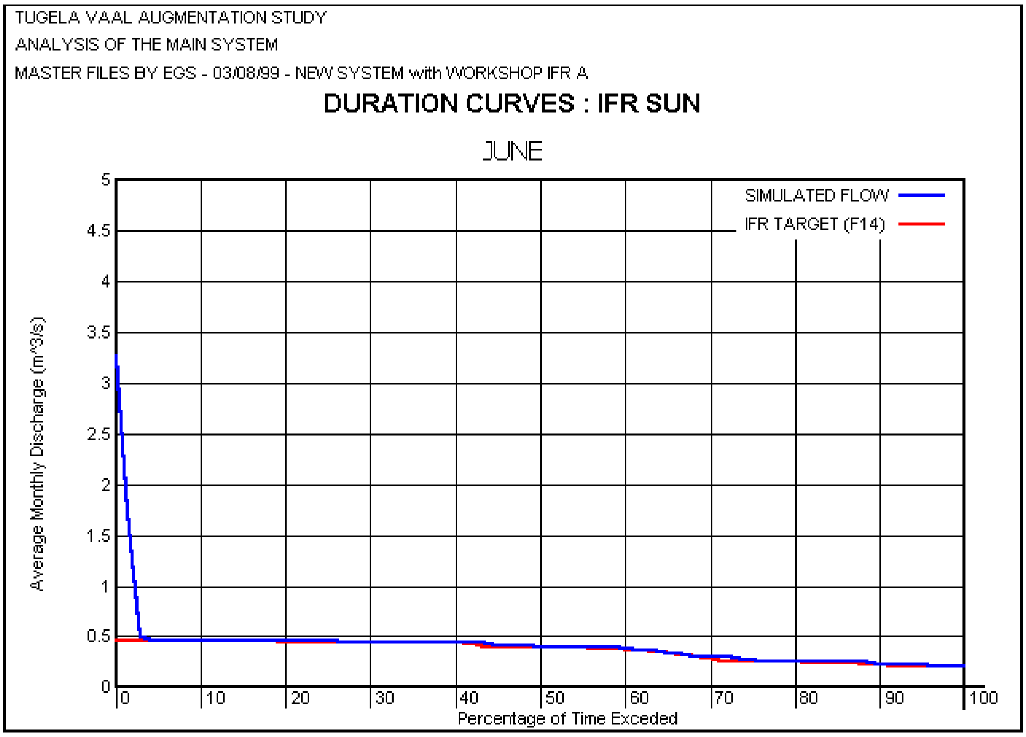


Figure F.9: Supply of IFR SUN

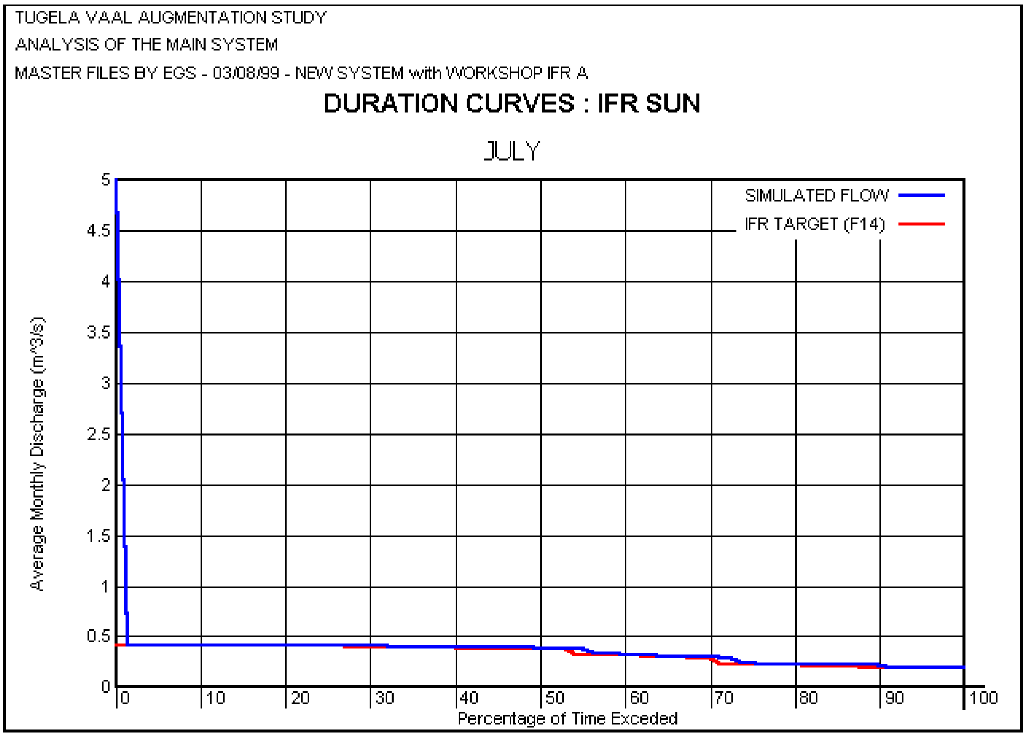


Figure F.10: Supply of IFR SUN

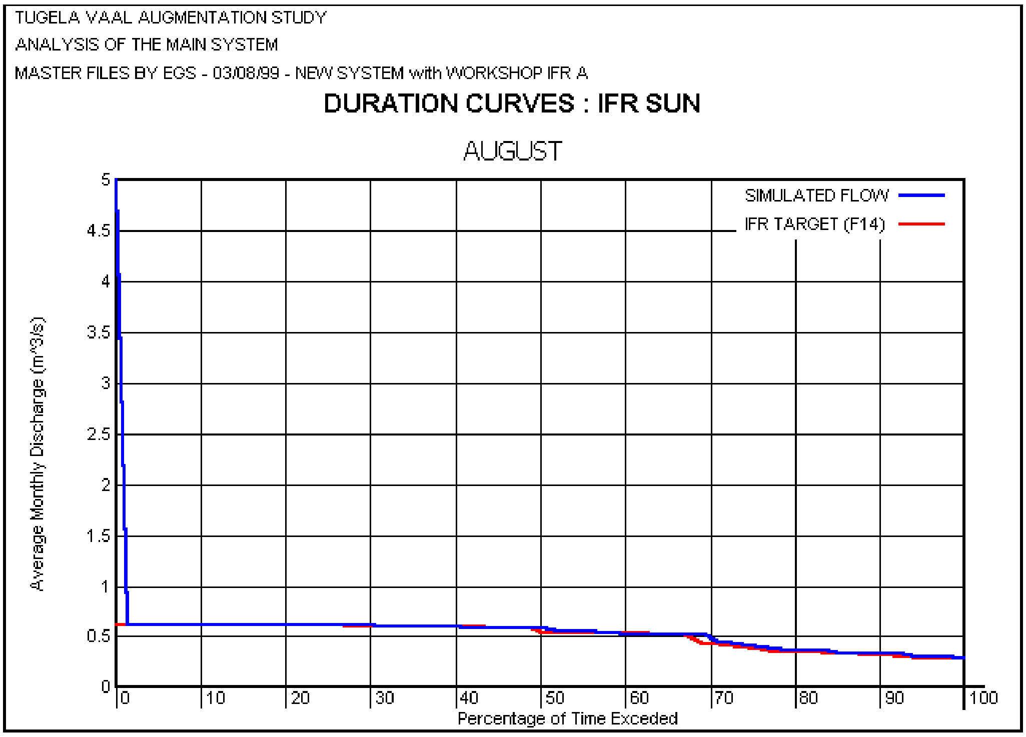


Figure F.11: Supply of IFR SUN

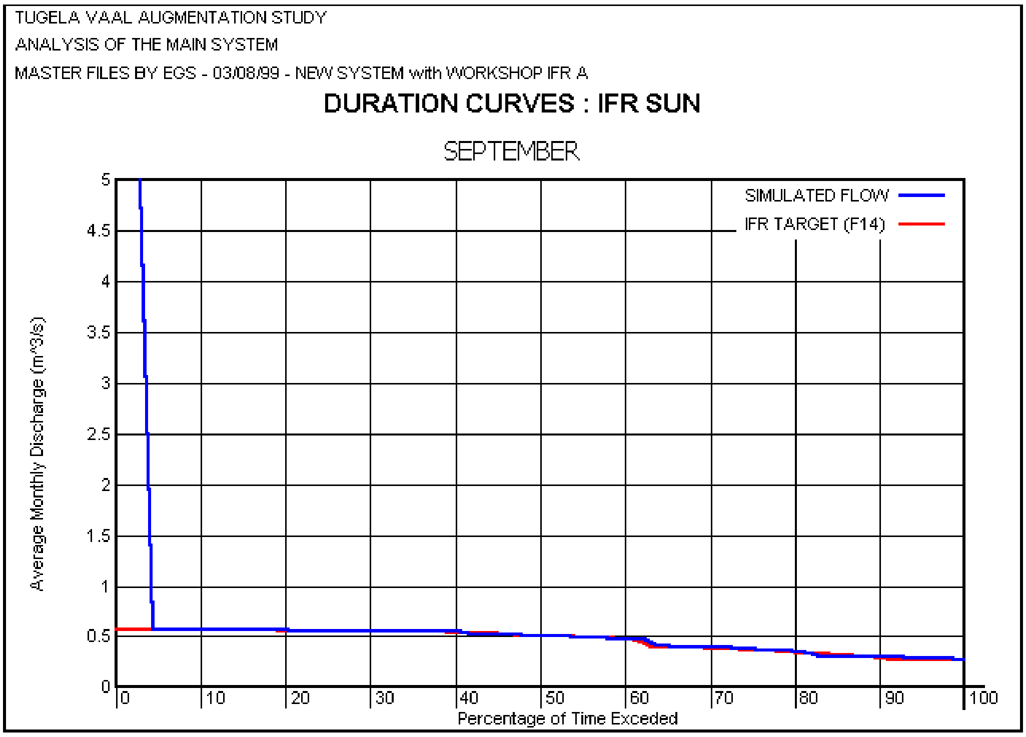


Figure F.12: Supply of IFR SUN

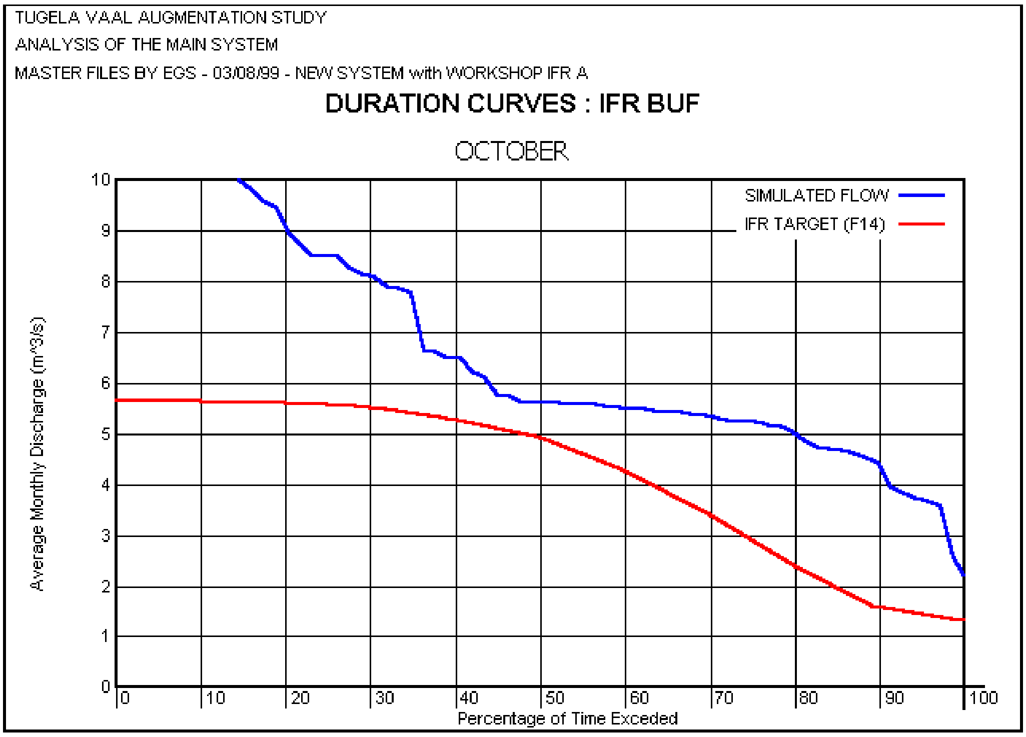


Figure F.13: Supply of IFR BUF

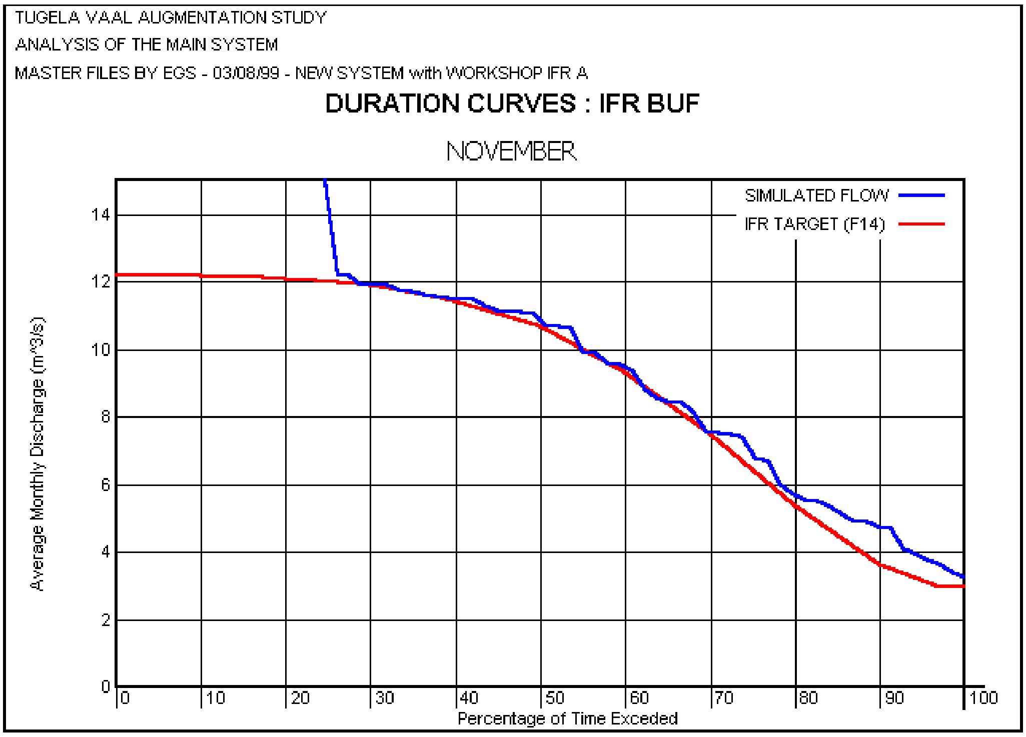


Figure F.14: Supply of IFR BUF

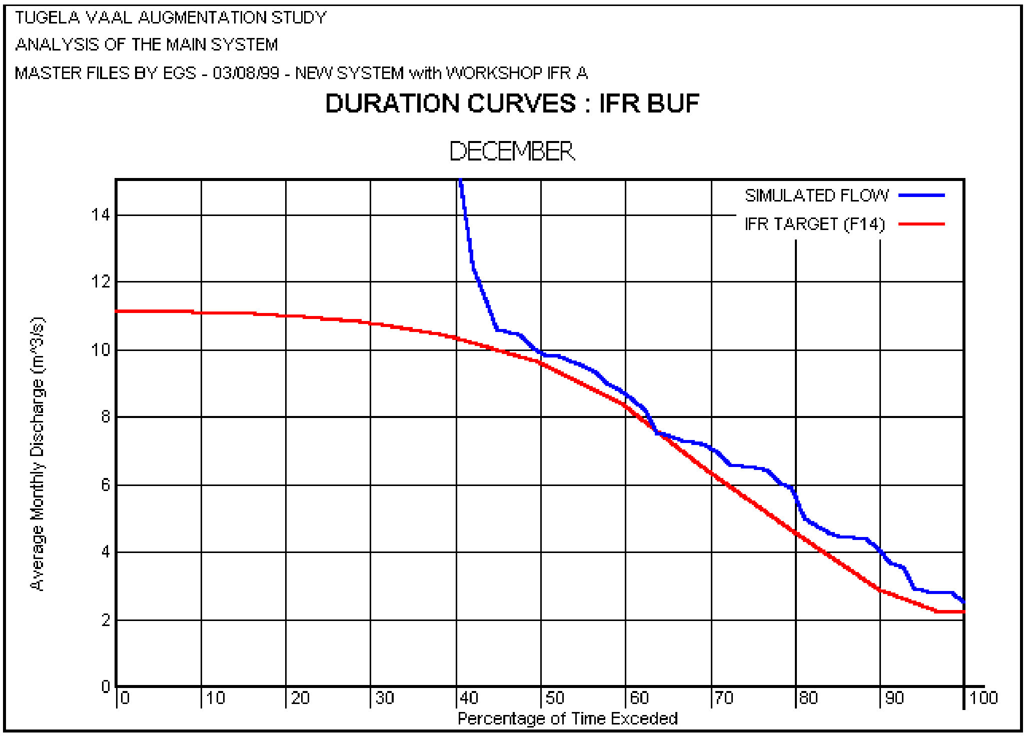


Figure F.15: Supply of IFR BUF

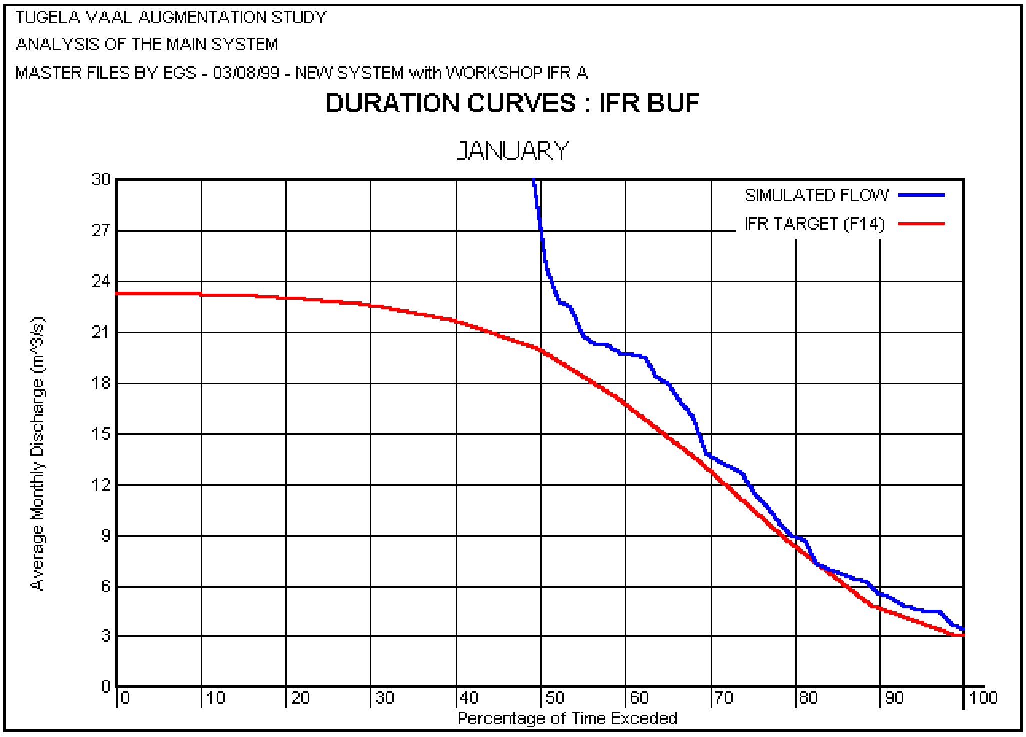


Figure F.16: Supply of IFR BUF

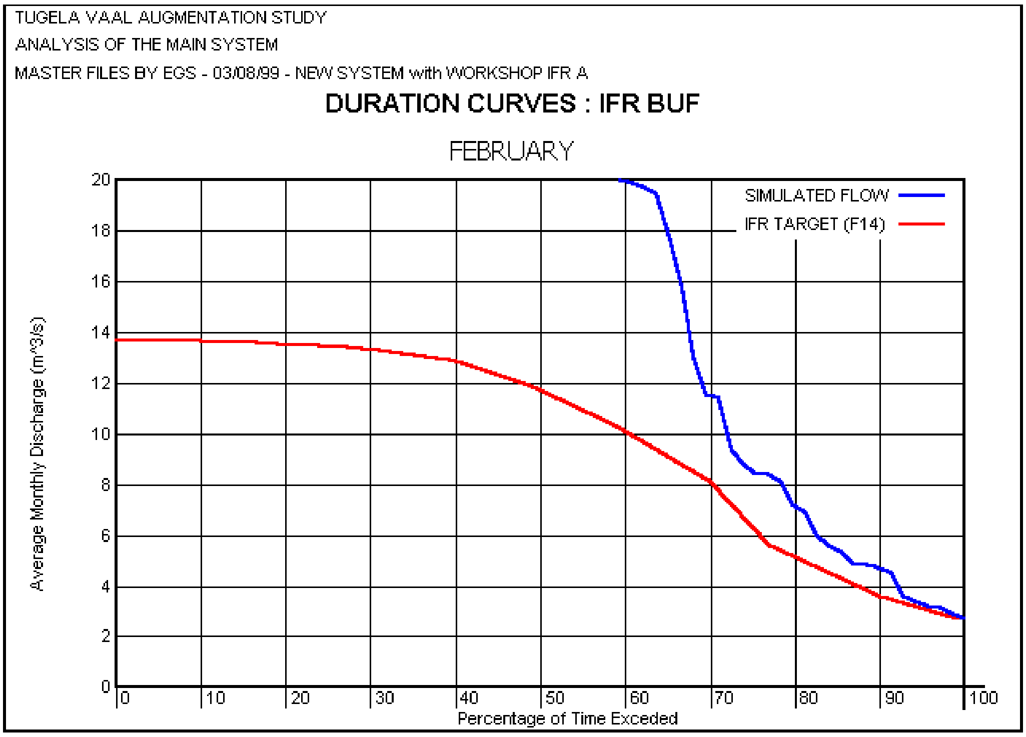


Figure F.17: Supply of IFR BUF

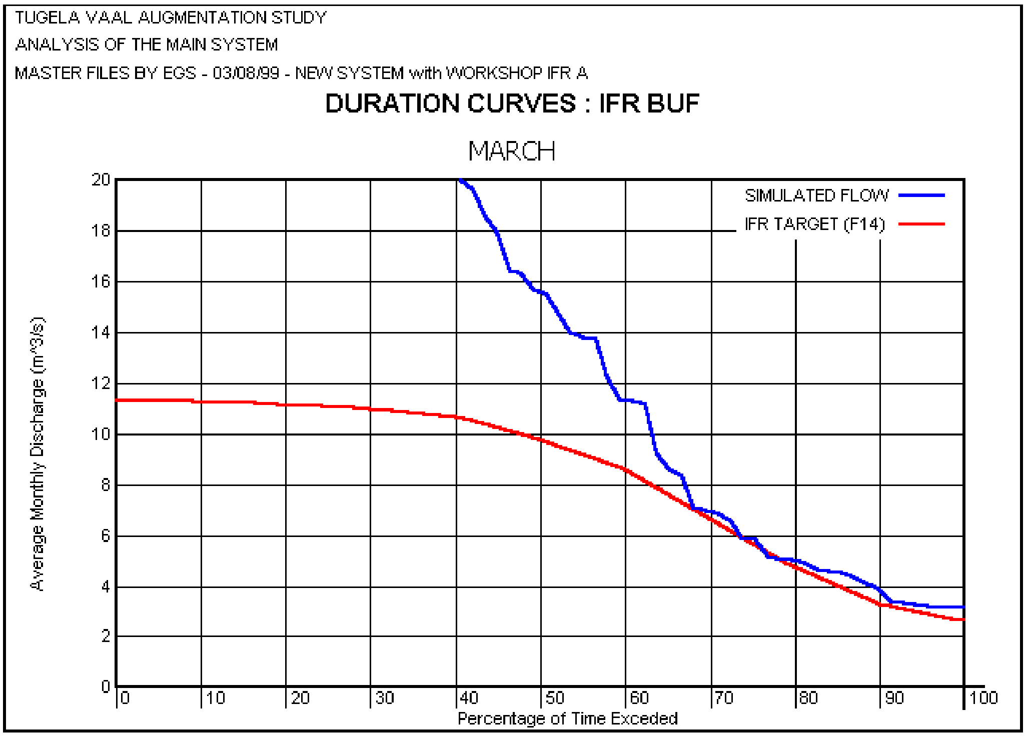


Figure F.18: Supply of IFR BUF

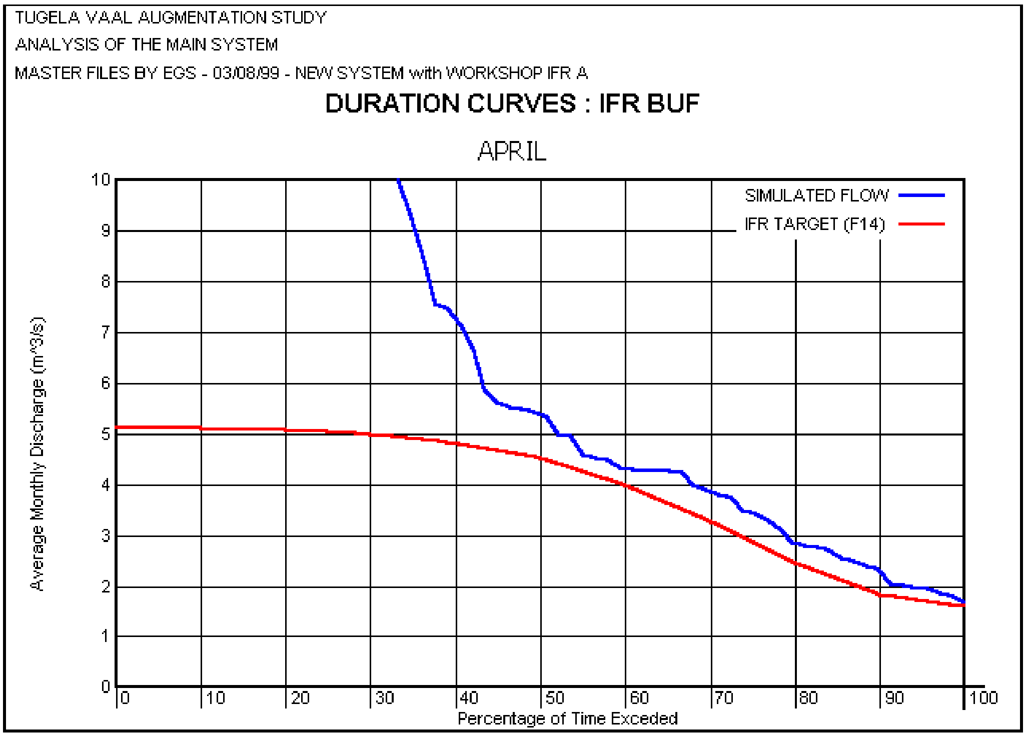


Figure F.19: Supply of IFR BUF

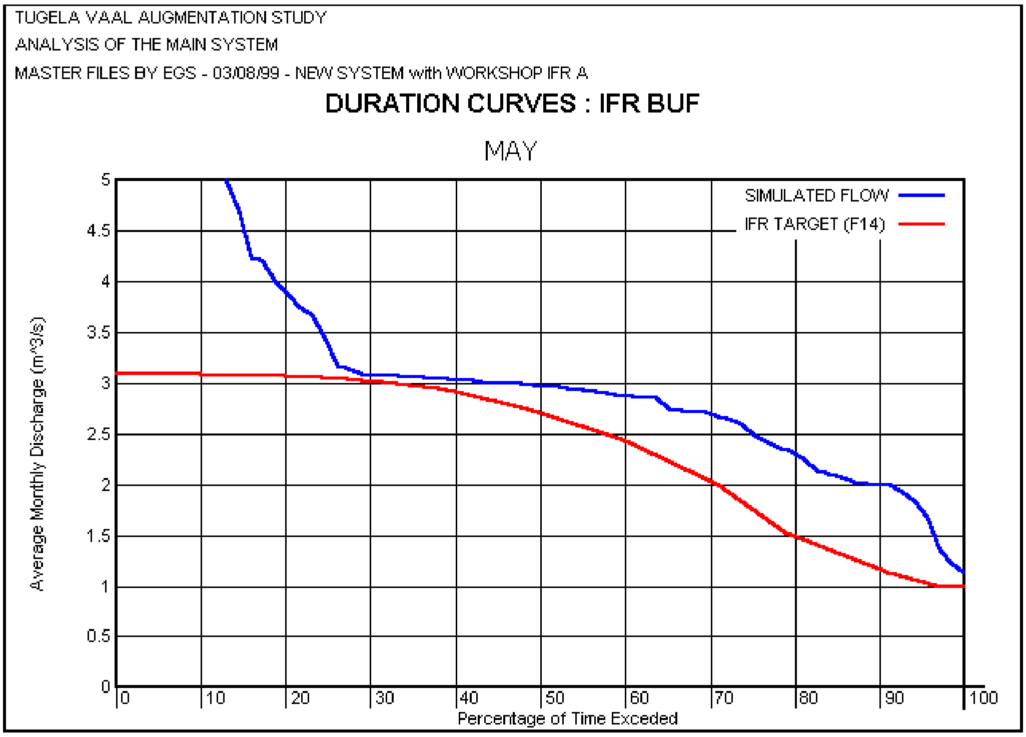


Figure F.20: Supply of IFR BUF

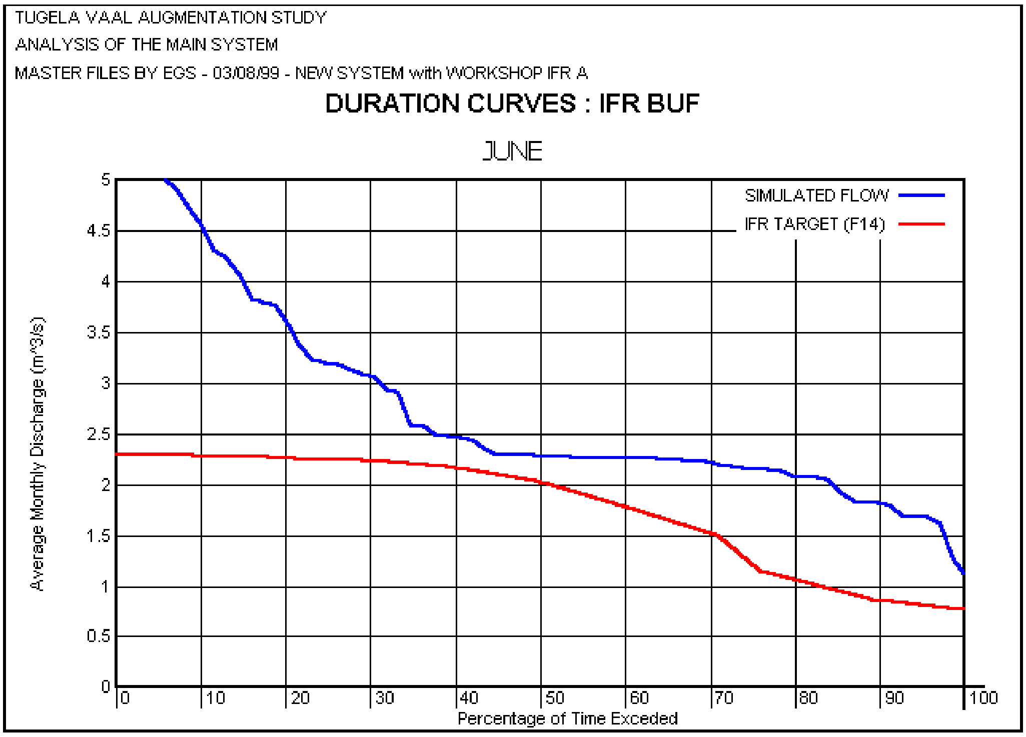


Figure F.21: Supply of IFR BUF

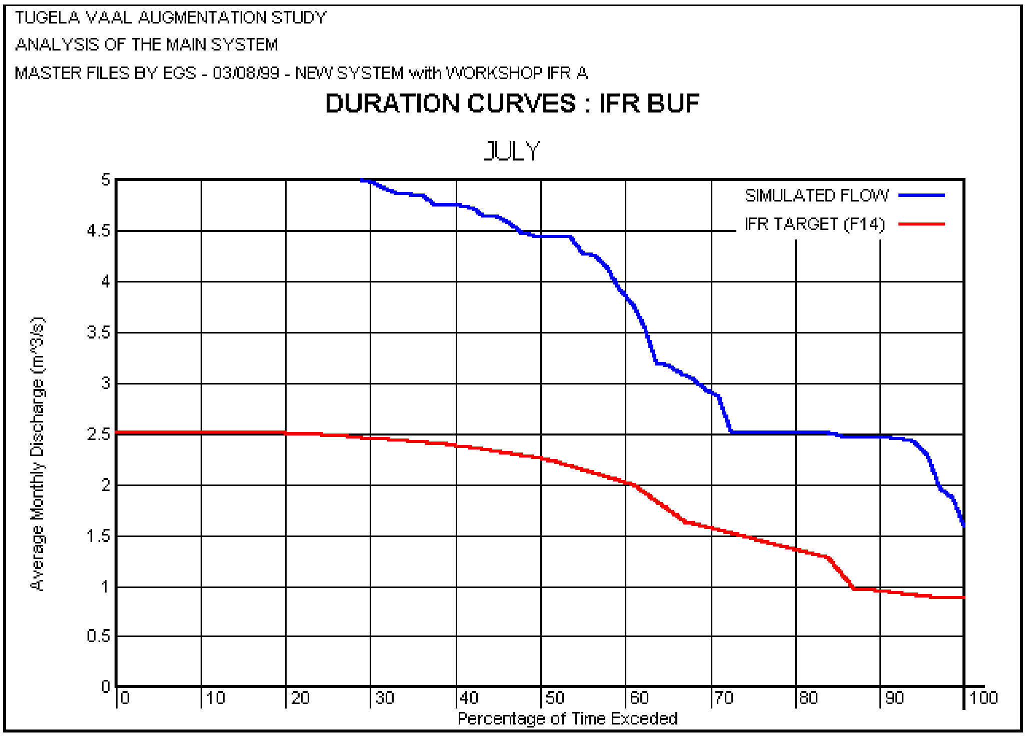


Figure F.22: Supply of IFR BUF

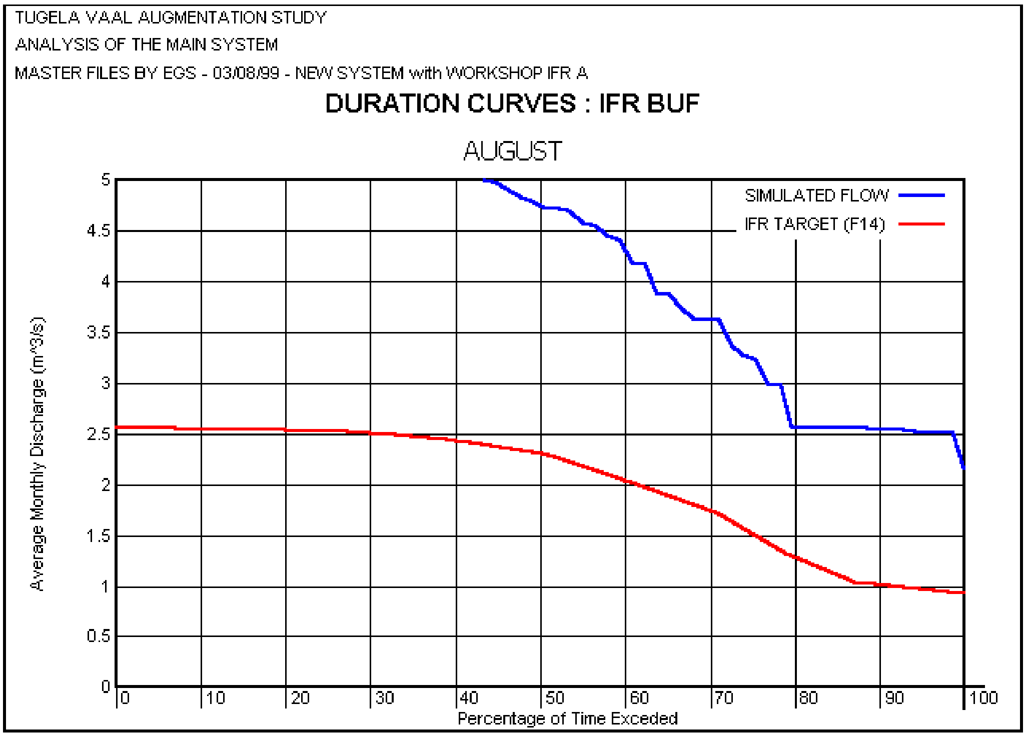


Figure F.23: Supply of IFR BUF

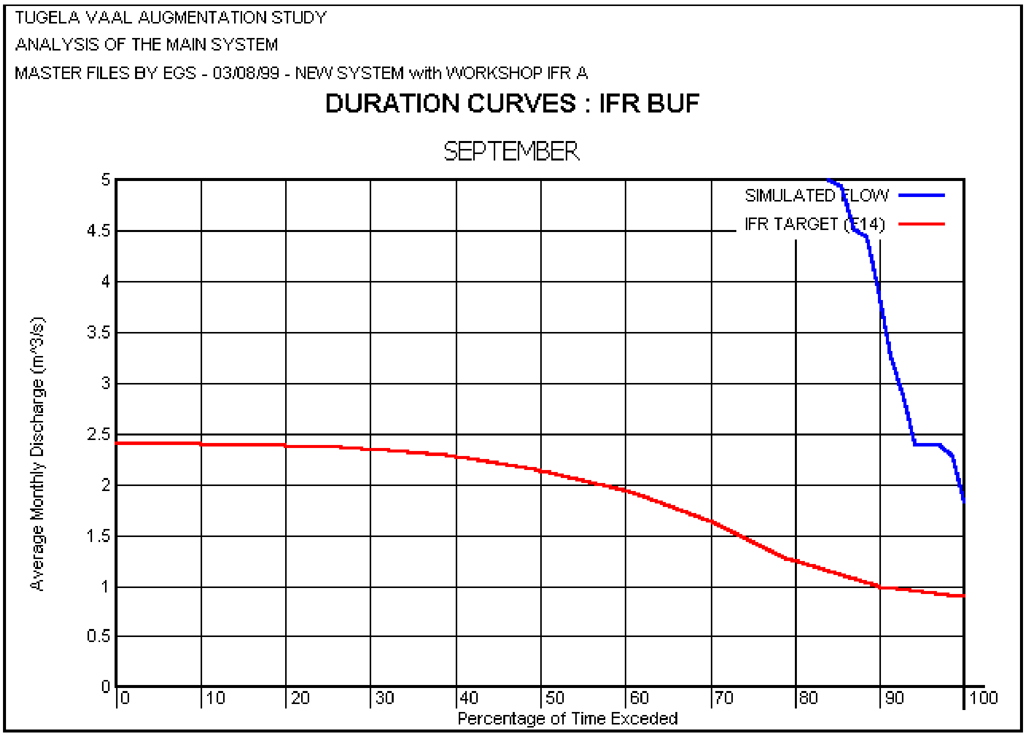


Figure F.24: Supply of IFR BUF

Data for IFR Sun Downstream of Uitkyk Dam

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	0.3	0.0	0.6	0.0	0.5	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.4	0.0	0.3	0.0	0.2	0.0	0.2	0.0	0.3	0.0	0.3
0.2	0.3	0.2	0.6	0.1	0.5	1.0	0.7	0.8	0.7	1.0	0.7	0.9	0.4	0.5	0.3	0.4	0.2	0.3	0.2	0.3	0.3	0.3	0.3
0.4	0.3	0.7	0.7	1.2	0.6	1.6	1.1	1.7	0.8	1.9	0.8	1.4	0.4	0.9	0.3	0.6	0.2	0.5	0.2	0.4	0.3	0.4	0.3
0.6	0.5	0.9	0.9	1.7	0.9	2.4	1.8	3.2	1.2	2.5	1.1	1.8	0.5	1.0	0.3	0.8	0.3	0.6	0.2	0.5	0.4	0.5	0.4
0.8	0.6	1.6	1.2	1.9	1.2	3.3	2.6	5.2	1.6	3.8	1.4	2.1	0.7	1.1	0.4	0.9	0.3	0.6	0.3	0.6	0.5	0.6	0.4
1.0	0.8	2.1	1.5	2.5	1.5	5.9	3.4	7.7	2.0	4.0	1.7	2.3	0.8	1.3	0.5	1.0	0.4	0.7	0.3	0.6	0.5	0.6	0.5
1.3	0.9	2.4	1.7	3.8	1.7	7.5	3.9	10.5	2.3	5.2	1.9	2.5	0.9	1.6	0.5	1.1	0.4	0.7	0.4	0.7	0.6	0.7	0.5
1.5	0.9	3.2	1.8	6.3	1.9	9.6	4.2	13.9	2.4	7.3	2.0	3.3	0.9	1.6	0.6	1.1	0.4	0.9	0.4	0.7	0.6	0.8	0.6
2.5	1.0	4.7	1.9	8.7	1.9	14.6	4.4	20.5	2.5	8.9	2.1	3.6	0.9	1.9	0.6	1.2	0.5	1.1	0.4	0.9	0.6	1.1	0.6
3.5	1.0	9.5	1.9	11.3	2.0	22.5	4.4	22.4	2.6	11.3	2.1	4.4	1.0	2.2	0.6	1.4	0.5	1.2	0.4	1.2	0.6	1.4	0.6
7.7	1.0	16.4	1.9	16.9	2.0	35.4	4.5	31.3	2.6	15.5	2.2	7.4	1.0	3.3	0.6	1.7	0.5	1.5	0.4	1.6	0.6	2.5	0.6
999.0	1.0	999.0	1.9	999.0	2.0	999.0	4.5	999.0	2.6	999.0	2.2	999.0	1.0	999.0	0.6	999.0	0.5	999.0	0.4	999.0	0.6	999.0	0.6

* Combined flow from inflow nodes 33 (TM14) and 34 (TM15).

Data for IFR Buf Downstream of Buffelshoek Dam

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	1.3	0.0	3.0	0.0	2.2	0.0	3.0	0.0	2.7	0.0	2.7	0.0	1.6	0.0	1.0	0.0	0.8	0.0	0.9	0.0	0.9	0.0	0.9
0.5	1.3	0.6	3.0	0.5	2.2	3.3	3.0	4.0	2.7	3.2	2.7	2.8	1.6	1.3	1.0	0.7	0.8	0.7	0.9	0.6	0.9	0.7	0.9
1.5	1.6	2.6	3.7	5.1	2.9	6.9	4.9	11.7	3.6	7.8	3.3	4.5	1.8	1.9	1.1	1.3	0.9	0.9	1.0	0.9	1.0	0.9	1.0
2.1	2.4	6.0	5.4	7.4	4.6	13.0	8.7	18.4	5.6	10.4	4.9	5.4	2.5	2.8	1.5	1.6	1.2	1.1	1.3	1.1	1.3	1.2	1.3
3.4	3.4	9.7	7.5	10.0	6.6	26.1	13.3	28.2	8.1	14.2	6.9	8.2	3.3	3.3	2.0	1.8	1.5	1.4	1.6	1.3	1.7	1.5	1.6
4.6	4.3	12.6	9.3	16.3	8.3	32.2	17.2	38.2	10.3	19.0	8.6	8.8	4.0	3.6	2.4	2.3	1.8	1.5	2.0	1.6	2.0	1.8	1.9
5.2	4.9	13.8	10.7	18.4	9.6	43.3	20.0	48.6	11.9	25.1	9.8	10.4	4.5	4.4	2.7	2.6	2.0	1.7	2.2	1.8	2.3	2.2	2.1
7.1	5.3	17.8	11.5	34.2	10.4	52.8	21.7	59.0	12.9	32.7	10.6	13.4	4.8	5.0	2.9	3.2	2.2	2.4	2.4	2.1	2.4	2.6	2.3
10.3	5.5	27.4	11.9	51.7	10.8	75.1	22.6	77.4	13.4	45.1	11.0	16.0	5.0	6.6	3.0	3.8	2.2	3.0	2.5	2.7	2.5	3.1	2.4
14.9	5.6	62.5	12.1	62.2	11.0	99.6	23.1	112.1	13.6	66.5	11.2	24.7	5.1	7.8	3.1	4.6	2.3	3.7	2.5	3.6	2.6	5.5	2.4
28.9	5.7	78.6	12.2	107.4	11.1	129.2	23.3	176.5	13.7	81.1	11.3	33.1	5.1	13.7	3.1	5.6	2.3	4.7	2.5	5.6	2.6	10.6	2.4
999.0	5.7	999.0	12.2	999.0	11.1	999.0	23.3	999.0	13.7	999.0	11.3	999.0	5.1	999.0	3.1	999.0	2.3	999.0	2.5	999.0	2.6	999.0	2.4

* Combined flow from inflow nodes 46 (TM24), 48 (TM25), 50 (TM26), 52 (TM31), 53 (TM27) and 56(TM28).

APPENDIX G

IFR AND EFR CURVES AND DATA

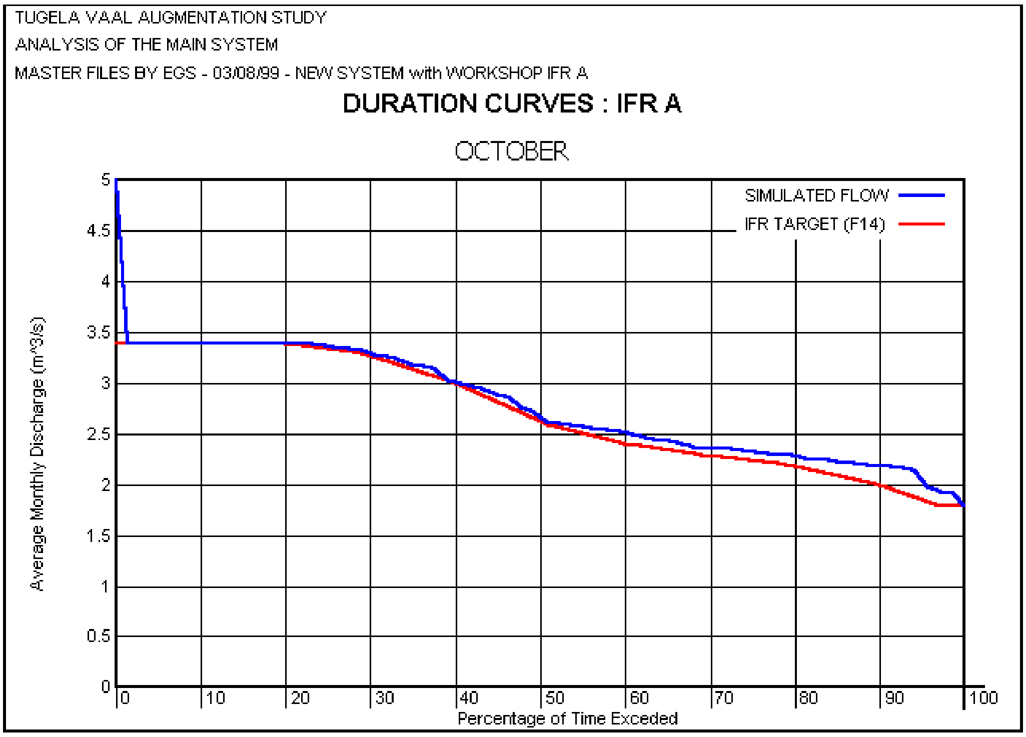


Figure G.1: Supply of IFR A

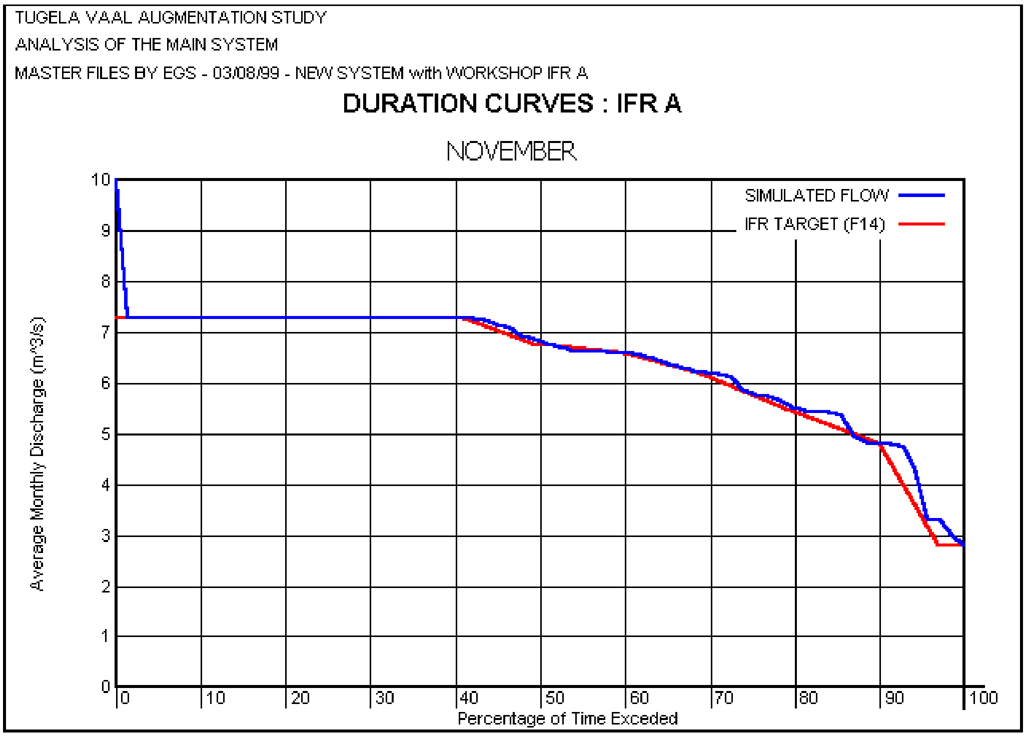


Figure G.2: Supply of IFR A

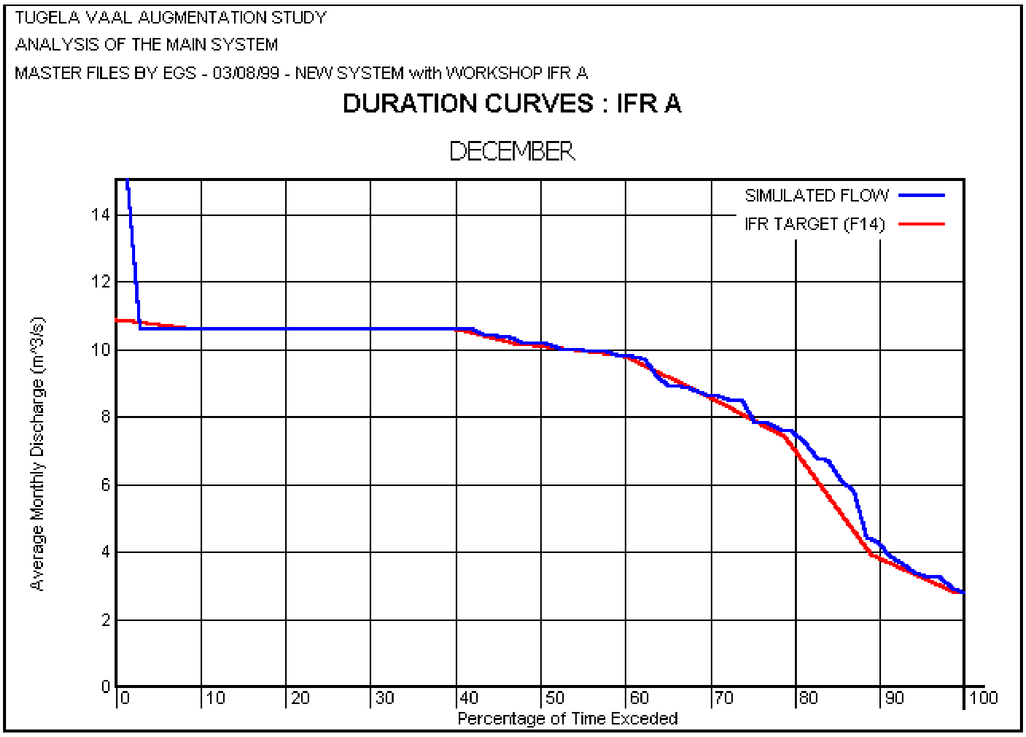


Figure G.3: Supply of IFR A

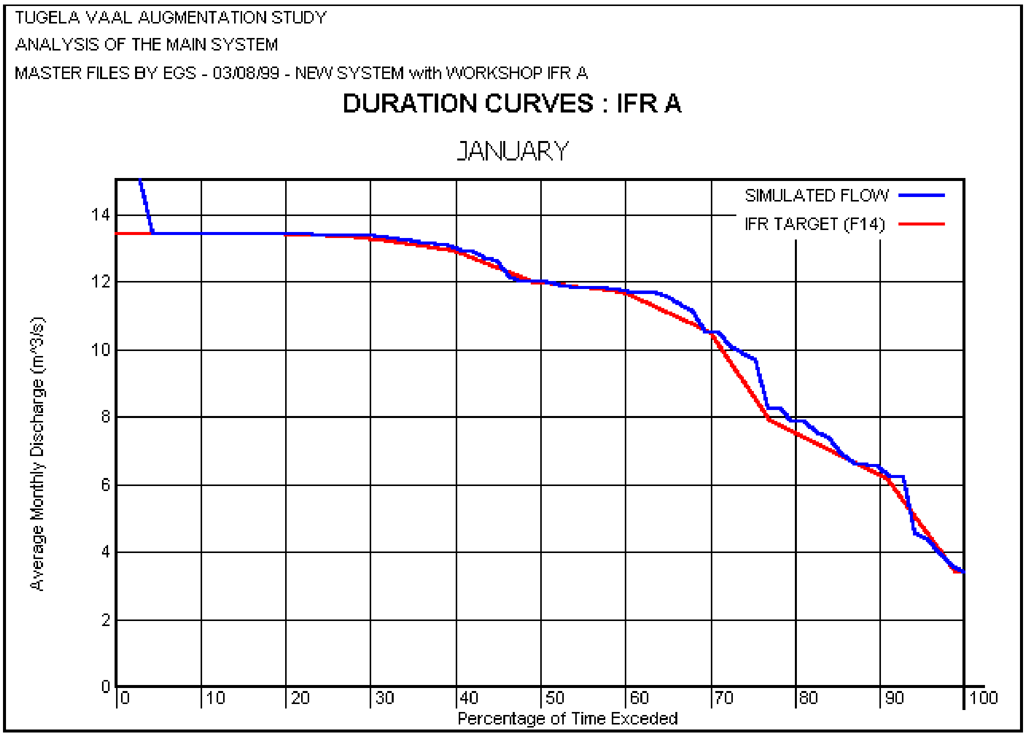


Figure G.4: Supply of IFR A

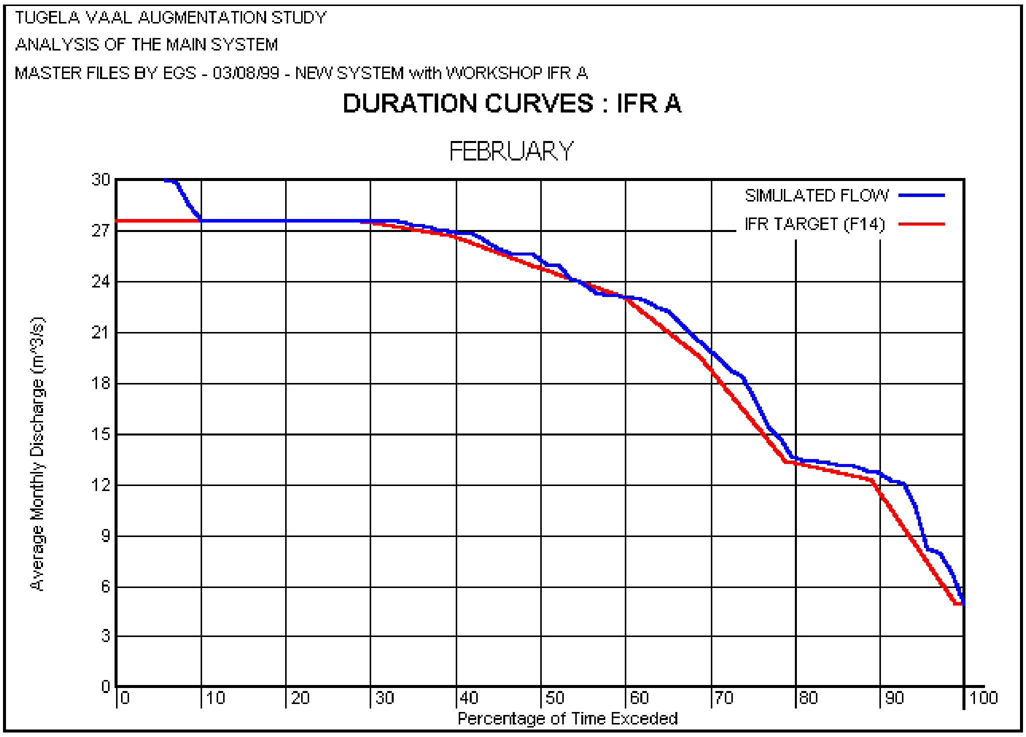


Figure G.5: Supply of IFR A

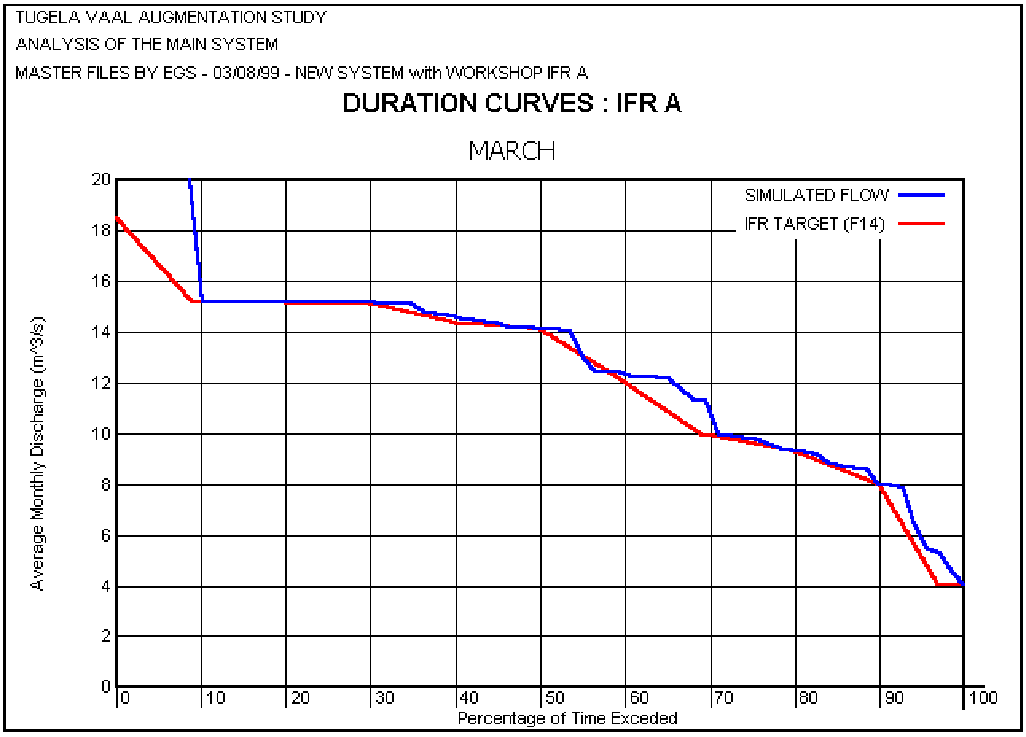


Figure G.6: Supply of IFR A

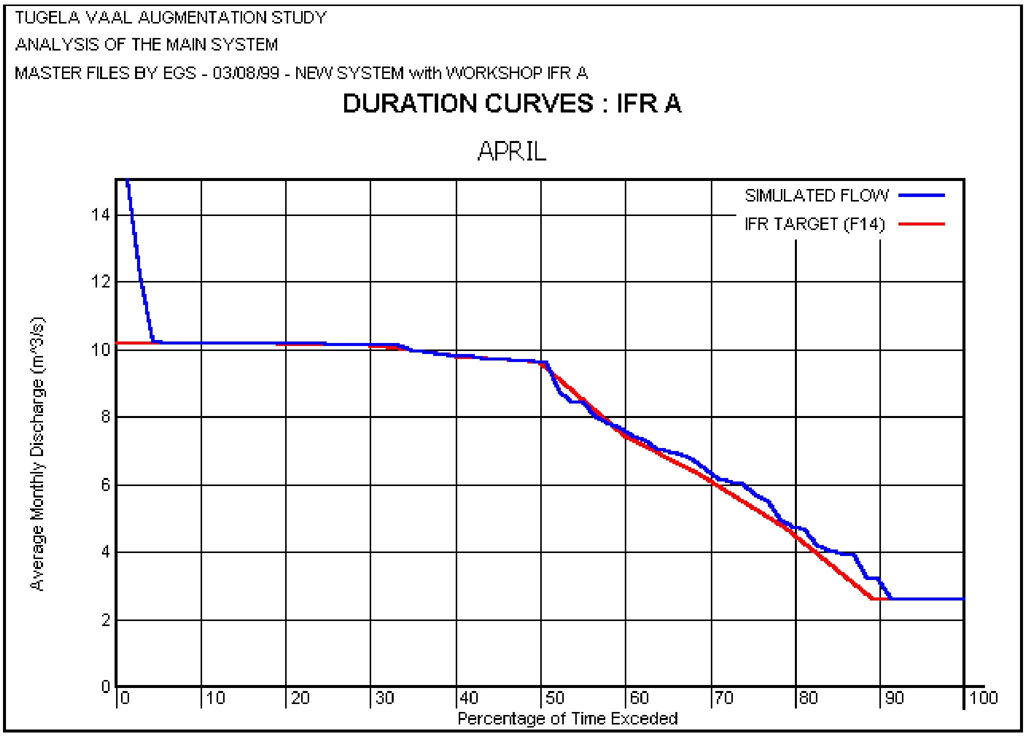


Figure G.7: Supply of IFR A

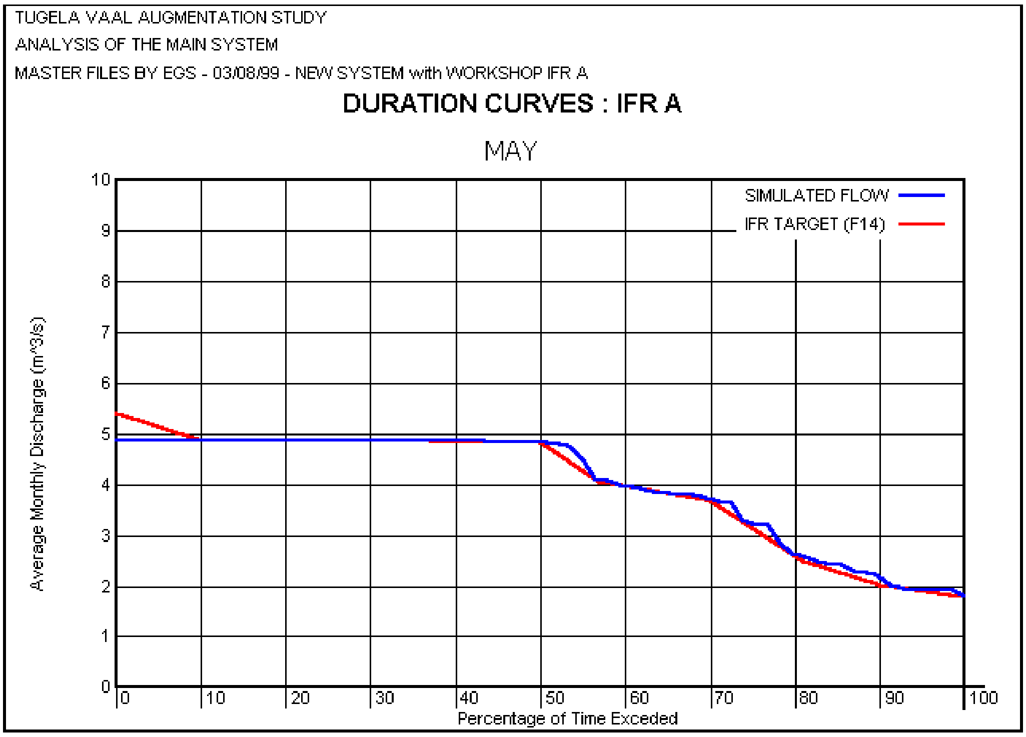


Figure G.8: Supply of IFR A

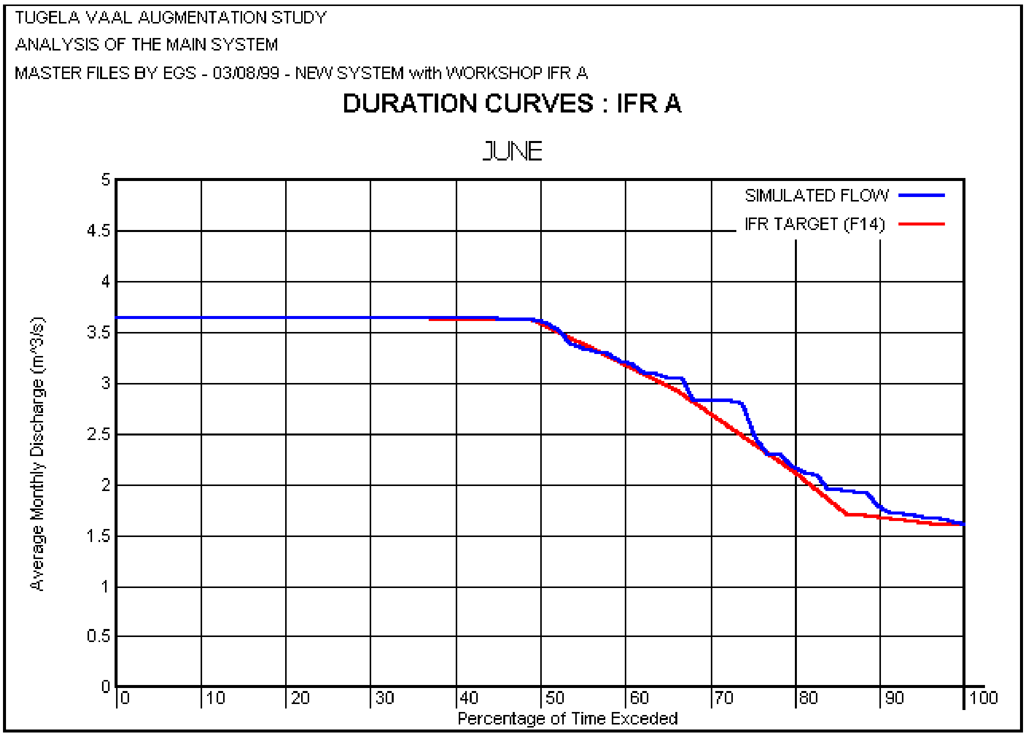


Figure G.9: Supply of IFR A

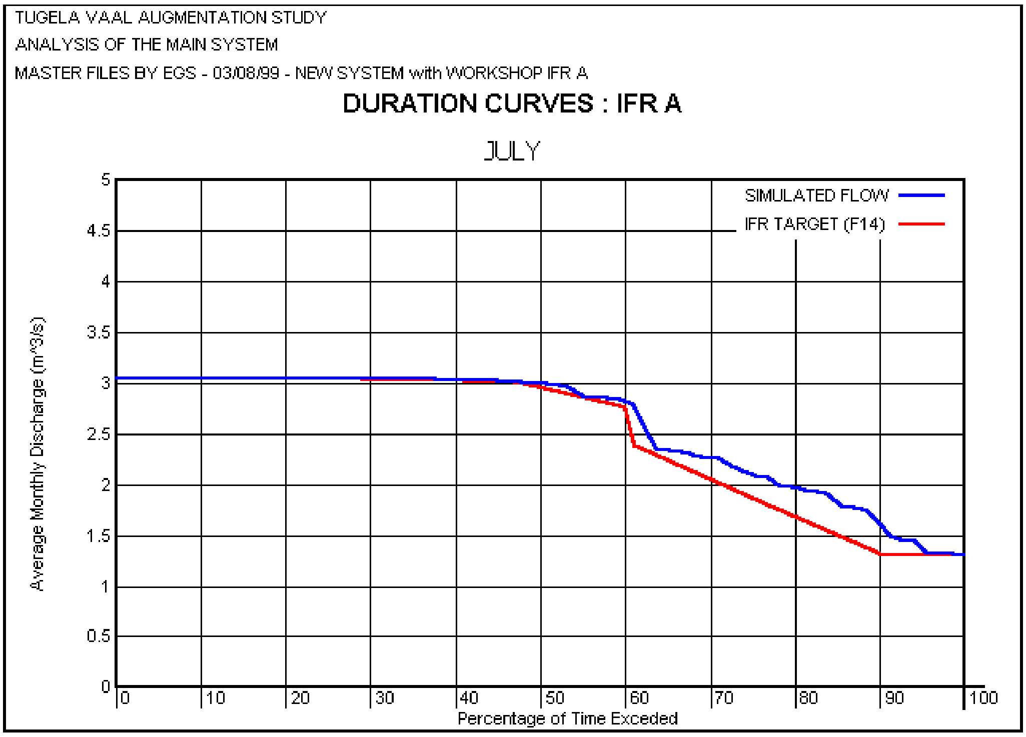


Figure G.10: Supply of IFR A

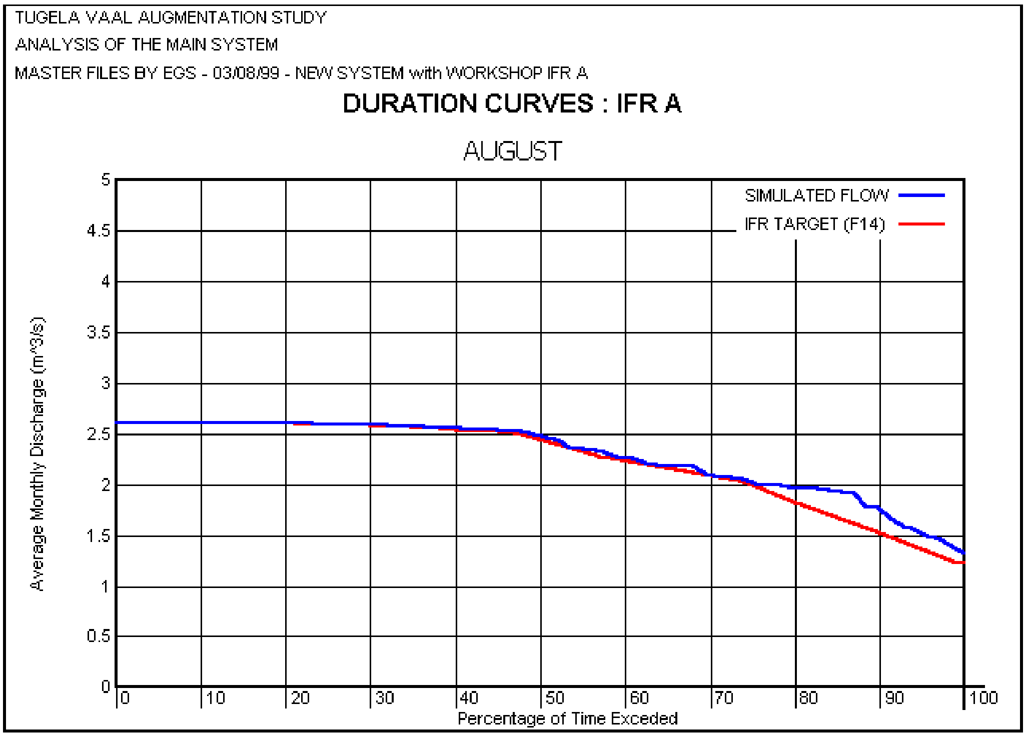


Figure G.11: Supply of IFR A

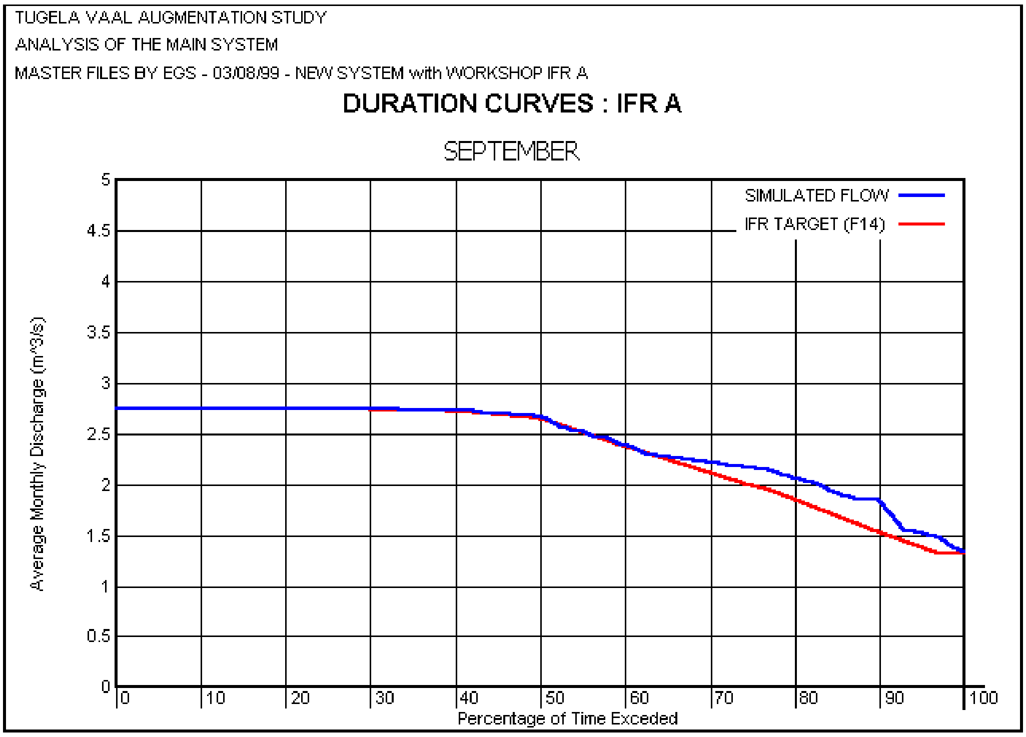


Figure G.12: Supply of IFR A

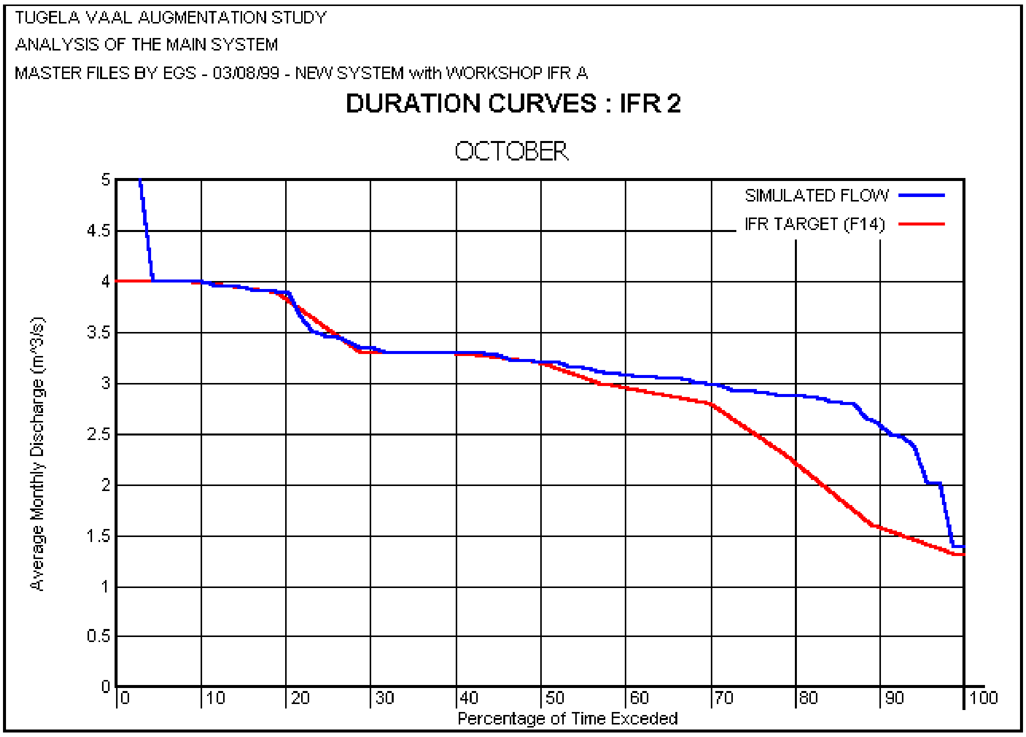


Figure G.13: Supply of IFR 2

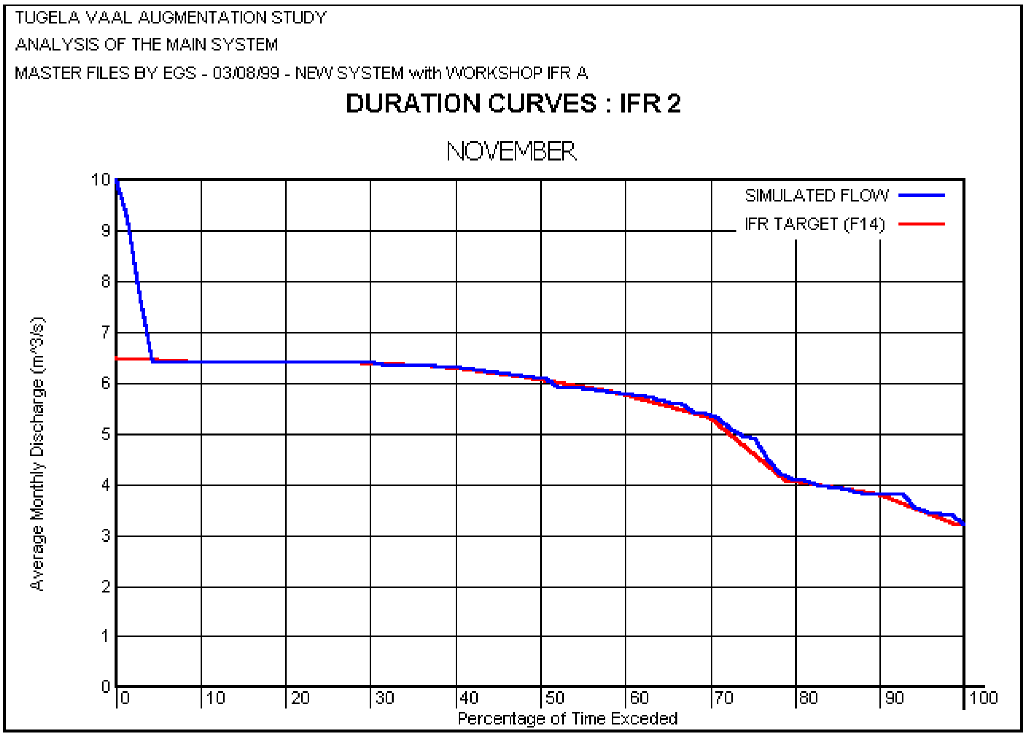


Figure G.14: Supply of IFR 2

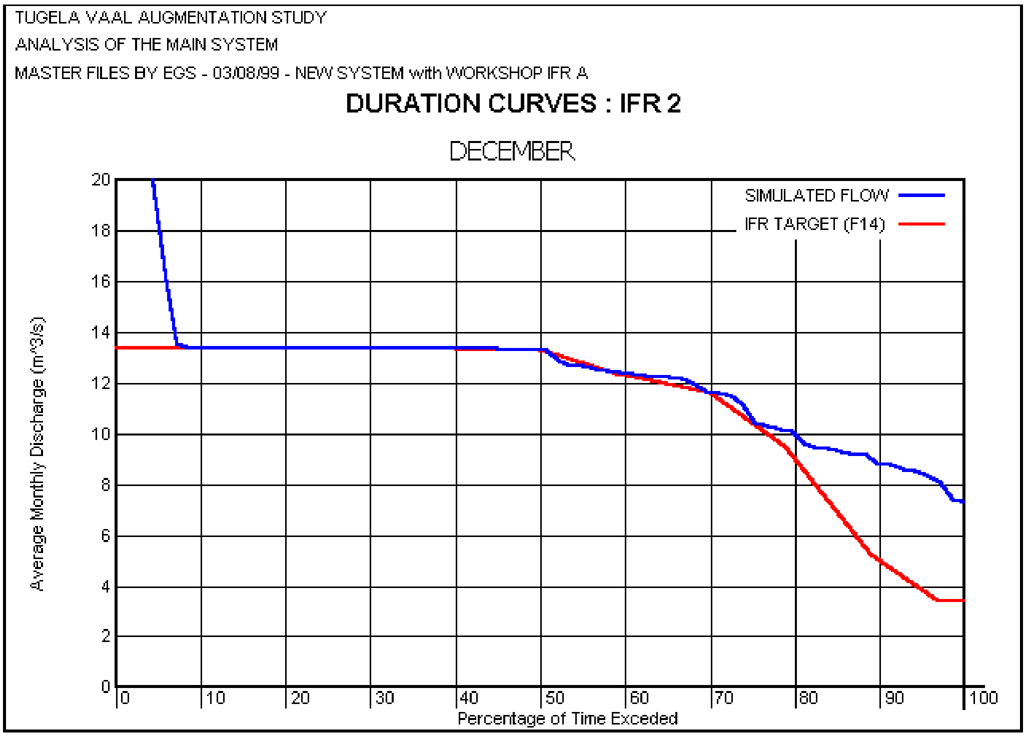


Figure G 15: Supply of IFR 2

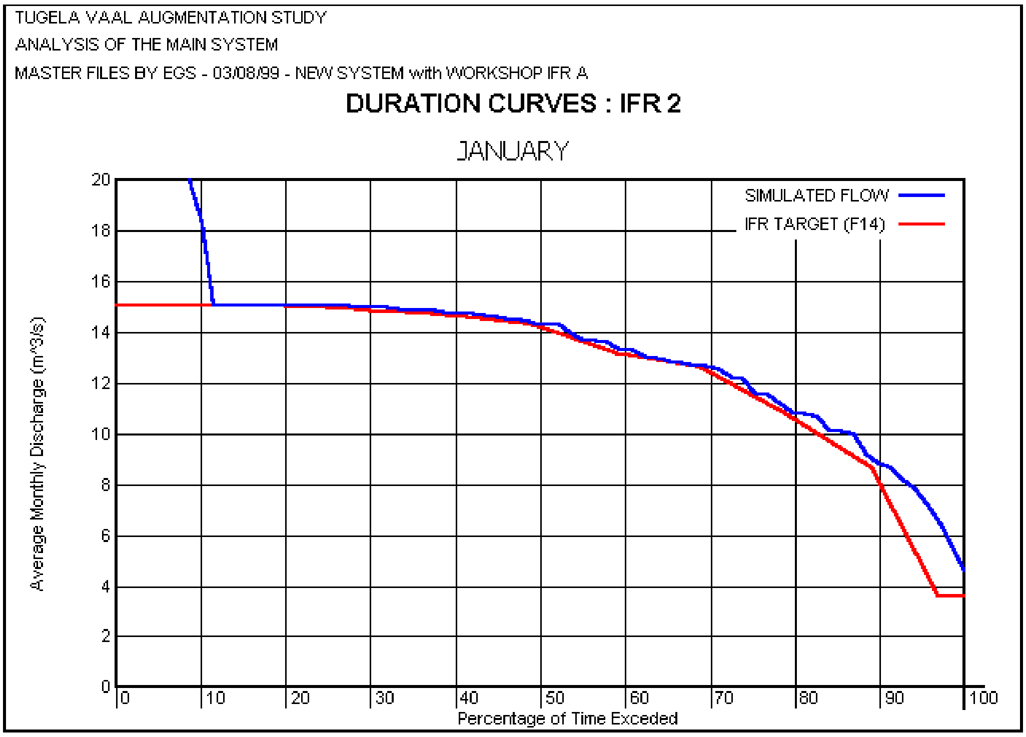


Figure G 16: Supply of IFR 2

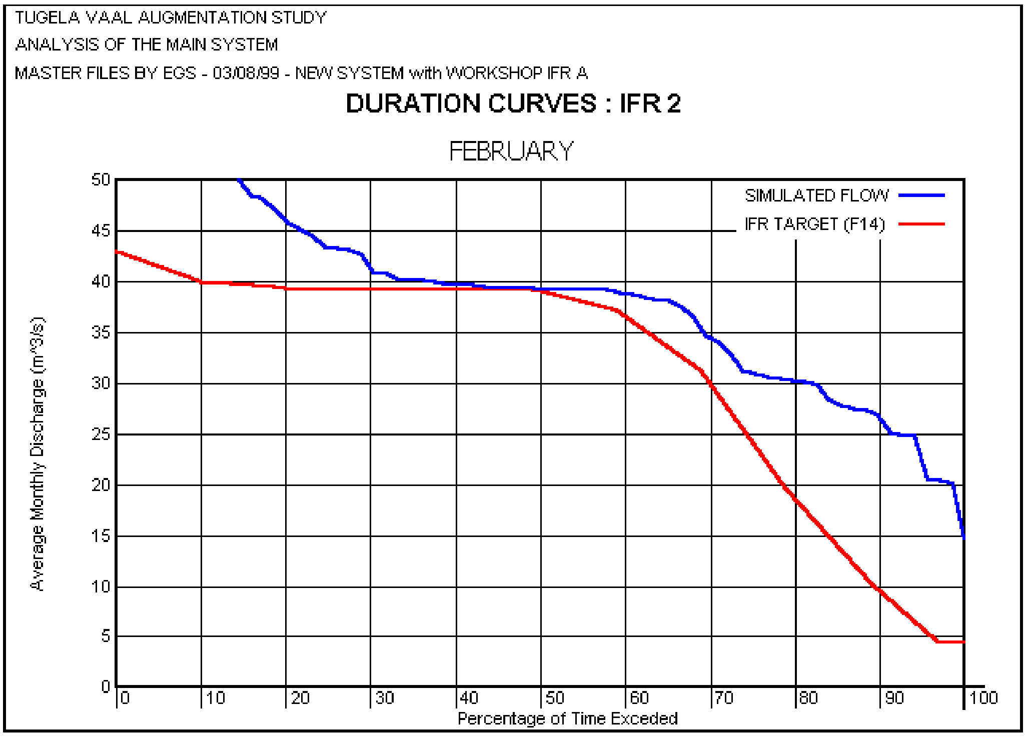


Figure G 17: Supply of IFR 2

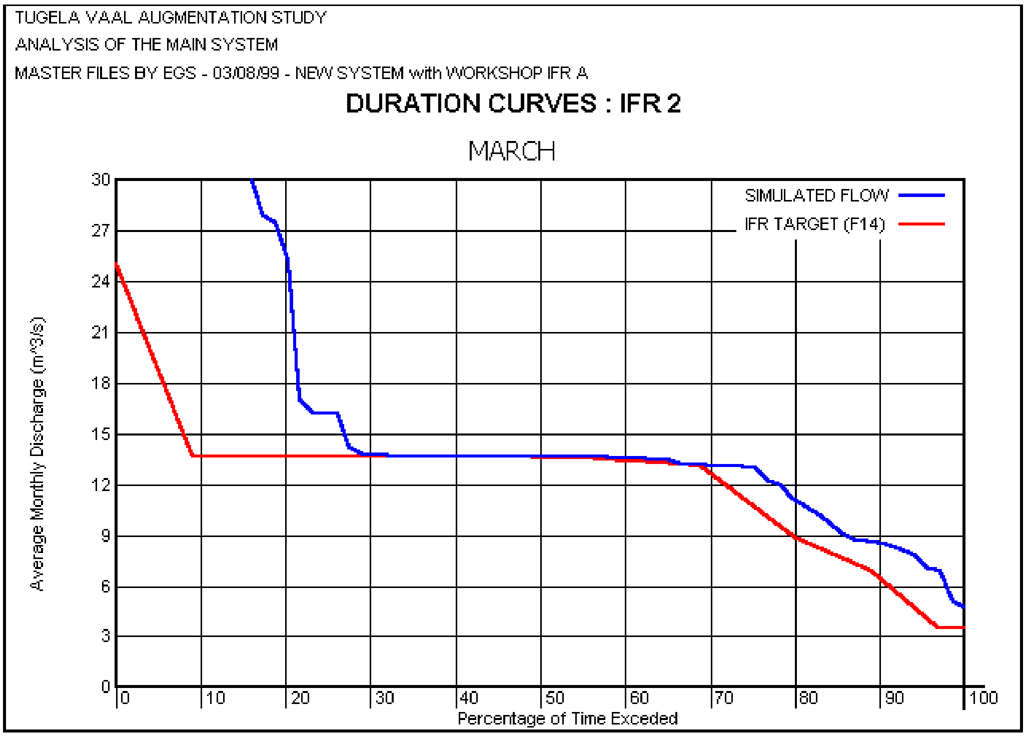


Figure G 18: Supply of IFR 2

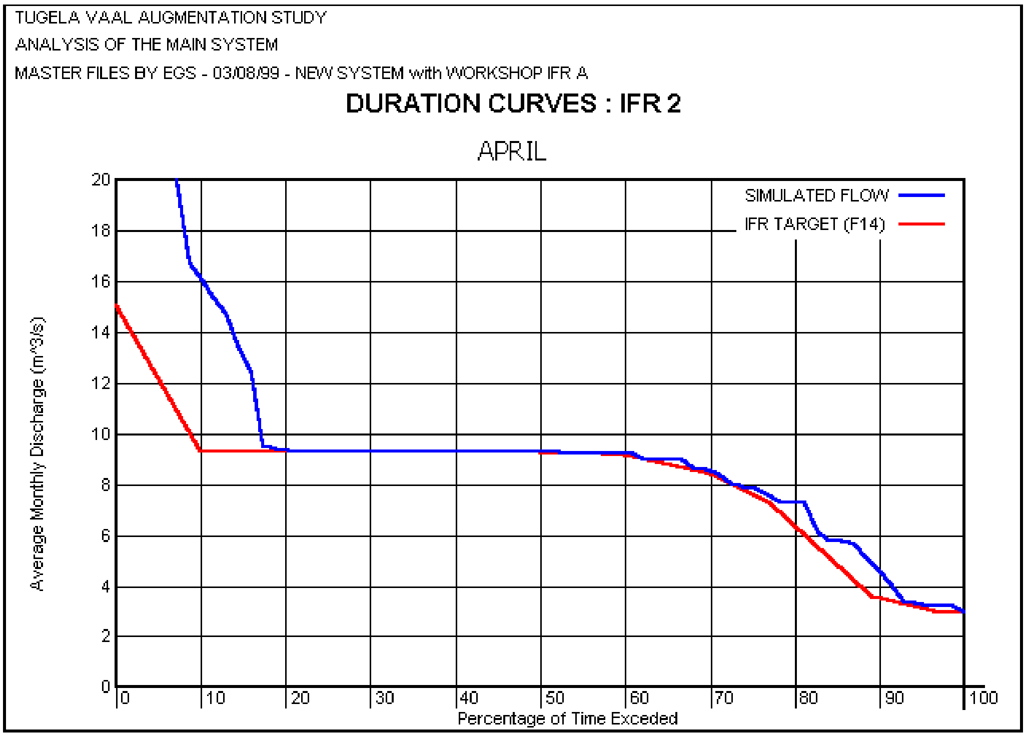


Figure G 19: Supply of IFR 2

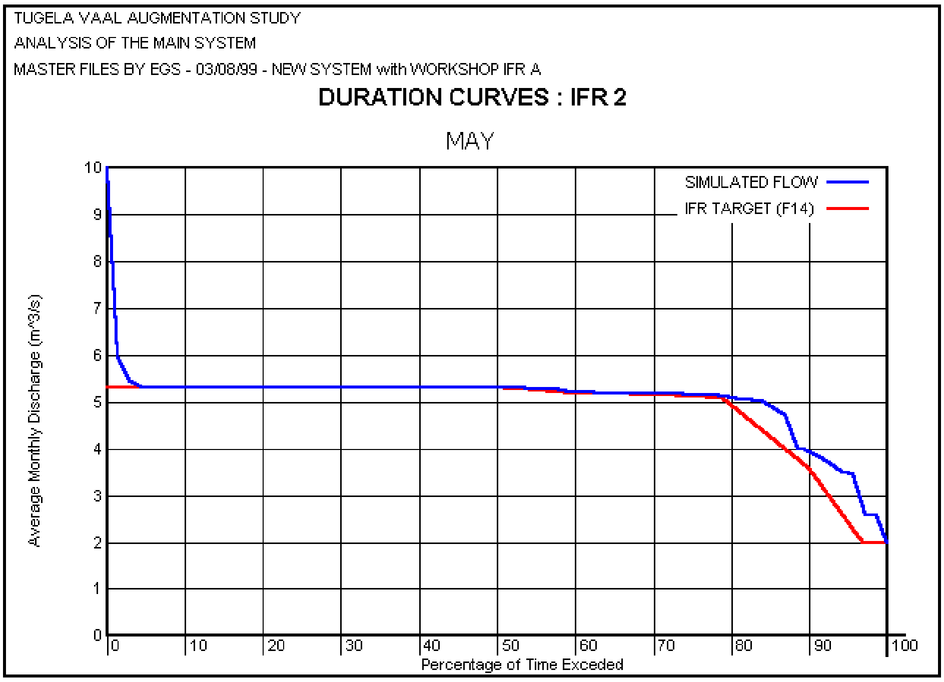


Figure G 20: Supply of IFR 2

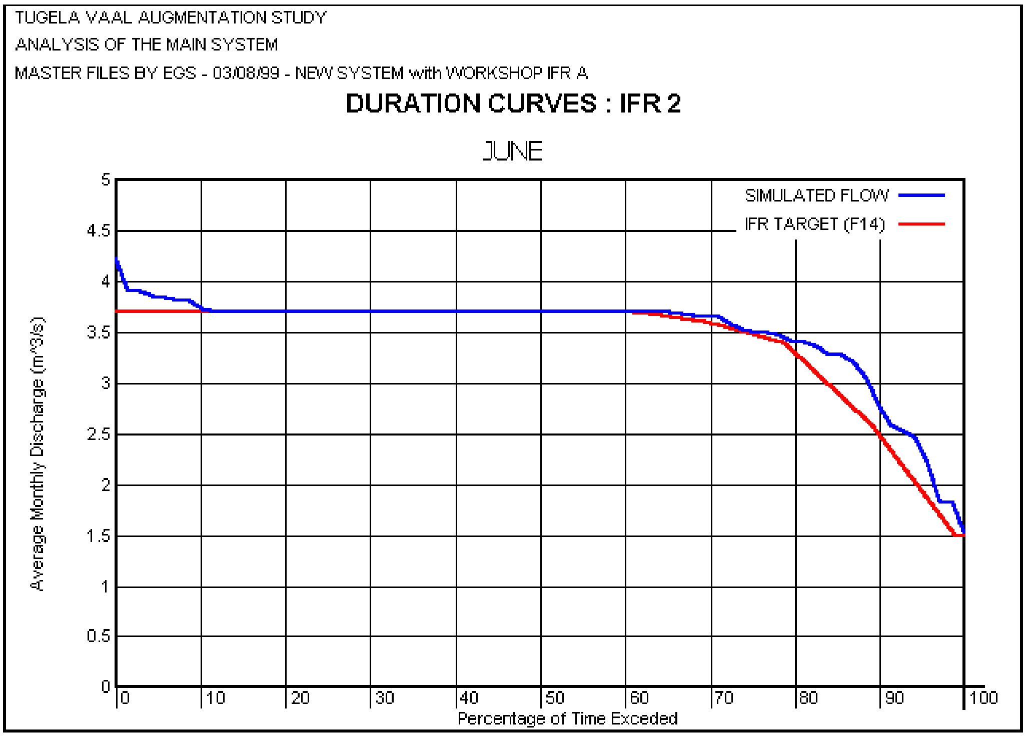


Figure G 21: Supply of IFR 2

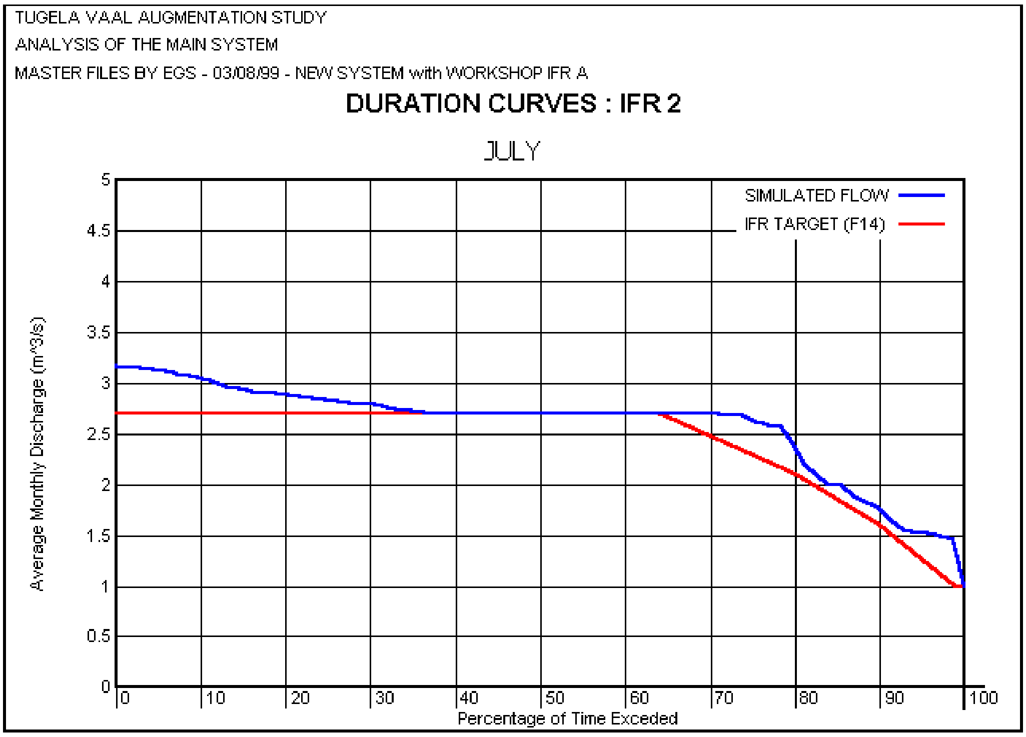


Figure G 22: Supply of IFR 2

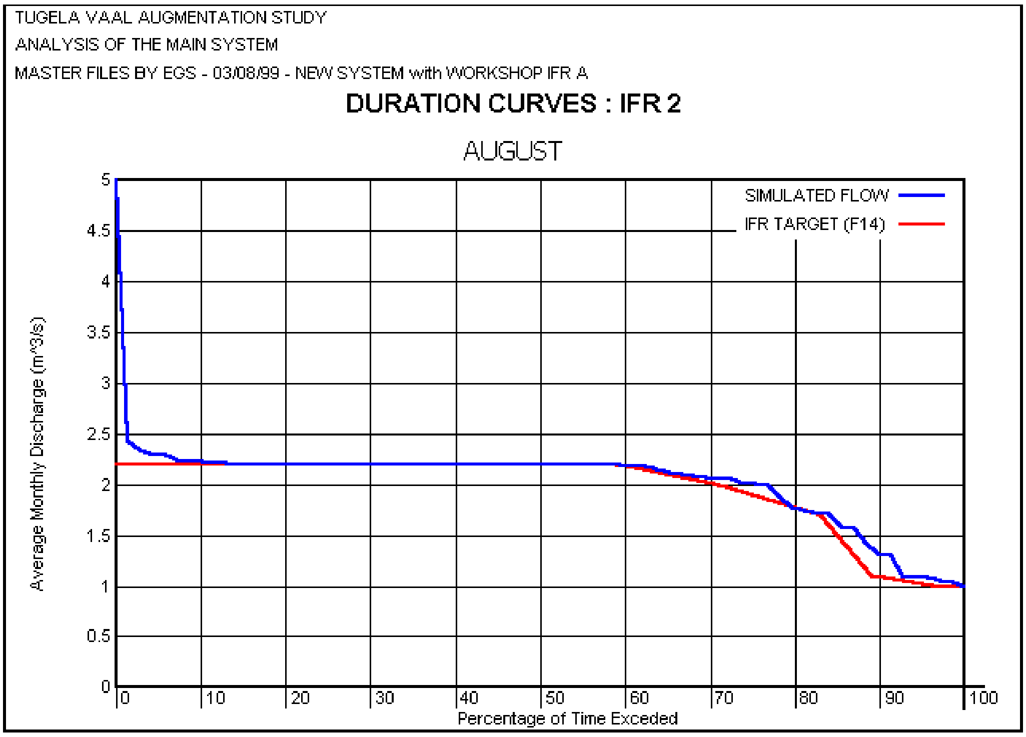


Figure G 23: Supply of IFR 2

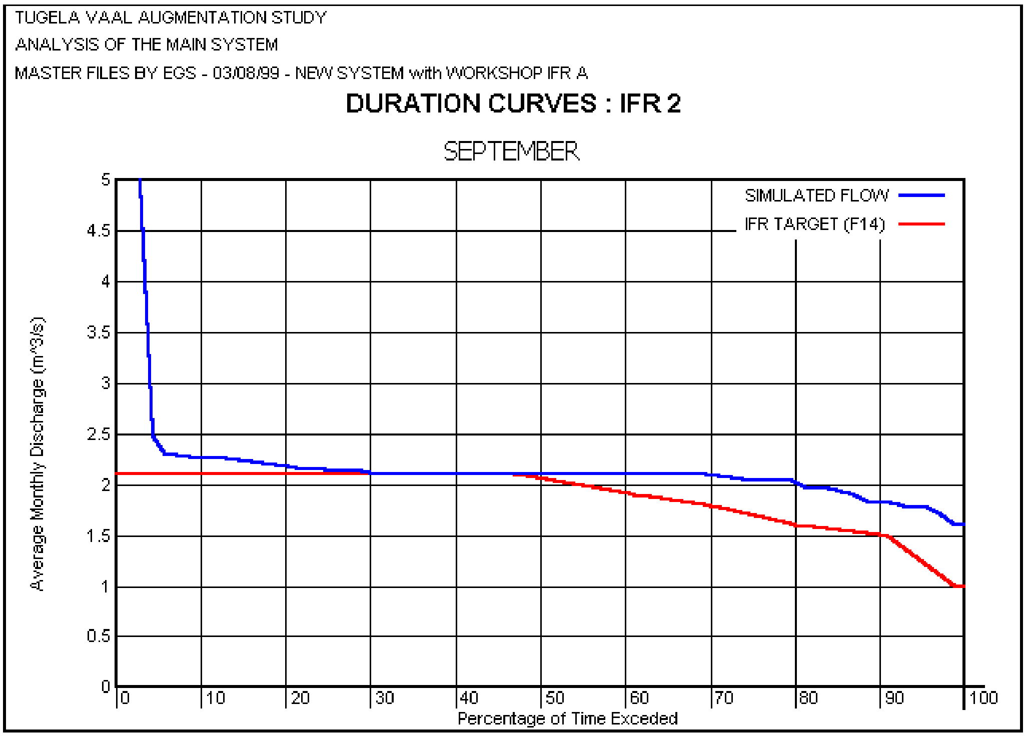


Figure G 24: Supply of IFR 2

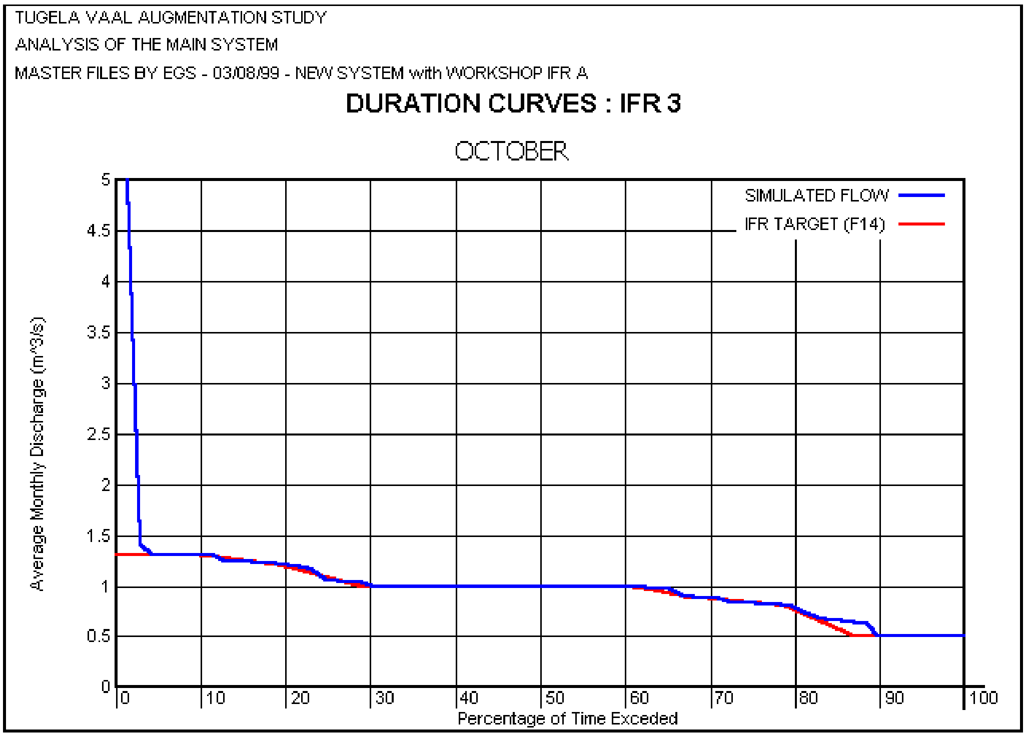


Figure G.25: Supply of IFR 3

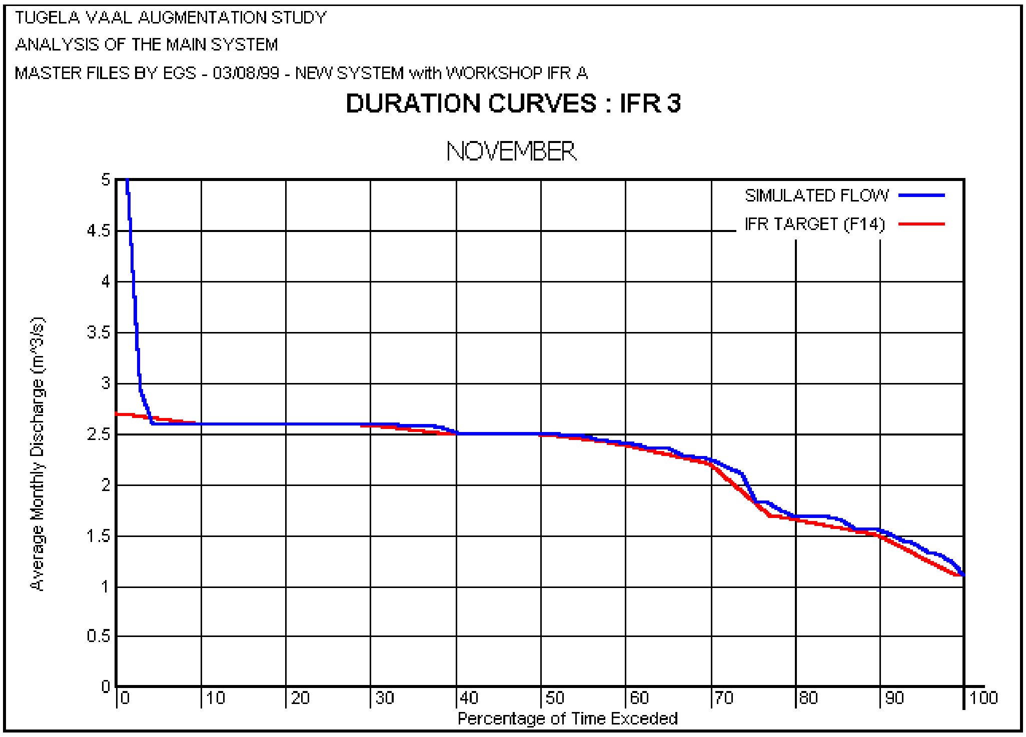


Figure G.126: Supply of IFR 3

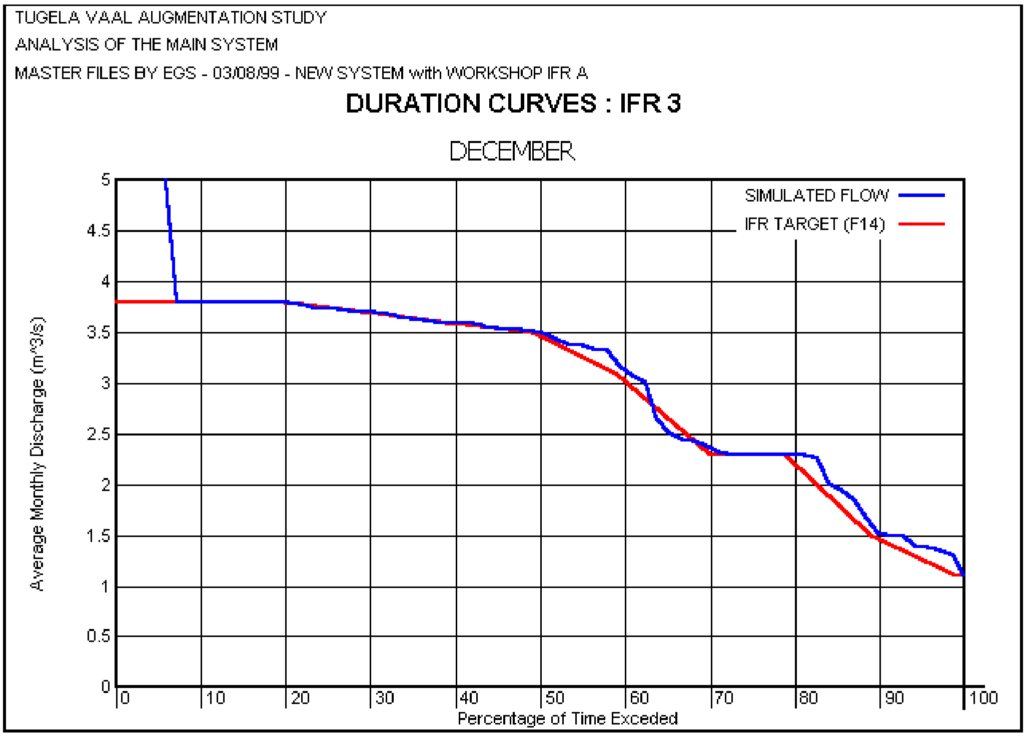


Figure G.27: Supply of IFR 3

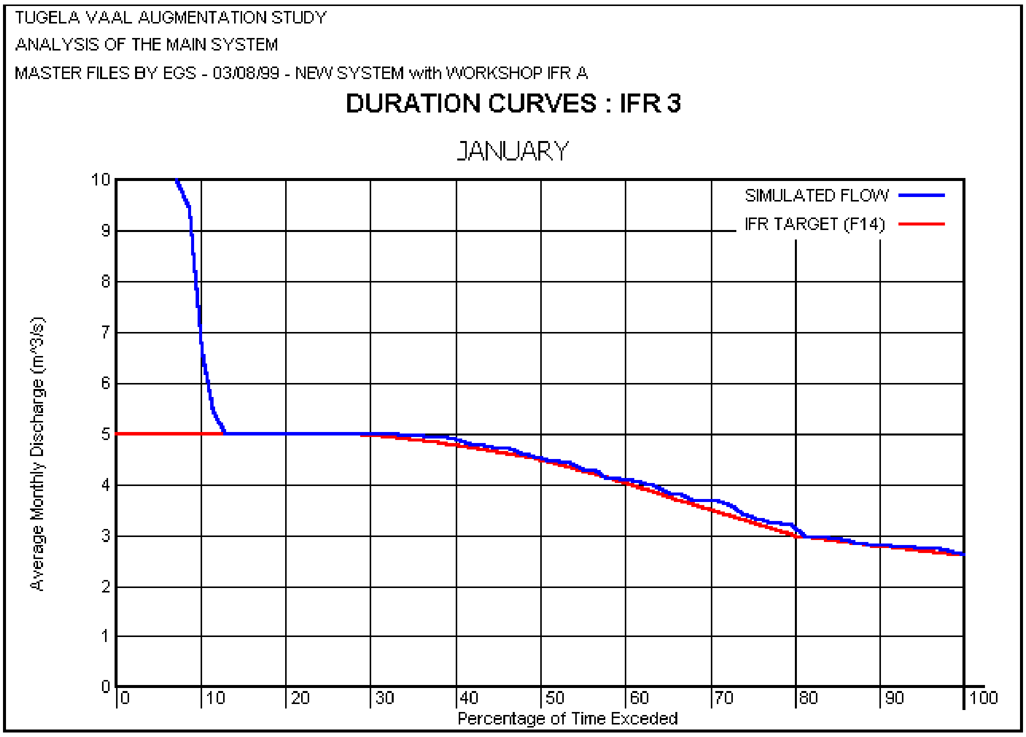


Figure.G 28: Supply of IFR 3

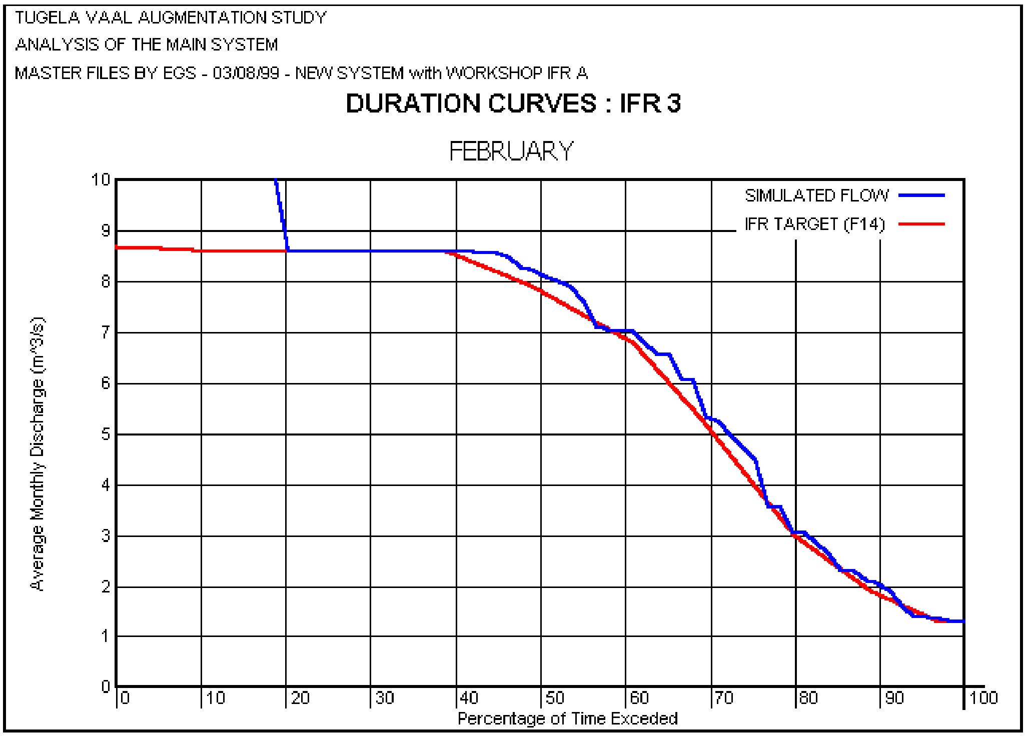


Figure G 29: Supply of IFR 3

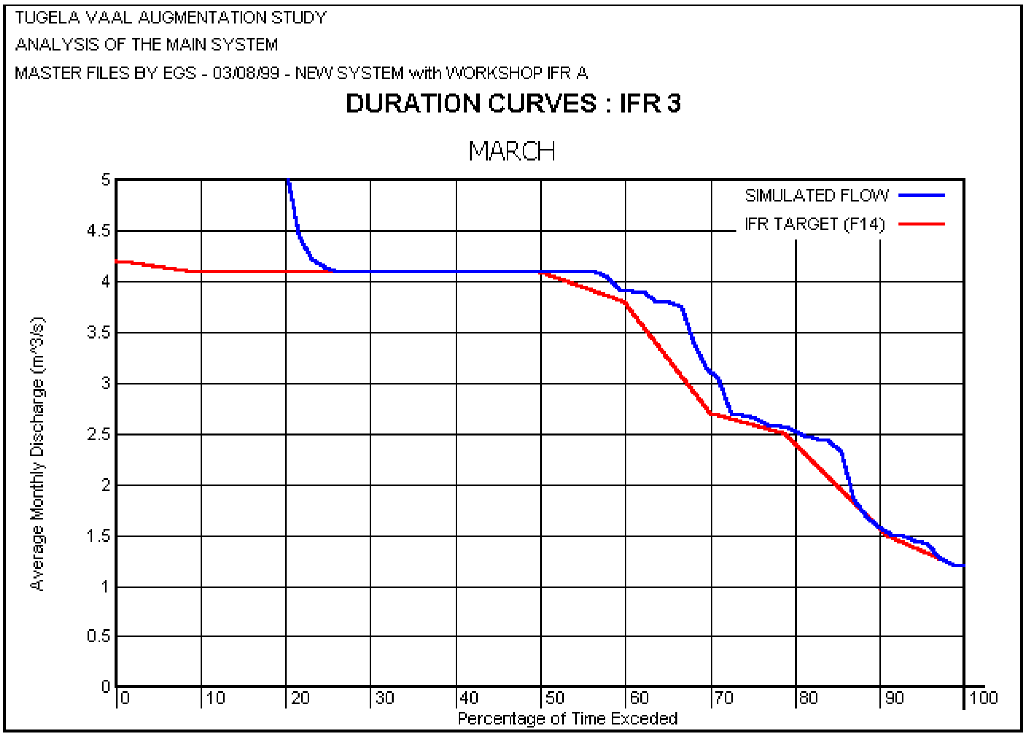


Figure G 30: Supply of IFR 3

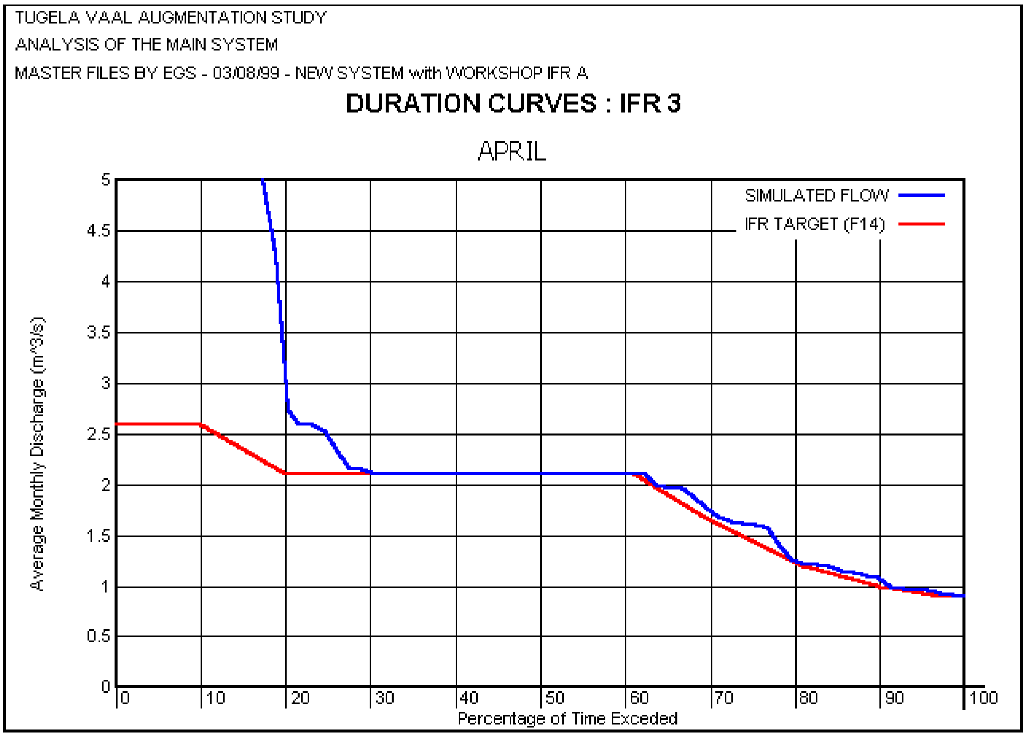


Figure G 31: Supply of IFR 3

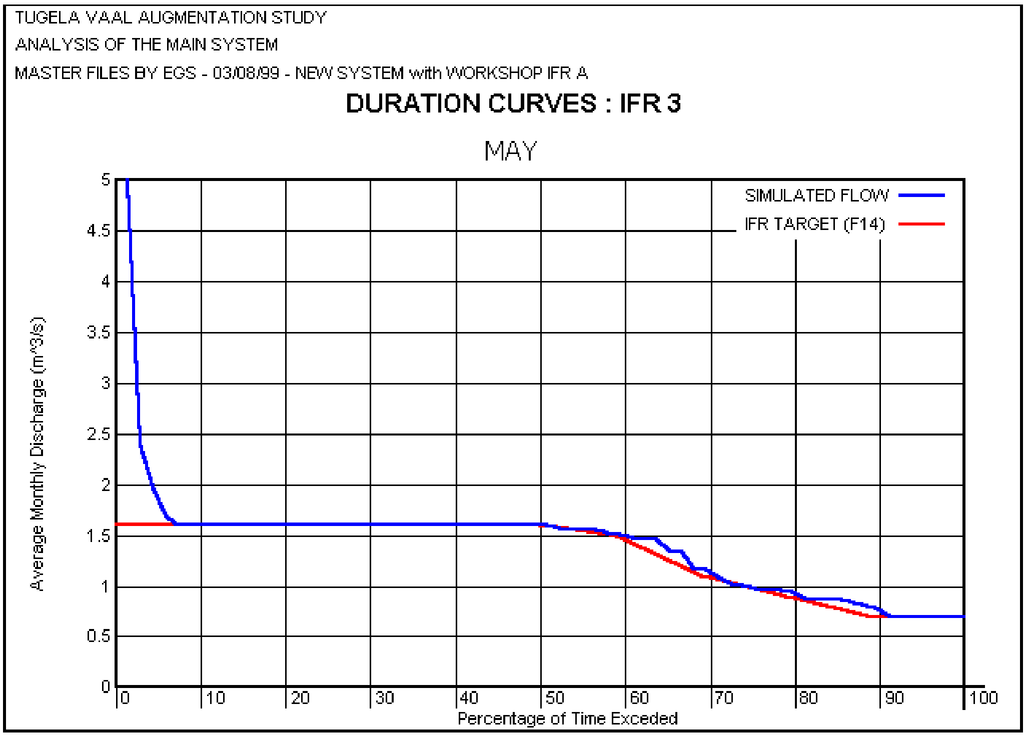


Figure G 32: Supply of IFR 3

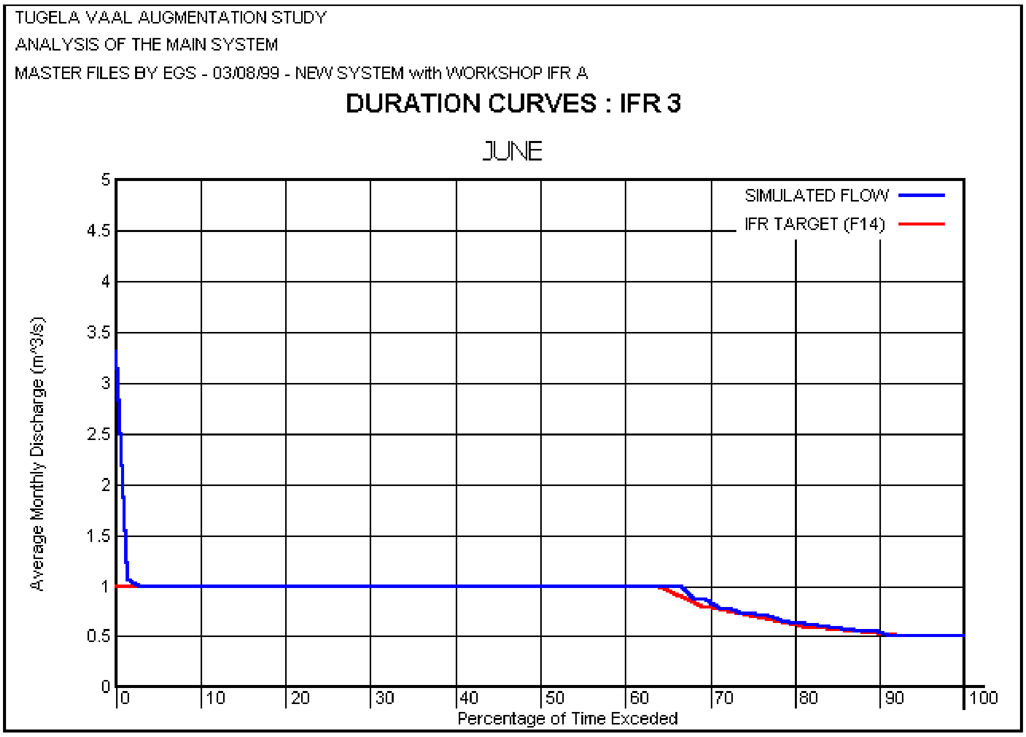


Figure G 33: Supply of IFR 3

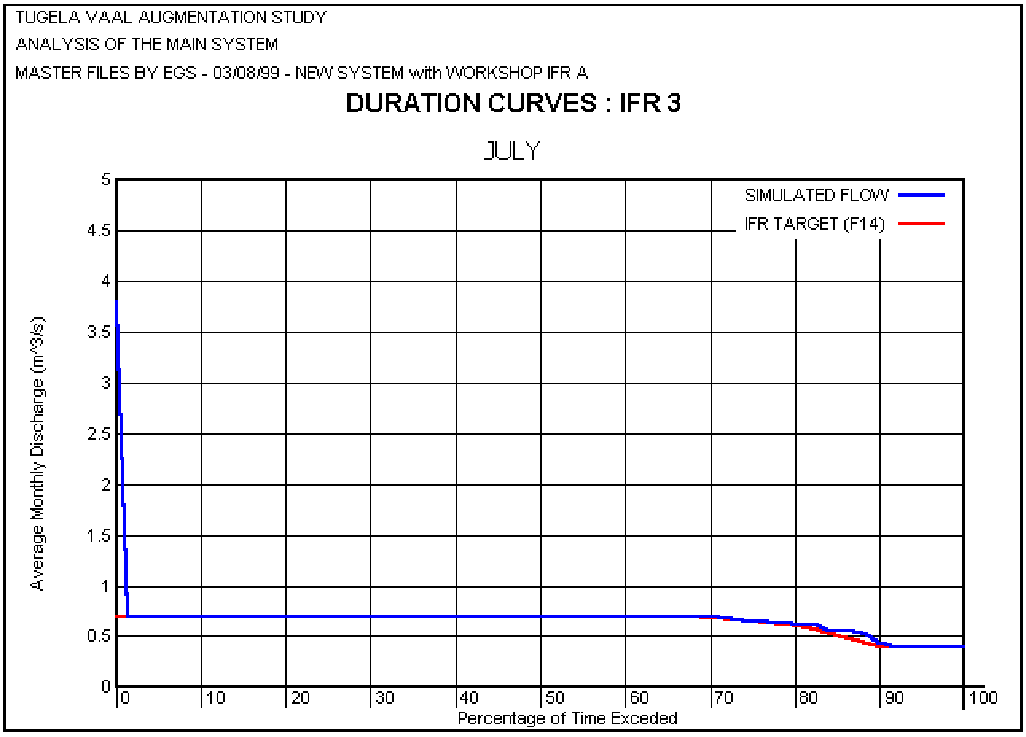


Figure G 34: Supply of IFR 3

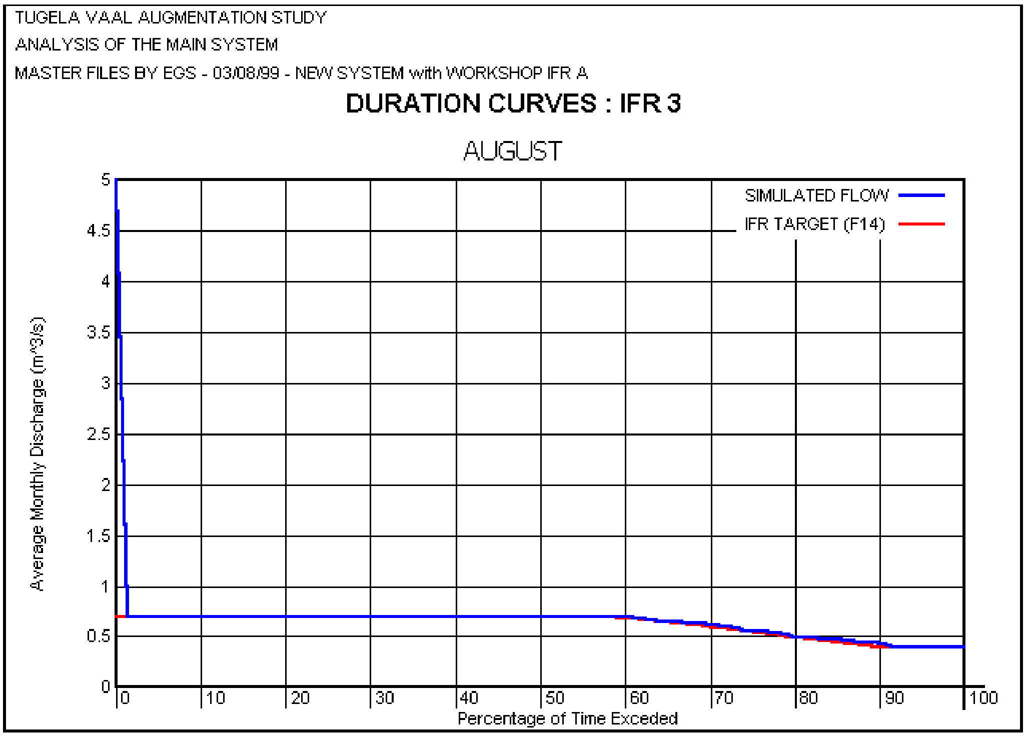


Figure G 35: Supply of IFR 3

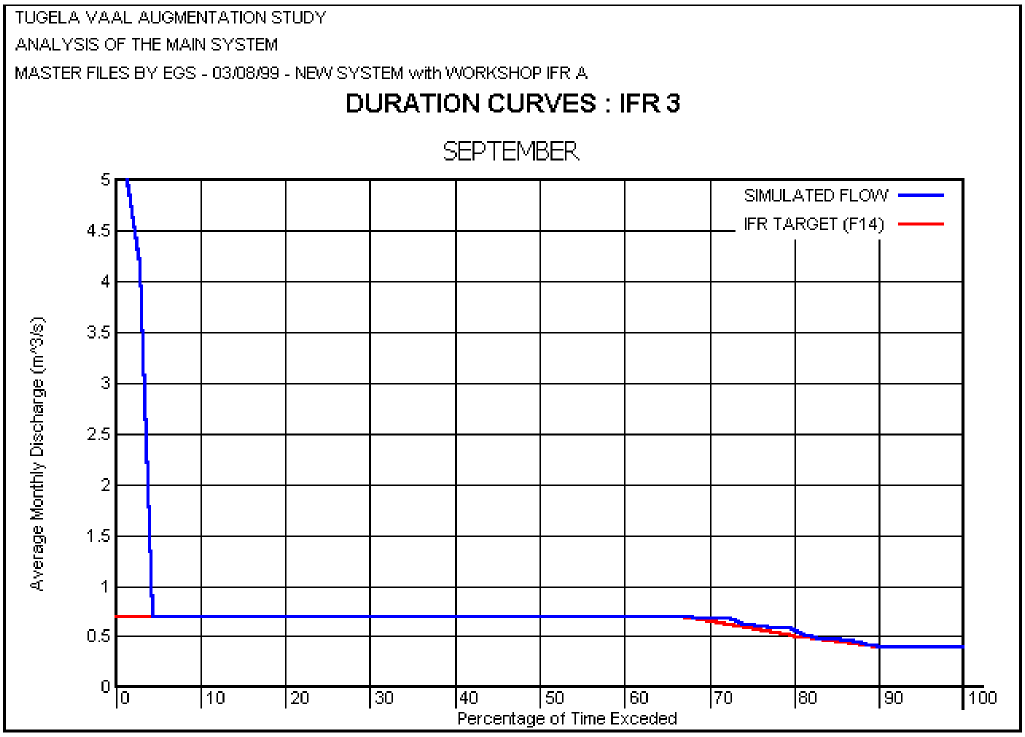


Figure G 36: Supply of IFR 3

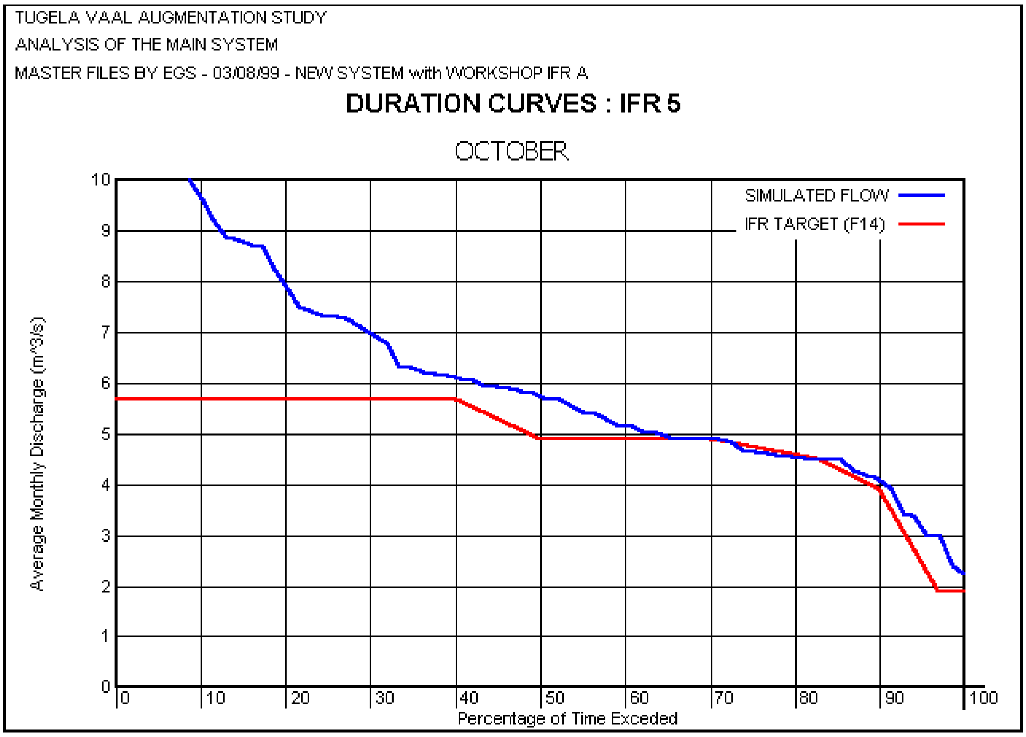


Figure G 37: Supply of IFR 5

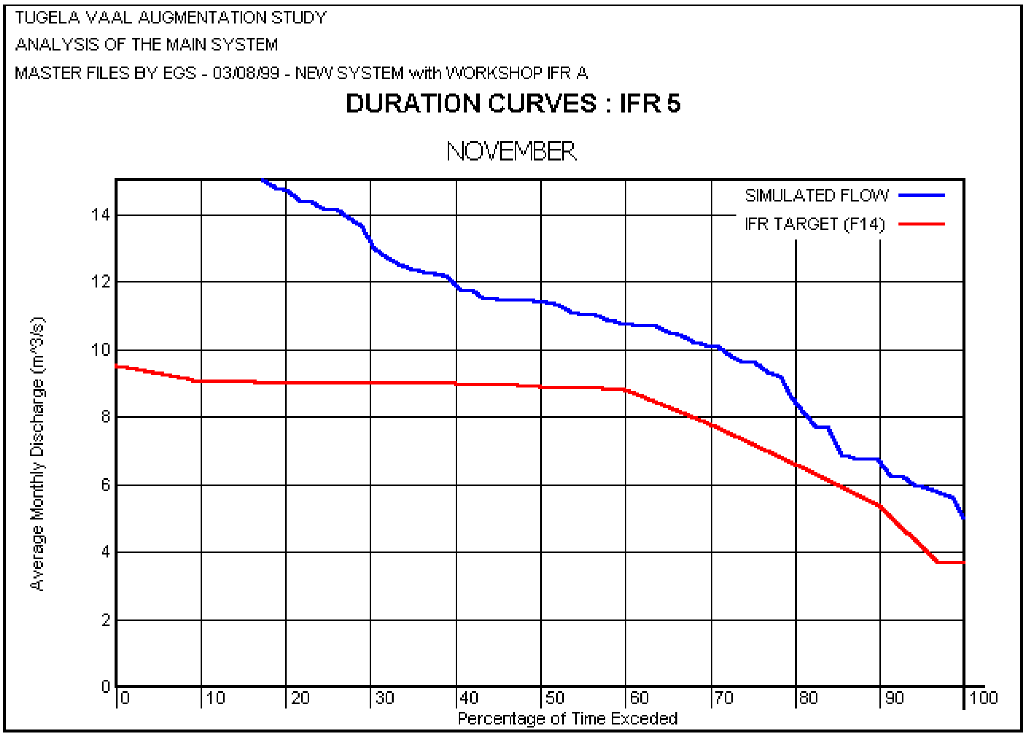


Figure G 38: Supply of IFR 5

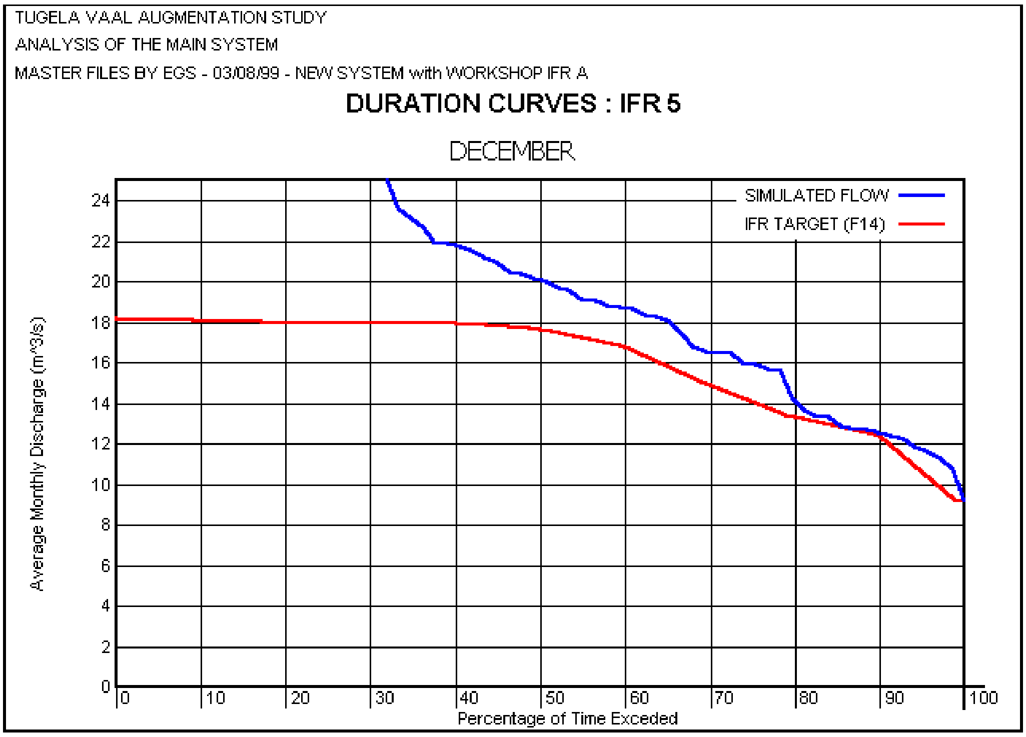


Figure G 39: Supply of IFR 5

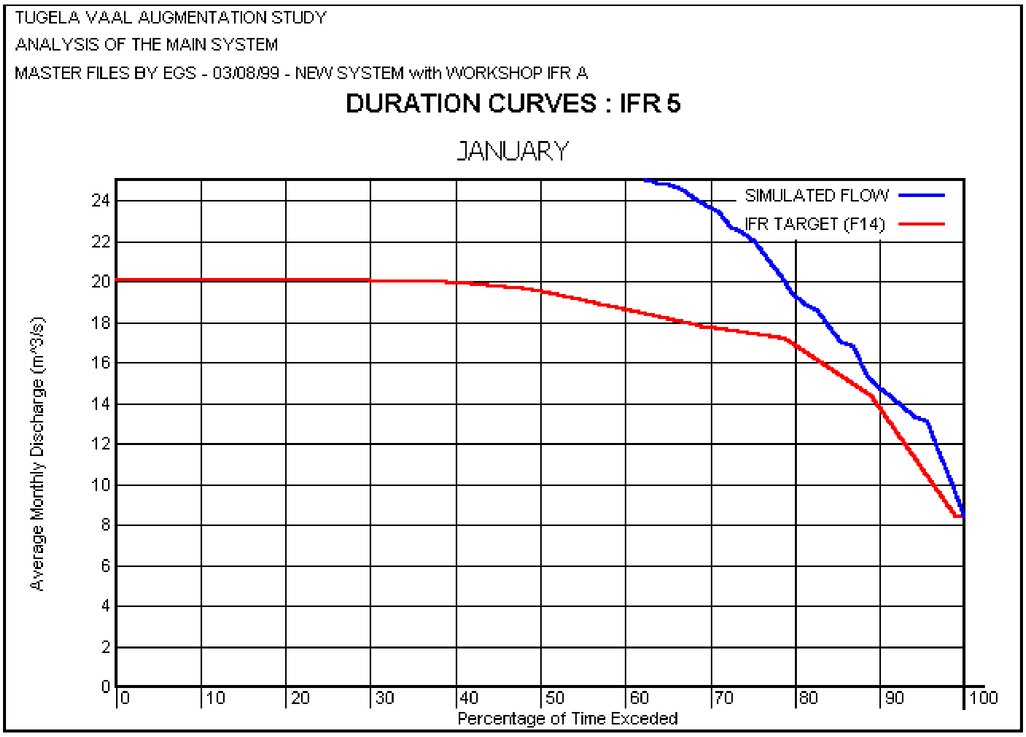


Figure G 40: Supply of IFR 5

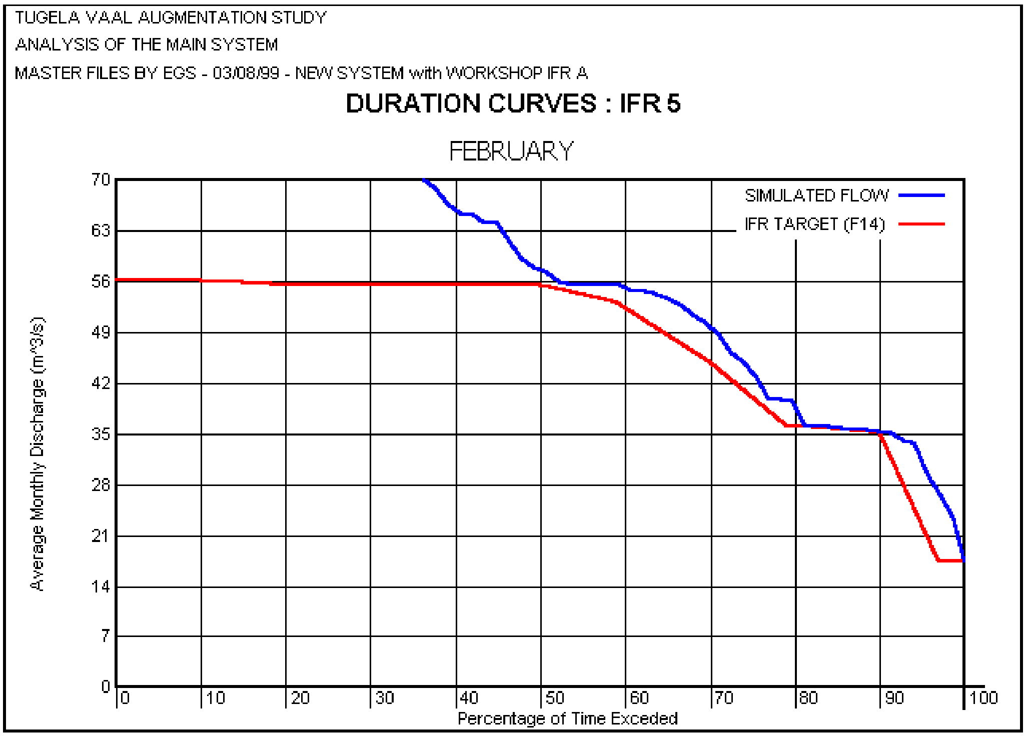


Figure G 41: Supply of IFR 5

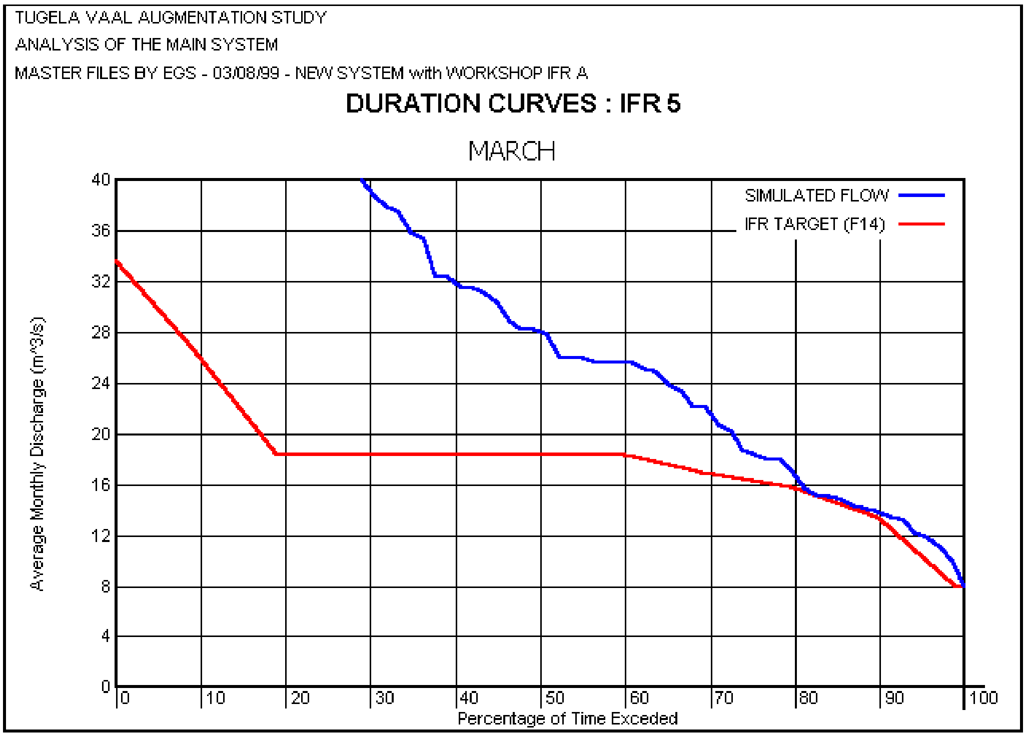


Figure G 42: Supply of IFR 5

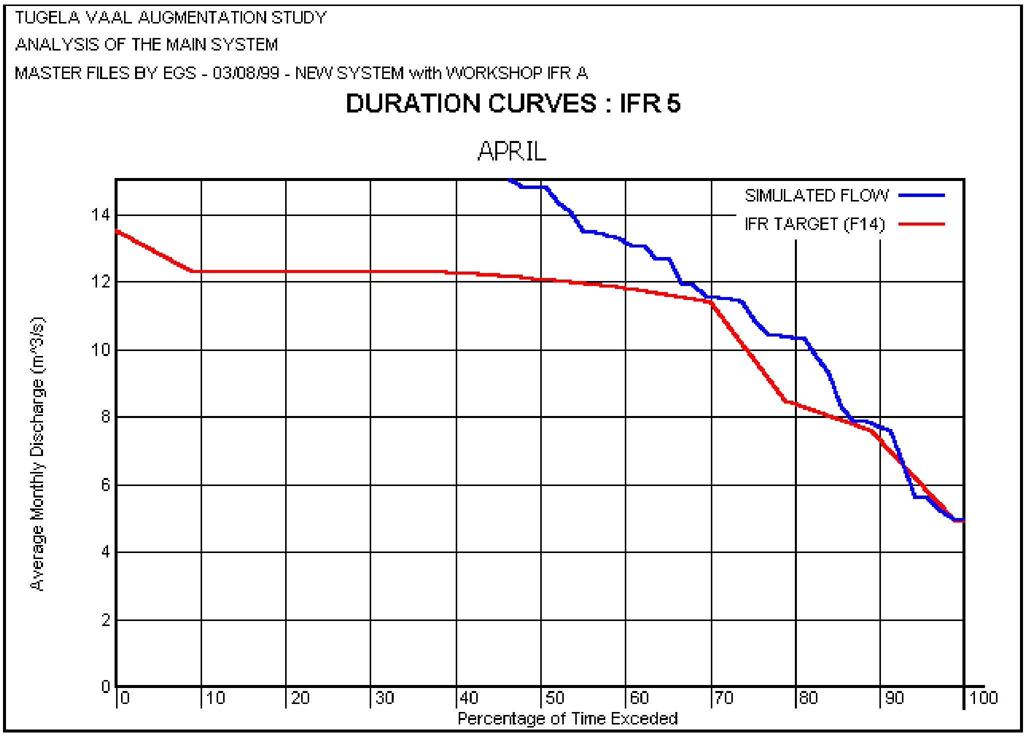


Figure G 43: Supply of IFR 5

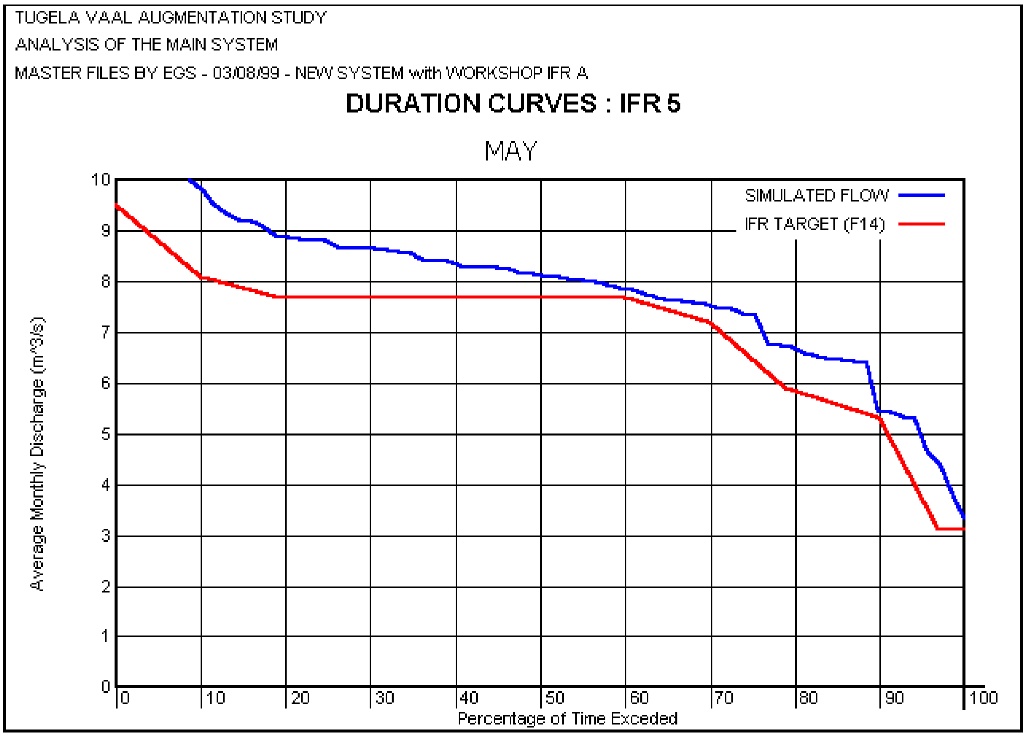


Figure G 44: Supply of IFR 5

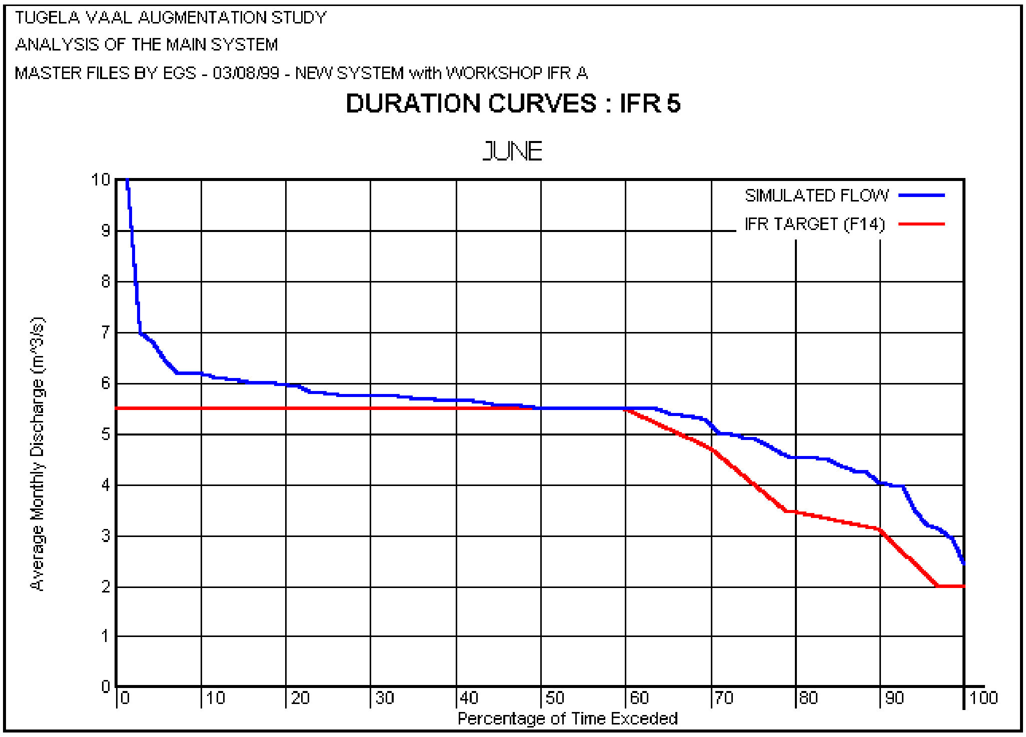


Figure G 45: Supply of IFR 5

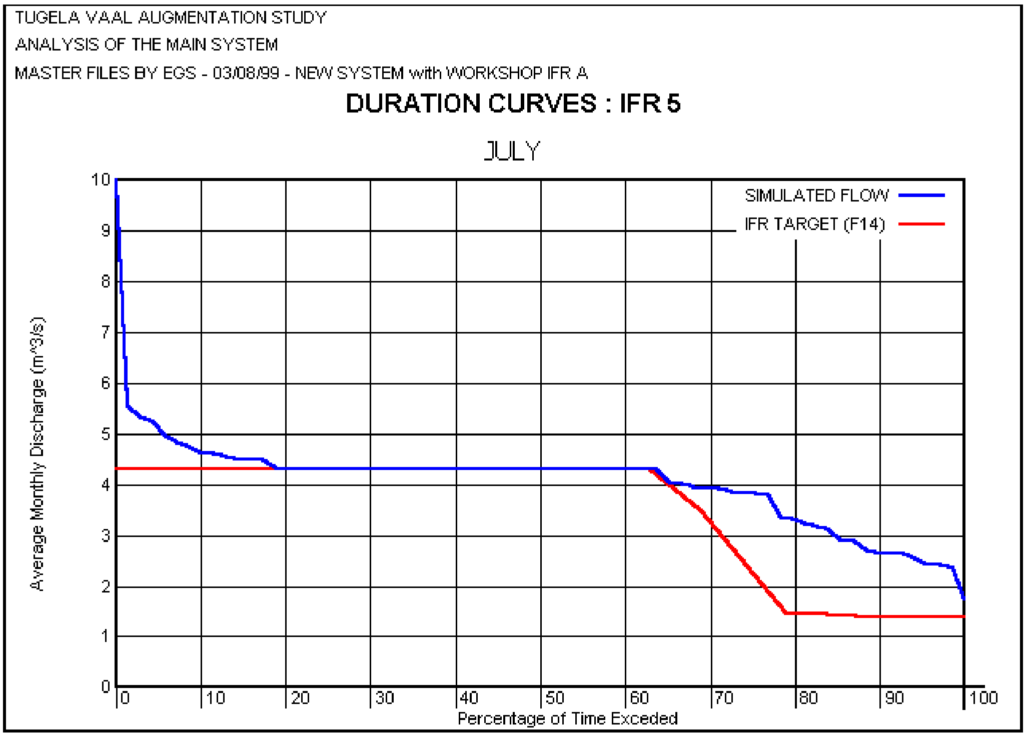


Figure G 46: Supply of IFR 5

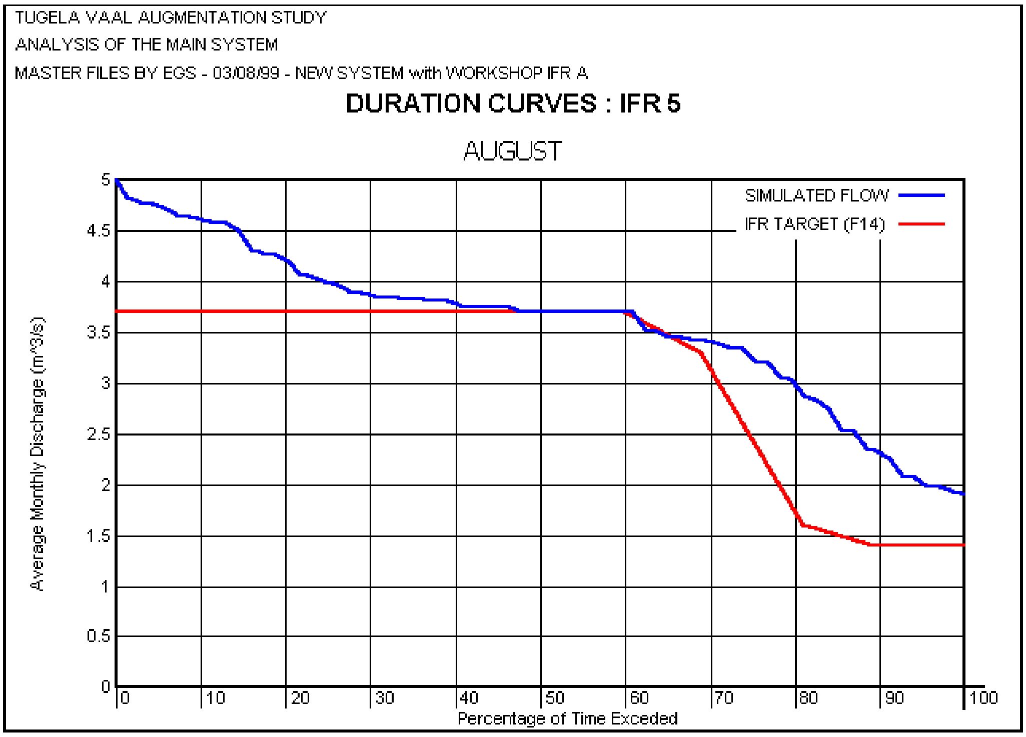


Figure G 47: Supply of IFR 5

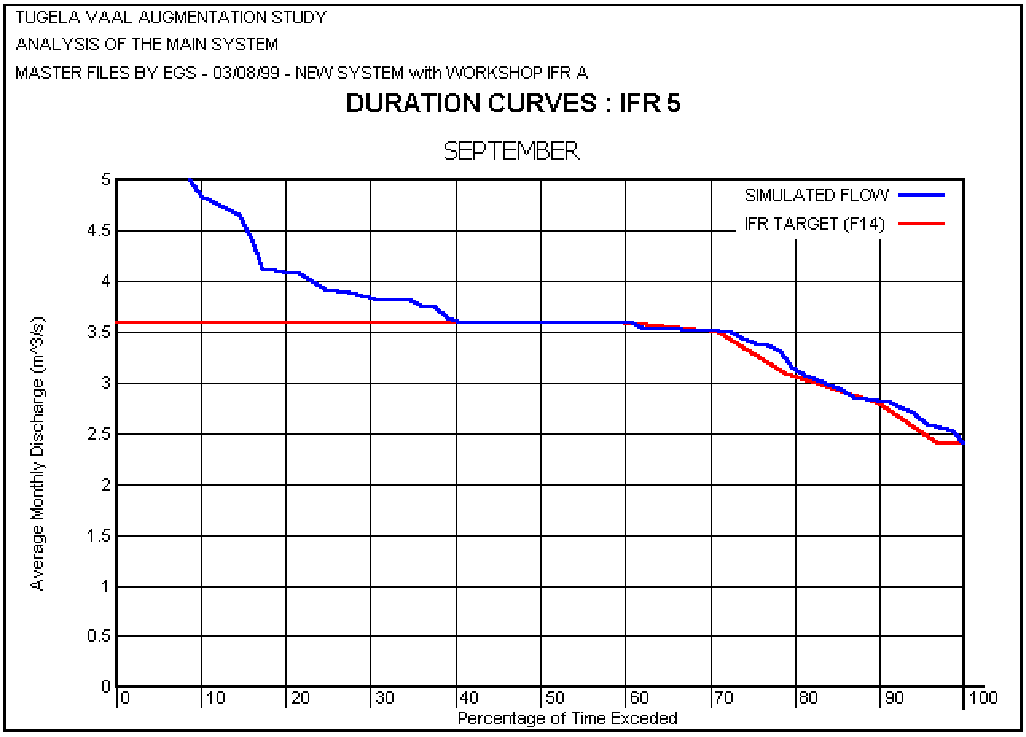


Figure G 48: Supply of IFR 5

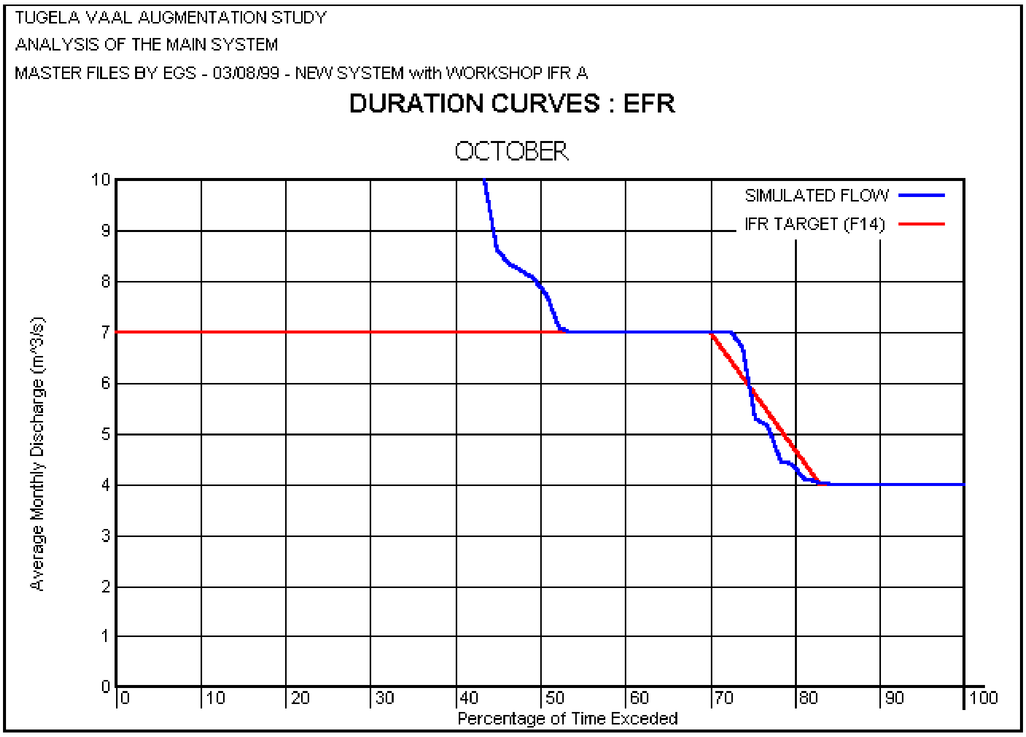


Figure 49: Supply of the EFR

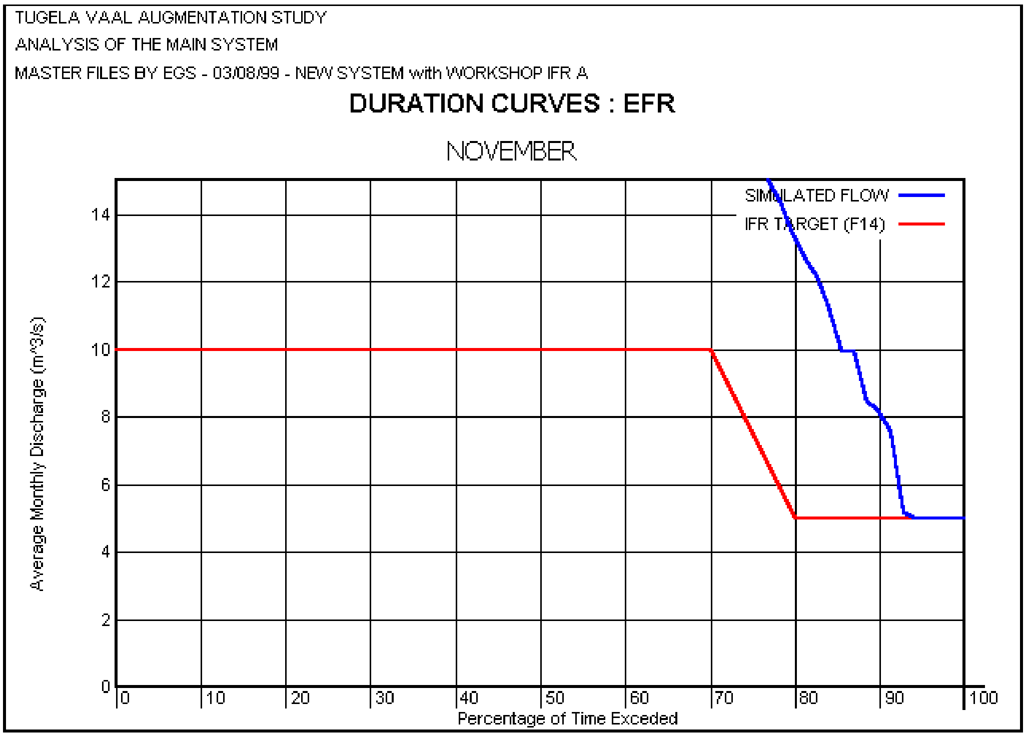


Figure 50: Supply of the EFR

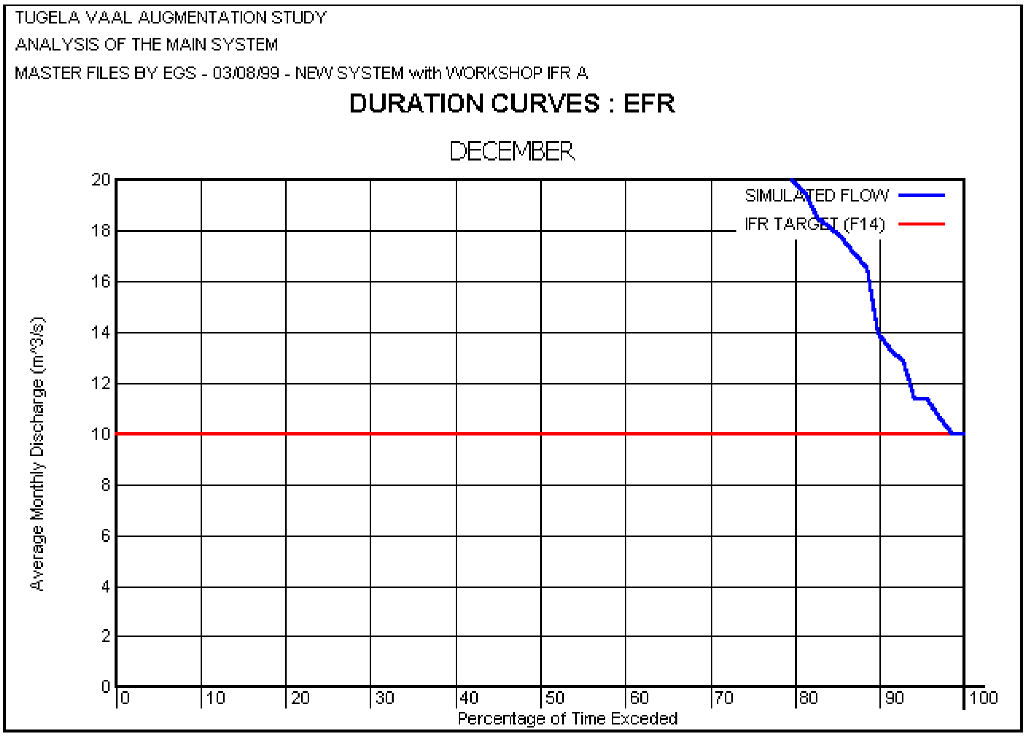


Figure 51: Supply of the EFR

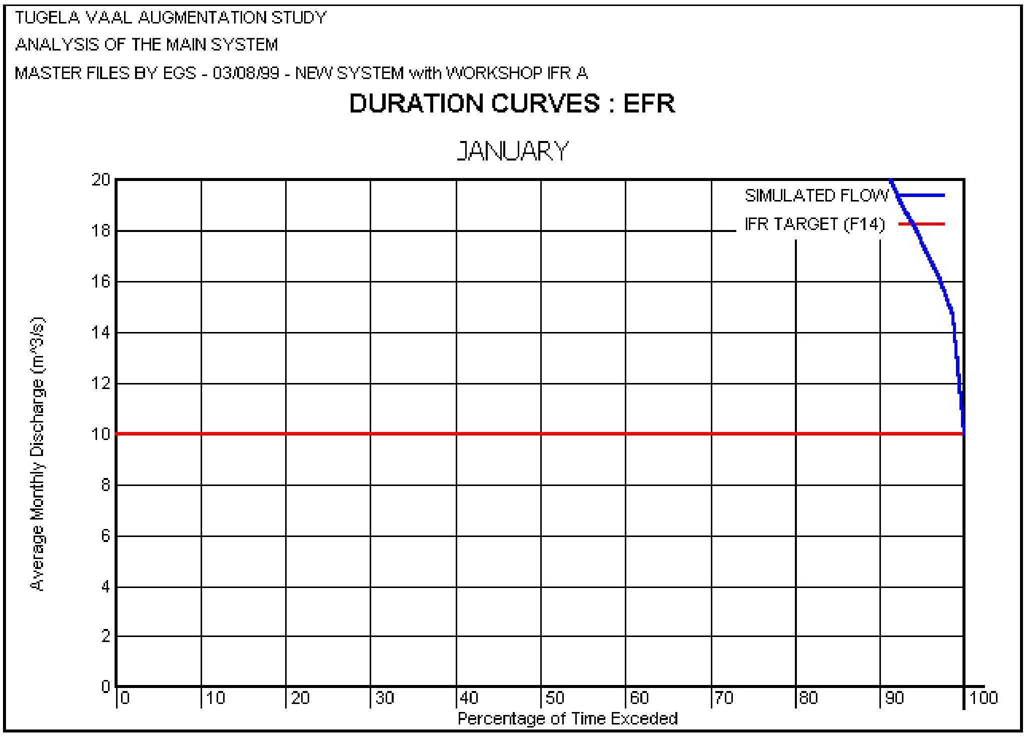


Figure 52: Supply of the EFR

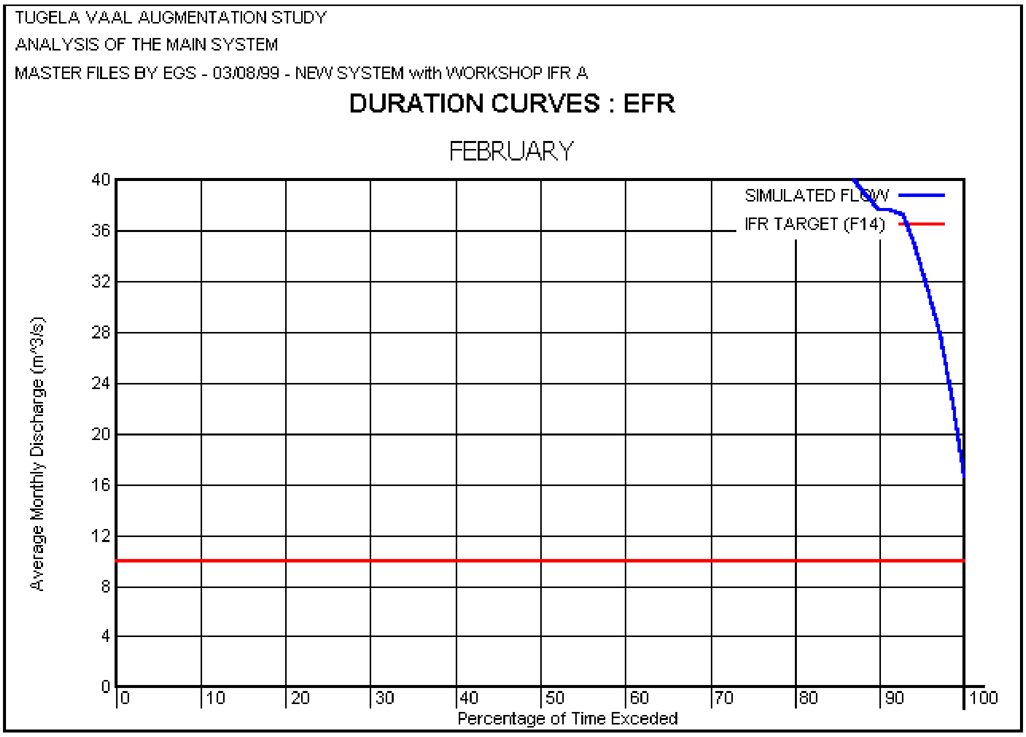


Figure 53: Supply of the EFR

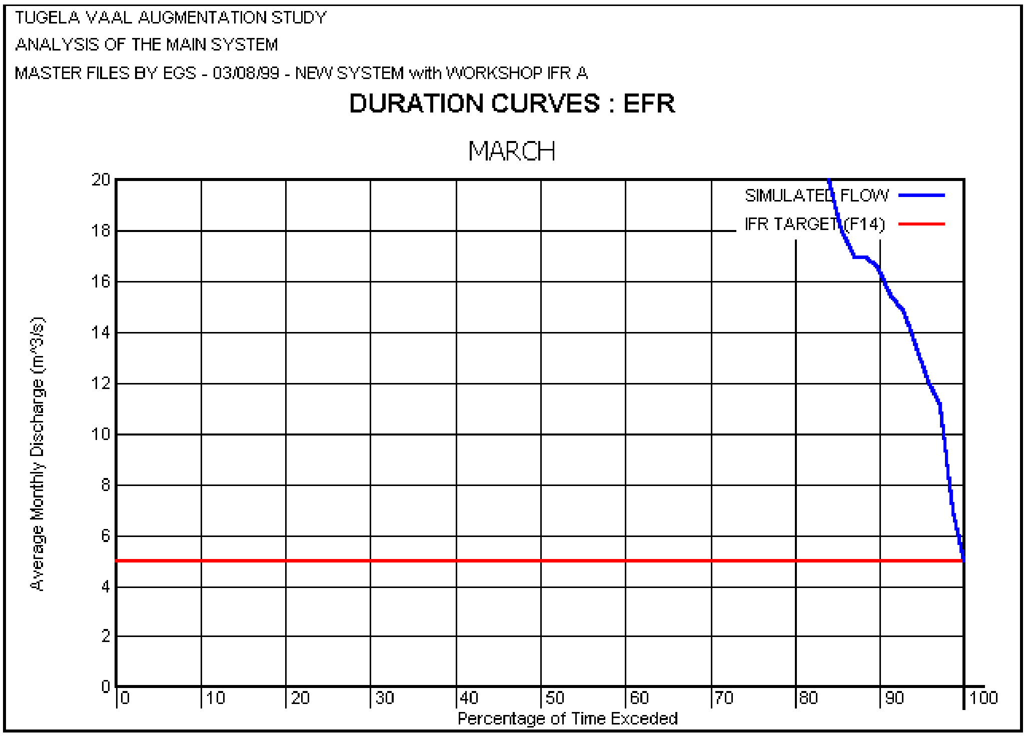


Figure 54: Supply of the EFR

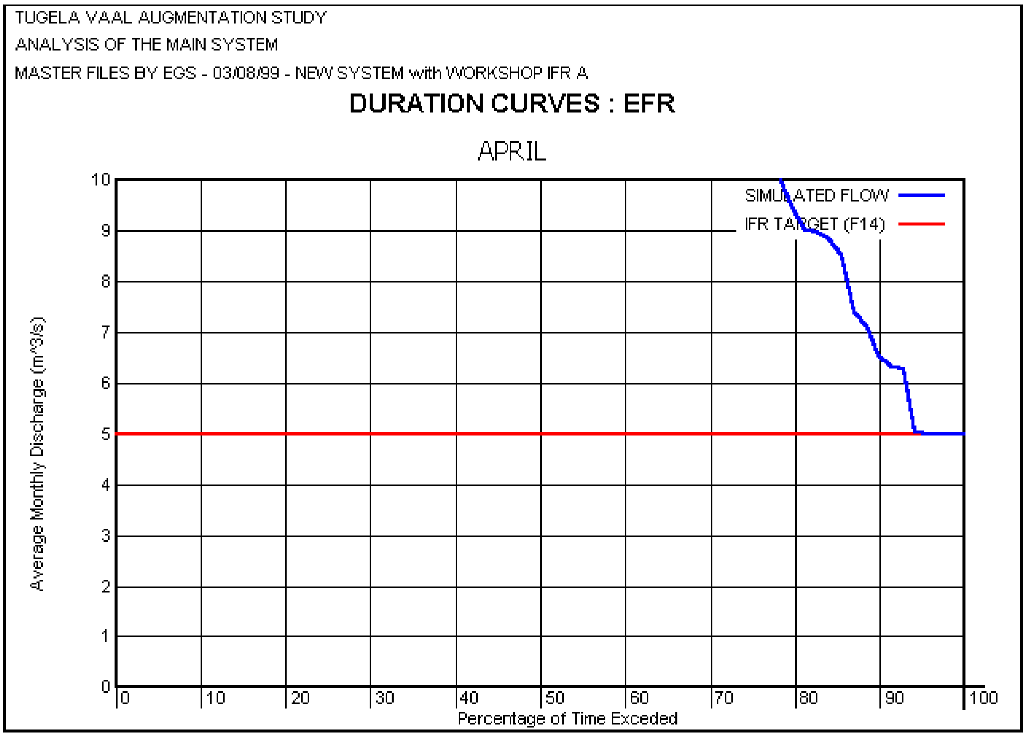


Figure 55: Supply of the EFR

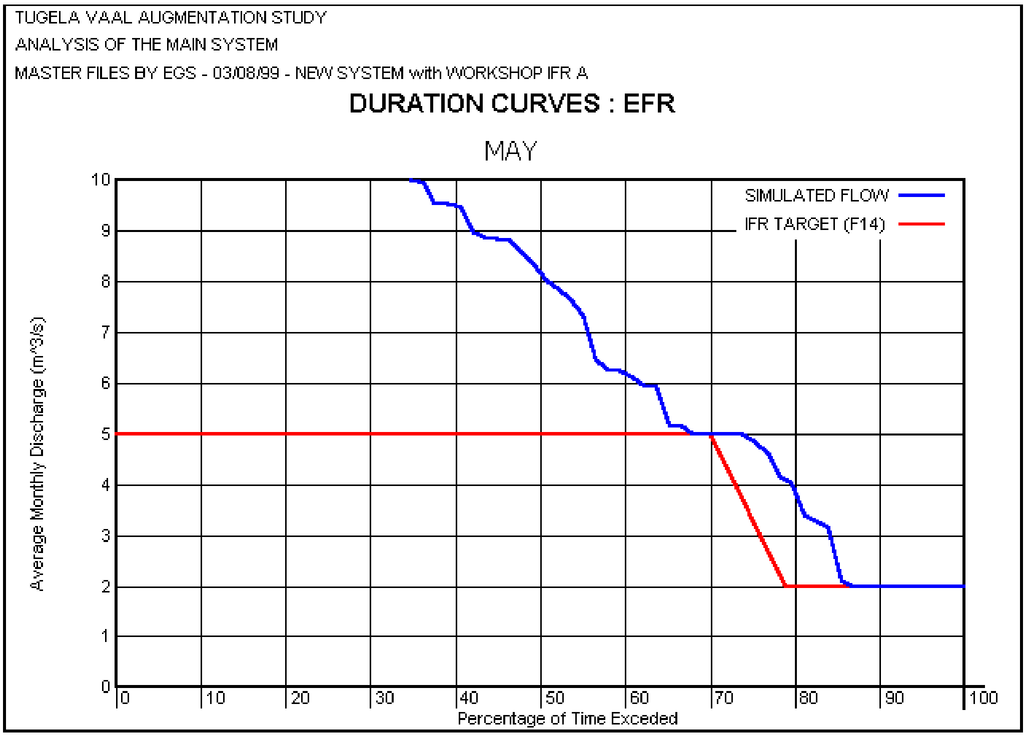


Figure 56: Supply of the EFR

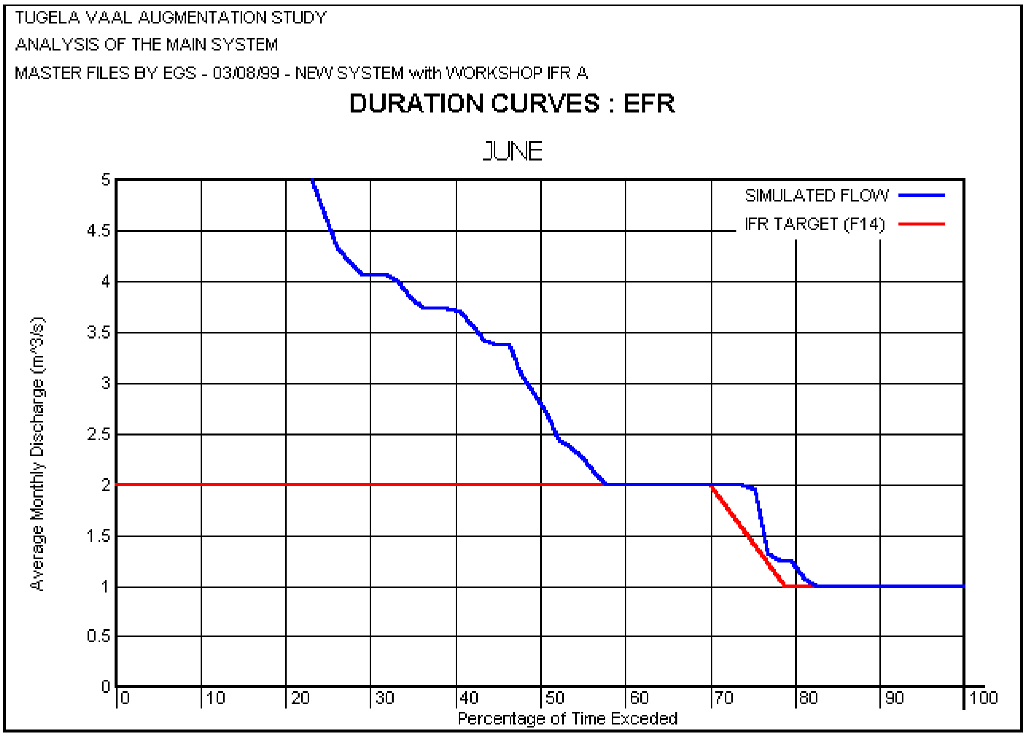


Figure 57: Supply of the EFR

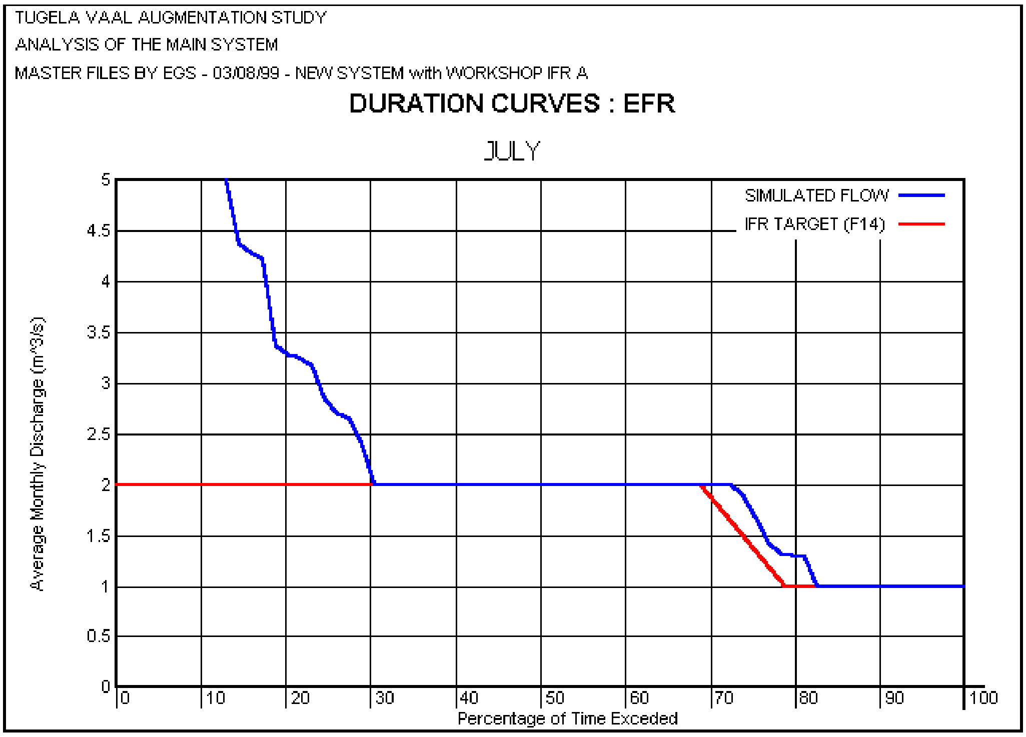


Figure 58: Supply of the EFR

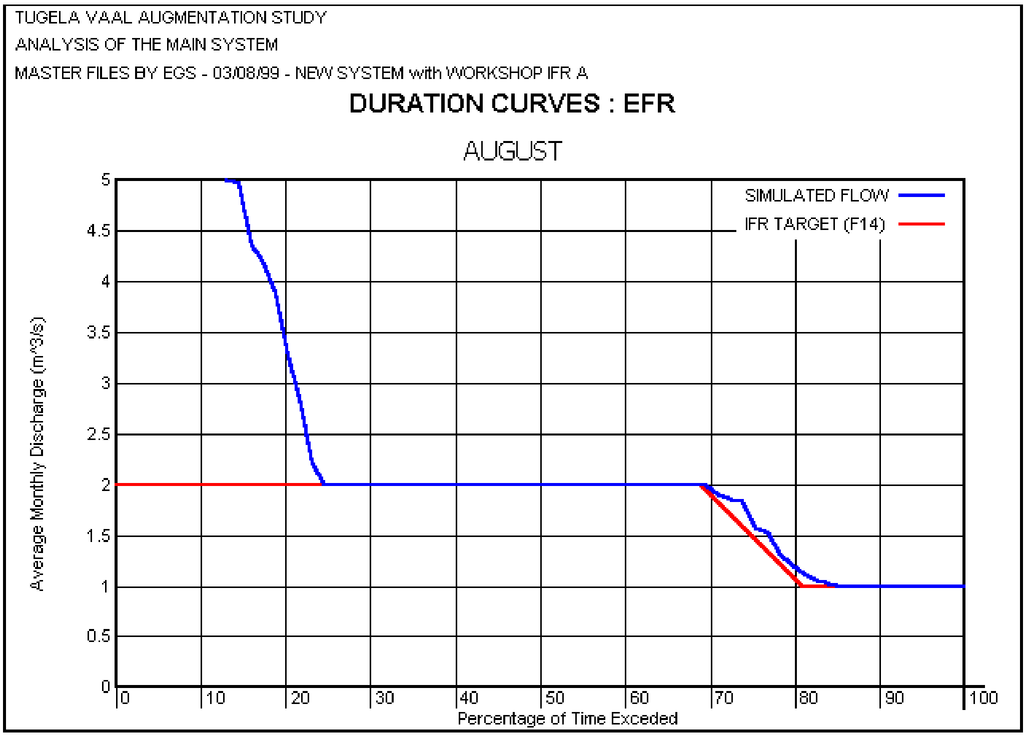


Figure 59: Supply of the EFR

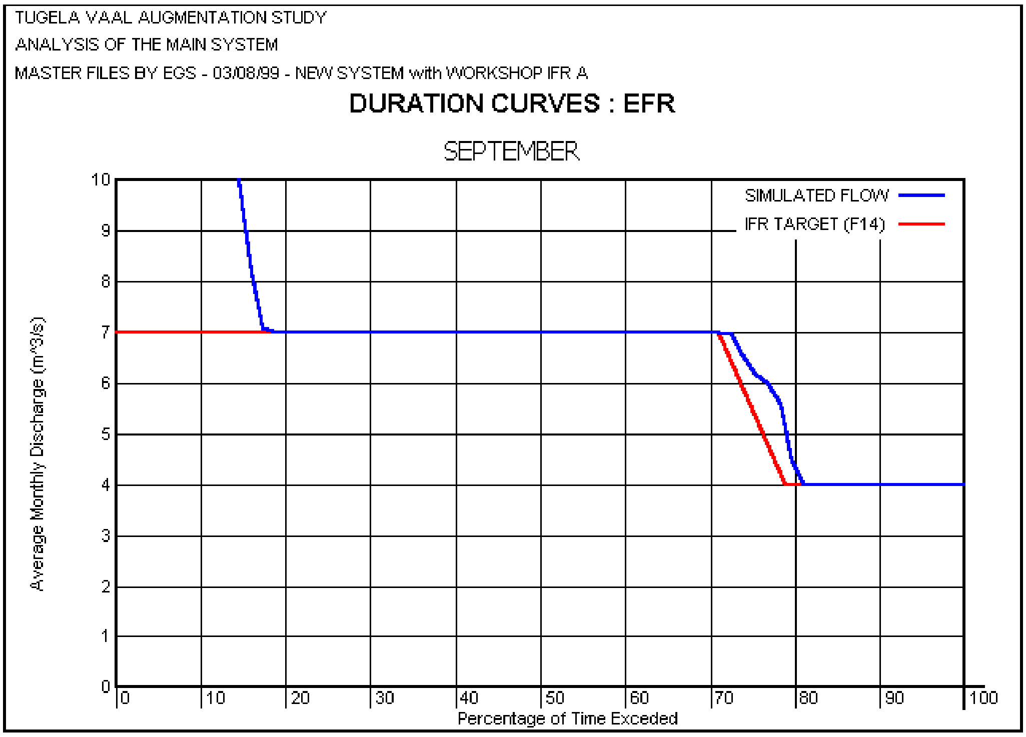


Figure 60: Supply of the EFR

Data for IFR A

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	1.8	0.0	2.8	0.0	2.8	0.0	3.4	0.0	4.9	0.0	4.1	0.0	2.6	0.0	1.8	0.0	1.6	0.0	1.3	0.0	1.2	0.0	1.3
0.6	1.8	0.7	2.8	0.6	2.8	2.5	3.4	3.9	4.9	3.5	4.1	2.6	2.6	1.9	1.8	1.5	1.6	1.1	1.3	0.9	1.2	0.8	1.3
0.8	2.0	1.3	4.8	2.7	3.9	7.3	6.2	10.9	12.3	9.2	8.0	6.5	2.6	3.5	2.0	2.6	1.7	1.7	1.3	1.3	1.5	1.0	1.6
1.0	2.2	2.1	5.5	3.9	7.4	12.1	7.9	16.0	13.4	14.5	9.3	8.1	4.7	4.2	2.5	2.9	2.1	2.0	1.8	1.4	1.8	1.1	2.0
1.3	2.3	3.9	6.2	8.7	8.6	14.9	10.5	19.4	19.5	16.0	10.0	9.1	6.3	4.7	3.7	3.2	2.9	2.2	2.4	1.5	2.0	1.2	2.0
1.6	2.4	4.7	6.6	10.9	9.8	17.2	11.7	26.1	23.1	20.7	12.3	9.8	7.4	4.9	4.1	3.3	3.2	2.3	2.8	1.7	2.3	1.4	2.4
2.0	2.6	6.9	6.8	14.8	10.2	21.1	12.0	29.9	25.0	24.9	14.1	11.3	9.6	5.2	4.8	3.6	3.6	2.5	3.0	1.9	2.5	1.5	2.7
2.7	3.0	9.9	7.3	16.9	10.6	30.1	12.9	34.0	26.7	28.1	14.4	13.2	9.8	5.7	4.9	3.8	3.7	2.6	3.0	2.0	2.6	1.7	2.7
4.2	3.3	11.9	7.3	19.9	10.6	34.1	13.3	41.7	27.6	31.6	15.2	15.2	10.1	6.1	4.9	4.0	3.7	2.8	3.0	2.2	2.6	1.8	2.8
6.7	3.4	15.9	7.3	23.5	10.6	38.9	13.4	51.6	27.6	38.5	15.2	17.4	10.2	7.2	4.9	4.8	3.7	3.3	3.0	2.5	2.6	2.4	2.8
11.8	3.4	21.2	7.3	32.7	10.6	49.9	13.4	62.0	27.6	44.0	15.2	20.4	10.2	8.8	4.9	5.6	3.7	3.8	3.0	3.0	2.6	3.9	2.8
999.0	3.4	999.0	7.3	999.0	10.9	999.0	13.4	999.0	27.6	999.0	18.5	999.0	10.2	999.0	5.4	999.0	3.7	999.0	3.0	999.0	2.6	999.0	2.8

* Combined flow from inflow nodes 1 (TM01), 6 (TM03), 8 (TM04) and 10 (TM05).

Data for IFR 2

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	1.3	0.0	3.2	0.0	3.4	0.0	3.6	0.0	4.4	0.0	3.5	0.0	3.0	0.0	2.0	0.0	1.5	0.0	1.0	0.0	1.0	0.0	1.0
1.2	1.3	1.1	3.2	1.1	3.4	8.2	3.6	9.3	4.4	8.2	3.5	6.3	3.0	4.1	2.0	2.9	1.5	2.1	1.0	2.1	1.0	1.7	1.0
1.9	1.6	3.1	3.8	6.1	5.2	15.1	8.7	22.8	10.2	18.8	6.9	11.2	3.6	6.2	3.6	4.4	2.6	3.1	1.6	2.4	1.1	1.9	1.5
2.4	2.3	4.8	4.1	8.8	9.5	24.7	10.8	33.2	19.6	28.9	8.9	15.9	7.3	7.5	5.1	5.0	3.4	3.5	2.1	2.6	1.7	2.3	1.6
3.2	2.8	9.1	5.3	17.3	11.6	31.8	12.6	50.3	31.3	37.2	13.1	17.8	8.4	8.5	5.2	5.7	3.6	3.8	2.7	2.9	2.0	2.5	1.8
4.6	3.0	11.3	5.8	23.1	12.4	42.5	13.2	62.6	37.2	44.9	13.5	20.9	9.2	9.6	5.2	5.9	3.7	4.1	2.7	3.3	2.2	2.7	1.9
5.6	3.2	15.5	6.1	29.4	13.3	48.4	14.3	69.0	39.3	53.5	13.7	21.9	9.3	10.3	5.3	6.5	3.7	4.5	2.7	3.5	2.2	2.9	2.1
8.0	3.3	20.8	6.3	39.2	13.4	61.1	14.7	79.3	39.3	63.4	13.7	29.2	9.3	11.1	5.3	7.2	3.7	4.9	2.7	3.8	2.2	3.7	2.1
11.1	3.3	26.1	6.4	47.7	13.4	88.0	14.9	98.3	39.3	71.7	13.7	33.1	9.3	12.4	5.3	7.6	3.7	5.5	2.7	4.7	2.2	4.6	2.1
17.1	3.9	34.0	6.4	59.6	13.4	99.6	15.1	133.0	39.4	89.7	13.7	39.8	9.3	14.1	5.3	8.7	3.7	6.4	2.7	5.1	2.2	5.9	2.1
26.4	4.0	57.1	6.4	69.7	13.4	126.9	15.1	163.8	40.1	113.3	13.7	46.8	9.3	19.2	5.3	10.6	3.7	7.4	2.7	7.6	2.2	12.0	2.1
999.0	4.0	999.0	6.5	999.0	13.4	999.0	15.1	999.0	43.0	999.0	25.1	999.0	15.1	999.0	5.3	999.0	3.7	999.0	2.7	999.0	2.2	999.0	2.1

* Combined flow from inflow nodes 1 (TM01), 6 (TM03), 8 (TM04), 10 (TM05), 14 (TM07), 27 (TM10), 17 (TM08) and 22 (TM11).

Data for IFR 3

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	0.5	0.0	1.1	0.0	1.1	0.0	2.6	0.0	1.3	0.0	1.2	0.0	0.9	0.0	0.7	0.0	0.5	0.0	0.4	0.0	0.4	0.0	0.4
0.5	0.5	0.5	1.1	0.8	1.1	2.2	2.6	5.0	1.3	2.5	1.2	2.1	0.9	1.5	0.7	1.1	0.5	0.8	0.4	0.6	0.4	0.5	0.4
1.0	0.5	1.5	1.5	3.4	1.5	6.9	2.8	7.5	1.9	4.6	1.5	2.8	1.0	1.9	0.7	1.4	0.5	1.1	0.4	0.9	0.4	0.8	0.4
1.2	0.8	2.5	1.7	5.1	2.3	8.6	3.0	9.3	3.0	6.6	2.5	4.4	1.2	2.4	0.9	1.7	0.6	1.3	0.6	1.1	0.5	1.0	0.5
1.5	0.9	4.7	2.2	7.0	2.3	10.3	3.7	11.1	5.3	9.0	2.7	5.5	1.7	2.7	1.1	2.0	0.8	1.5	0.7	1.2	0.6	1.2	0.7
2.1	1.0	6.0	2.4	9.1	3.1	11.2	4.1	13.2	6.8	10.9	3.8	6.6	2.1	3.1	1.5	2.1	1.0	1.6	0.7	1.3	0.7	1.3	0.7
2.7	1.0	6.9	2.5	11.1	3.5	13.8	4.5	15.6	7.9	14.0	4.1	7.8	2.1	3.6	1.6	2.4	1.0	1.7	0.7	1.6	0.7	1.5	0.7
3.4	1.0	8.0	2.5	13.2	3.6	15.7	4.8	16.7	8.6	16.4	4.1	9.7	2.1	4.0	1.6	2.6	1.0	1.8	0.7	1.7	0.7	1.7	0.7
5.3	1.0	10.0	2.6	16.0	3.7	20.2	5.0	21.5	8.6	18.0	4.1	12.3	2.1	5.3	1.6	3.2	1.0	2.2	0.7	1.9	0.7	2.2	0.7
7.6	1.2	12.4	2.6	18.4	3.8	27.3	5.0	31.2	8.6	20.4	4.1	15.2	2.1	5.9	1.6	3.5	1.0	2.3	0.7	2.3	0.7	3.1	0.7
9.4	1.3	18.1	2.6	26.9	3.8	35.3	5.0	39.0	8.6	26.5	4.1	19.8	2.6	7.2	1.6	4.7	1.0	3.1	0.7	3.7	0.7	7.0	0.7
999.0	1.3	999.0	2.7	999.0	3.8	999.0	5.0	999.0	8.7	999.0	4.2	999.0	2.6	999.0	1.6	999.0	1.0	999.0	0.7	999.0	0.7	999.0	0.7

* Combined flow from inflow nodes 37 (TM19), 38 (TM18), 40 (TM13), 41 (TM17) and 42 (TM09).

Data for IFR 5

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	1.9	0.0	3.7	0.0	9.2	0.0	8.4	0.0	17.4	0.0	7.9	0.0	4.9	0.0	3.1	0.0	2.0	0.0	1.4	0.0	1.4	0.0	2.4
1.1	1.9	0.9	3.7	0.9	9.2	6.2	8.4	7.5	17.4	7.0	7.9	5.7	4.9	3.1	3.1	2.1	2.0	1.6	1.4	1.6	1.4	1.3	2.4
1.8	3.9	2.9	5.4	5.9	12.4	12.0	14.4	15.9	35.3	14.7	13.4	9.3	7.6	4.5	5.3	3.0	3.1	2.3	1.4	1.9	1.4	1.7	2.8
2.4	4.5	6.1	6.6	9.3	13.4	25.0	17.2	26.4	36.2	20.2	15.7	11.3	8.5	5.6	5.9	3.6	3.5	2.6	1.5	2.1	1.6	2.0	3.1
3.5	4.9	8.8	7.8	13.0	15.1	30.7	17.8	45.6	44.9	32.2	17.0	14.0	11.4	6.3	7.2	3.9	4.7	2.9	3.5	2.4	3.3	2.2	3.5
4.5	4.9	11.3	8.8	17.8	16.8	36.5	18.9	58.0	53.3	36.3	18.3	15.8	11.8	7.2	7.7	4.7	5.5	3.0	4.3	2.7	3.7	2.5	3.6
6.5	4.9	12.7	8.9	23.8	17.7	41.5	19.6	66.8	55.6	41.3	18.4	21.3	12.1	7.8	7.7	5.0	5.5	3.4	4.3	3.0	3.7	2.7	3.6
7.9	5.7	17.0	9.0	34.3	18.0	57.8	20.0	76.0	55.6	55.0	18.4	23.9	12.3	9.6	7.7	5.2	5.5	3.6	4.3	3.2	3.7	3.3	3.6
10.4	5.7	24.0	9.0	48.8	18.0	88.5	20.1	96.1	55.6	59.8	18.4	27.0	12.3	10.2	7.7	5.9	5.5	4.6	4.3	3.7	3.7	4.6	3.6
18.5	5.7	35.3	9.0	58.0	18.0	113.4	20.1	129.5	55.6	85.2	18.4	32.8	12.3	12.6	7.7	7.1	5.5	5.4	4.3	5.5	3.7	6.2	3.6
24.4	5.7	57.1	9.1	80.7	18.1	149.5	20.1	160.9	56.2	99.0	26.8	41.0	12.3	14.5	8.1	8.5	5.5	6.9	4.3	7.4	3.7	12.6	3.6
999.0	5.7	999.0	9.5	999.0	18.2	999.0	20.1	999.0	56.3	999.0	33.6	999.0	13.5	999.0	9.5	999.0	5.5	999.0	4.3	999.0	3.7	999.0	3.6

* Combined flow from inflow nodes 10 (TM05), 14 (TM07), 27 (TM10), 29 (TM16), 17 (TM08), 22 (TM11), 40 (TM13), 42 (TM09), 33 (TM14) and 34 (TM15).

Data for the EFR

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	4.0	0.0	5.0	0.0	10.0	0.0	10.0	0.0	10.0	0.0	5.0	0.0	5.0	0.0	2.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	4.0
1.1	4.0	0.9	5.0	0.9	10.0	6.2	10.0	7.5	10.0	7.0	5.0	5.7	5.0	3.1	2.0	2.1	1.0	1.6	1.0	1.6	1.0	1.3	4.0
1.8	4.0	2.9	5.0	5.9	10.0	12.0	10.0	15.9	10.0	14.7	5.0	9.3	5.0	4.5	2.0	3.0	1.0	2.3	1.0	1.9	1.0	1.7	4.0
2.4	4.0	6.1	5.0	9.3	10.0	25.0	10.0	26.4	10.0	20.2	5.0	11.3	5.0	5.6	2.0	3.6	1.0	2.6	1.0	2.1	1.0	2.0	4.0
3.5	7.0	8.8	10.0	13.0	10.0	30.7	10.0	45.6	10.0	32.2	5.0	14.0	5.0	6.3	5.0	3.9	2.0	2.9	2.0	2.4	2.0	2.2	7.0
4.5	7.0	11.3	10.0	17.8	10.0	36.5	10.0	58.0	10.0	36.3	5.0	15.8	5.0	7.2	5.0	4.7	2.0	3.0	2.0	2.7	2.0	2.5	7.0
6.5	7.0	12.7	10.0	23.8	10.0	41.5	10.0	66.8	10.0	41.3	5.0	21.3	5.0	7.8	5.0	5.0	2.0	3.4	2.0	3.0	2.0	2.7	7.0
7.9	7.0	17.0	10.0	34.3	10.0	57.8	10.0	76.0	10.0	55.0	5.0	23.9	5.0	9.6	5.0	5.2	2.0	3.6	2.0	3.2	2.0	3.3	7.0
10.4	7.0	24.0	10.0	48.8	10.0	88.5	10.0	96.1	10.0	59.8	5.0	27.0	5.0	10.2	5.0	5.9	2.0	4.6	2.0	3.7	2.0	4.6	7.0
18.5	7.0	35.3	10.0	58.0	10.0	113.4	10.0	129.5	10.0	85.2	5.0	32.8	5.0	12.6	5.0	7.1	2.0	5.4	2.0	5.5	2.0	6.2	7.0
24.4	7.0	57.1	10.0	80.7	10.0	149.5	10.0	160.9	10.0	99.0	5.0	41.0	5.0	14.5	5.0	8.5	2.0	6.9	2.0	7.4	2.0	12.6	7.0
999.0	7.0	999.0	10.0	999.0	10.0	999.0	10.0	999.0	10.0	999.0	5.0	999.0	5.0	999.0	5.0	999.0	2.0	999.0	2.0	999.0	2.0	999.0	7.0

* Combined flow from inflow nodes 10 (TM05), 14 (TM07), 27 (TM10), 29 (TM16), 17 (TM08), 22 (TM11), 40 (TM13), 42 (TM09), 33 (TM14) and 34 (TM15).

APPENDIX H

JANA AND MIELIETUIN STORAGE-ELEVATION-AREA CURVES AND DATA

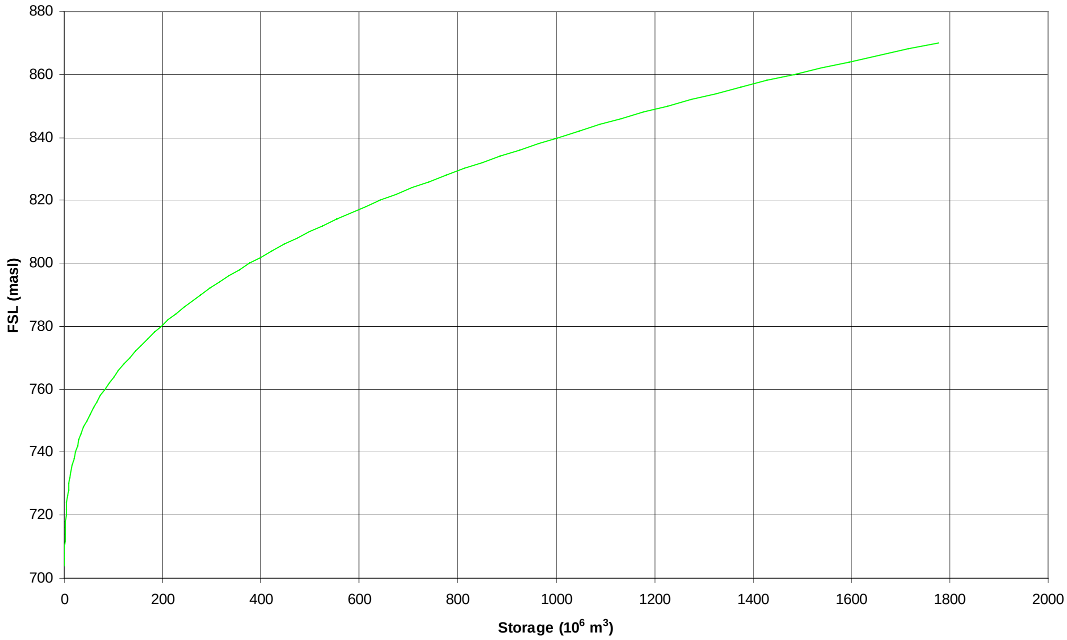


Figure H.1: Storage – Elevation Curve for Jana Dam

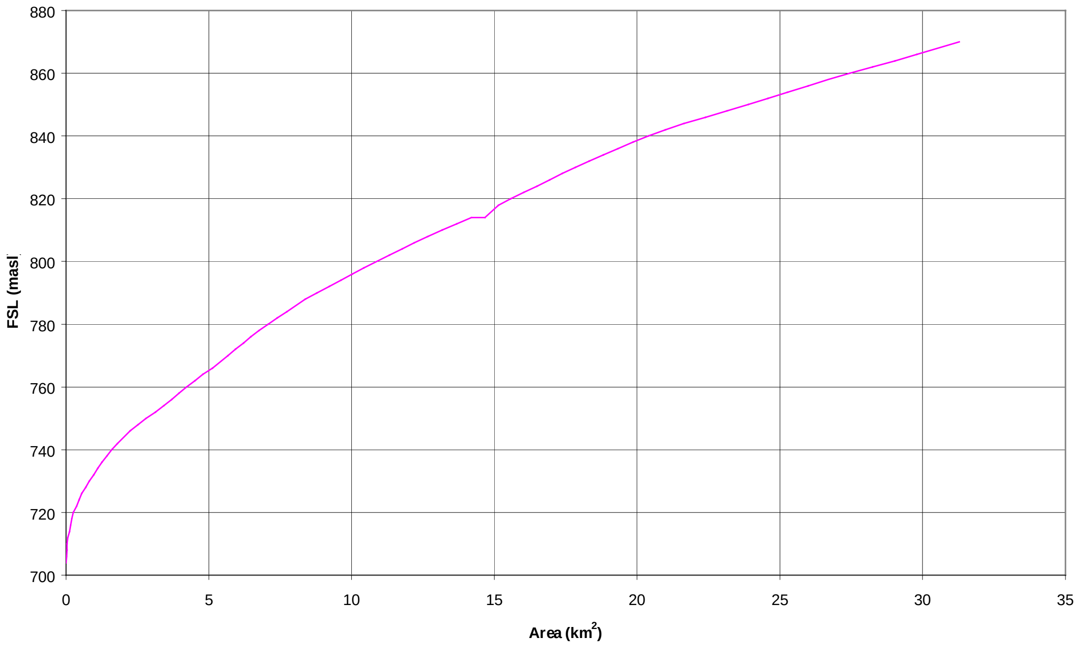


Figure H.2: Area – Elevation Curve for Jana Dam

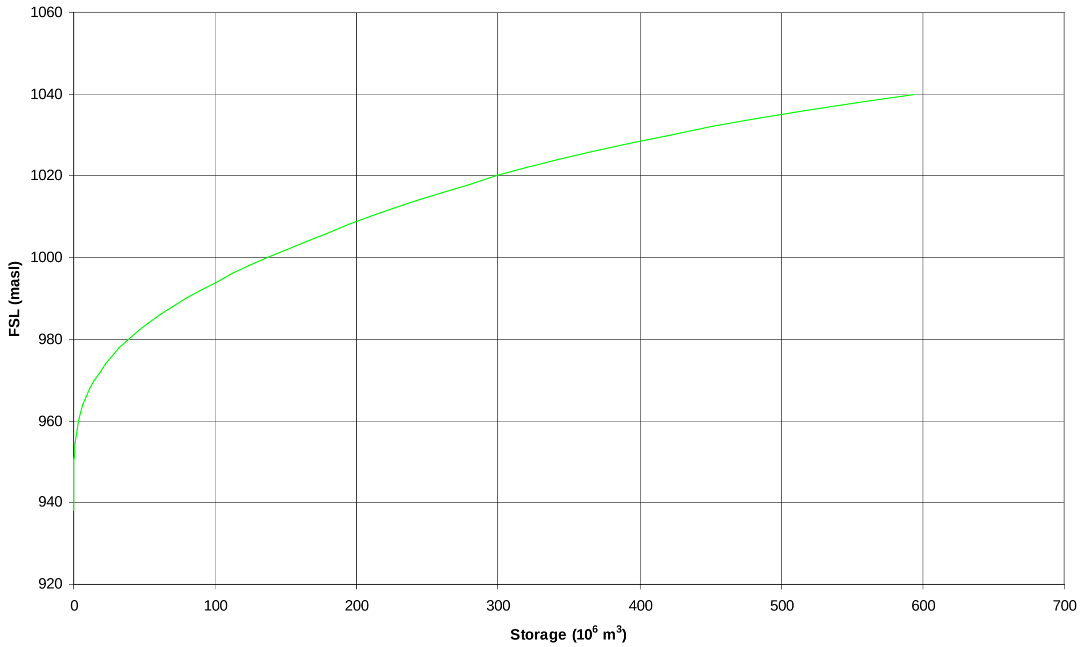


Figure H.3: Storage – Elevation Curve for Mielietuin Dam

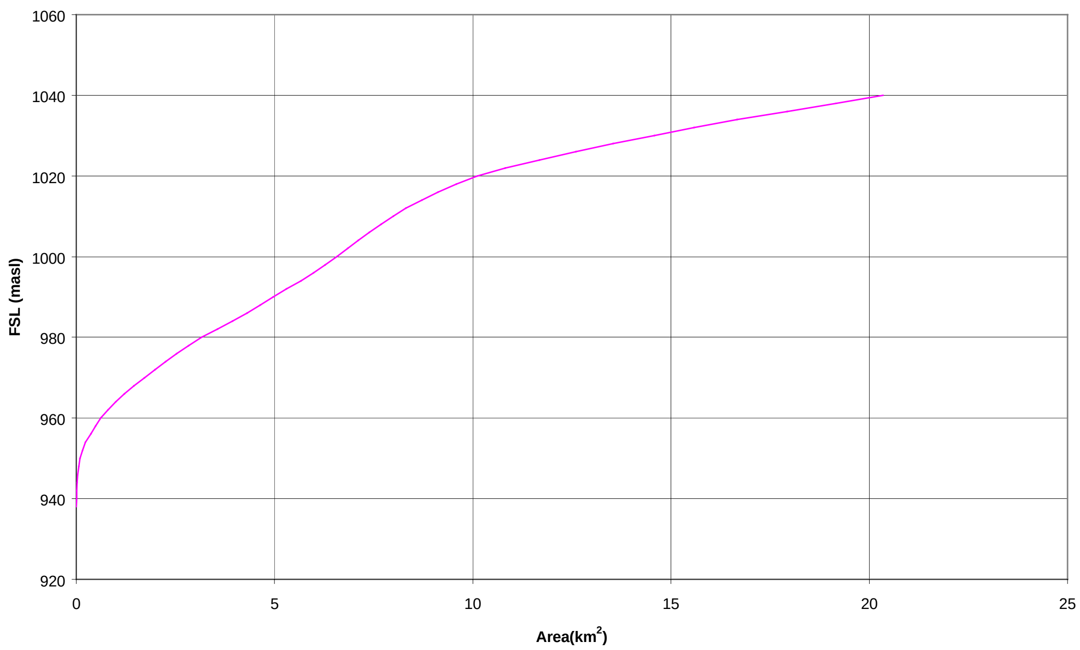


Figure H.4: Area – Elevation Curve for Mielietuin Dam

STORAGE – AREA – ELEVATION DATA FOR JANA DAM

JANA DAM AREA CAPACITY TABLE 9/3/1999

(Tin File: jannew.tin)

Contour Value (m)	Area (Ha)	Volume (Cu m)
704	0.3	238 045
706	2.3	498 726
708	3.3	791 367
710	4.3	1 104 592
712	6.9	1 452 104
714	13.4	1 885 049
716	16.1	2 417 690
718	19.9	3 013 729
720	25.5	3 681 070
722	37.5	4 469 216
724	45.9	5 528 018
726	54.4	6 769 851
728	69.5	8 180 420
730	81.6	9 906 424
732	97.1	11 917 300
734	111.0	14 215 543
736	126.3	16 800 626
738	143.6	19 707 559
740	160.2	22 984 164
742	179.6	26 597 164
744	202.9	30 634 772
746	224.2	35 143 283
748	253.4	40 128 698
750	279.9	45 695 218
752	313.0	51 830 888
754	341.9	58 612 925
756	369.9	65 941 227
758	395.4	73 824 095
760	421.3	82 230 846
762	451.4	91 162 856
764	479.3	100 695 999
766	512.7	110 790 182
768	540.4	121 569 084
770	566.6	132 885 572
772	593.5	144 721 356
774	621.7	157 100 689
776	647.6	170 048 752
778	675.4	183 526 678
780	706.8	197 578 366
782	740.5	212 275 370
784	773.6	227 636 643
786	805.3	243 669 977
788	837.7	260 349 738
790	878.2	277 696 860
792	921.6	295 889 367
794	963.1	315 017 598
796	1003.0	334 927 155
798	1042.8	355 634 350
800	1089.0	377 156 990
802	1132.4	399 629 167
804	1177.2	422 941 844
806	1219.4	447 160 644
808	1266.9	472 242 597
810	1317.4	498 310 404
812	1369.1	525 414 349
814	1419.6	553 541 105
814	1467.4	553 540 554
818	1514.2	612 730 504
820	1557.7	643 718 230
822	1602.7	675 569 204
824	1649.9	708 325 156
826	1693.6	742 026 394
828	1737.6	776 593 129
830	1784.2	812 068 910
832	1831.9	848 489 815
834	1881.8	885 893 846

836	1933.2	924 319 855
838	1985.3	963 773 725
840	2040.8	1 004 293 973
842	2099.0	1 045 942 063
844	2162.6	1 088 822 002
846	2239.1	1 133 147 157
848	2316.1	1 178 939 891
850	2389.1	1 226 147 956
852	2457.6	1 274 623 565
854	2527.4	1 324 446 396
856	2598.5	1 375 704 900
858	2670.5	1 428 393 076
860	2744.8	1 482 562 749
862	2824.9	1 538 276 892
864	2903.7	1 595 592 466
866	2979.8	1 654 440 813
868	3054.3	1 714 801 011
870	3127.8	1 776 629 663

STORAGE – AREA – ELEVATION DATA FOR MIELIETUIN DAM

MIELIETUIN DAM AREA CAPACITY TABLE : REVISED

09/03/1999

(Tin File : mtnew.tin)

Contour (m)	Area (Ha)	Volume (Cu m)
938	0.1	0
940	0.6	2 000
942	0.9	14 407
944	2.3	36 722
946	3.7	88 913
948	6.4	176 457
950	9.2	324 192
952	15.3	553 060
954	23.4	925 032
956	37.2	1 491 652
958	48.9	2 344 082
960	61.3	3 429 855
962	79.6	4 817 531
964	99.2	6 582 229
966	121.3	8 775 121
968	145.2	11 419 125
970	171.9	14 570 979
972	198.6	18 239 291
974	225.5	22 448 875
976	253.4	27 200 923
978	283.0	32 530 981
980	316.6	38 496 588
982	356.0	45 192 412
984	393.6	52 658 697
986	430.3	60 866 607
988	463.9	69 767 374
990	496.3	79 316 499
992	529.6	89 546 755
994	566.9	100 443 629
996	597.9	112 053 184
998	627.5	124 275 655
1000	655.8	137 093 500
1002	684.3	150 458 952
1004	711.3	164 398 536
1006	738.7	178 883 916
1008	768.2	193 936 387
1010	799.2	209 582 598
1012	831.3	225 867 793
1014	871.5	242 820 559
1016	911.6	260 627 029
1018	957.9	279 278 743
1020	1011.1	298 932 263
1022	1082.1	319 769 064
1024	1168.5	342 201 859
1026	1260.0	366 427 294
1028	1354.7	392 542 043
1030	1458.8	420 575 970
1032	1558.5	450 717 496
1034	1667.1	482 899 367
1036	1793.3	517 466 071
1038	1917.0	554 585 820
1040	2034.7	594 070 276

APPENDIX I

RUNOFF TIME SERIES

Runoff – TM01.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.42	3.23	2.65	2.45	7.38	21.69	9.89	3.22	2.22	1.53	1.05	.72	58.44
1921	.50	13.03	13.57	5.98	3.85	4.45	2.71	1.62	1.21	.93	.97	.86	49.69
1922	4.68	15.34	16.55	21.35	26.93	11.42	4.16	2.78	2.03	1.69	1.40	1.03	109.39
1923	.74	.57	.58	5.40	5.48	10.76	5.31	2.14	1.53	1.07	.74	.62	34.94
1924	3.62	13.34	19.39	13.78	15.57	40.32	19.56	6.31	4.24	3.12	2.24	1.62	143.10
1925	1.49	3.95	2.97	17.11	9.20	12.62	6.53	2.59	1.79	1.28	.90	2.20	62.63
1926	1.70	6.43	5.70	10.77	17.78	15.12	6.32	2.93	2.00	1.44	1.13	.87	72.18
1927	6.20	3.32	8.26	8.42	6.46	11.46	5.70	2.36	1.65	1.15	.80	.57	56.35
1928	.63	.96	3.66	15.75	8.27	15.19	8.20	3.21	3.19	3.74	2.49	8.87	74.16
1929	4.89	8.22	8.79	17.50	9.00	11.98	6.85	3.08	2.11	1.48	1.04	.74	75.68
1930	.60	.61	4.59	14.58	8.97	4.69	3.68	2.39	1.57	1.31	1.10	.82	44.90
1931	.60	3.70	2.22	2.80	22.01	19.32	7.11	3.10	2.23	1.63	1.14	.80	66.66
1932	.61	2.30	3.79	3.75	4.95	4.67	2.58	1.60	1.16	.86	.64	.46	27.37
1933	.32	7.55	14.08	39.91	25.82	14.24	7.20	4.32	3.11	2.85	3.30	2.23	124.93
1934	2.47	12.18	22.92	11.44	11.84	7.72	3.86	2.58	1.85	1.32	.93	.65	79.77
1935	.48	5.71	3.71	2.81	12.30	10.98	4.51	3.08	2.28	1.56	1.09	.76	49.27
1936	.79	21.01	12.78	15.40	18.63	8.63	3.68	2.47	1.68	1.15	.78	.54	87.55
1937	.42	.41	5.04	7.59	8.82	4.20	6.82	3.90	2.18	2.13	2.15	1.67	45.32
1938	4.23	3.06	11.25	13.72	33.20	21.74	7.69	3.91	2.75	2.01	1.61	1.34	106.51
1939	2.56	16.15	12.31	5.04	8.05	5.24	3.12	3.56	2.93	2.00	1.42	1.32	63.70
1940	1.10	1.62	9.13	16.91	17.07	7.49	3.48	2.56	1.88	1.35	.99	.72	64.30
1941	.63	.63	.97	7.85	7.07	12.12	6.73	2.85	1.96	1.42	1.08	.97	44.28
1942	3.02	13.14	18.26	11.98	6.08	11.33	25.17	11.85	4.14	4.65	7.44	4.06	121.14
1943	23.59	28.50	21.37	17.89	28.18	13.26	4.94	3.34	5.10	3.37	1.89	3.99	155.43
1944	5.31	4.88	2.86	2.87	12.64	27.98	12.40	4.05	2.76	1.91	1.31	.89	79.87
1945	.64	.53	.47	7.74	11.46	15.50	6.89	2.71	1.94	1.37	.95	.65	50.83
1946	4.33	7.55	4.30	2.32	5.87	13.87	6.89	2.68	1.84	1.30	.91	.74	52.60
1947	2.34	7.44	9.44	17.12	11.96	25.11	13.15	4.71	3.06	2.11	1.45	1.00	98.87
1948	1.09	1.39	1.44	4.90	6.66	9.06	5.38	2.60	1.74	1.25	.88	.67	37.07
1949	1.18	4.79	9.72	13.90	13.23	25.30	12.28	4.48	3.11	2.24	1.70	1.34	93.27
1950	1.43	1.26	13.18	7.44	6.31	7.47	4.20	2.28	1.64	1.20	1.00	1.07	48.48
1951	1.85	1.42	1.72	13.38	30.23	15.70	5.53	3.36	2.34	1.70	1.32	1.00	79.56
1952	1.01	3.83	11.36	9.27	20.38	12.52	5.54	3.32	2.32	1.67	1.20	.87	73.28
1953	.74	3.05	8.46	7.66	10.20	12.65	5.75	2.57	1.95	1.48	1.06	.82	56.40
1954	1.59	9.87	8.95	23.47	30.86	15.17	5.97	3.75	2.71	1.93	1.34	.91	106.50
1955	.66	2.90	5.71	4.88	18.53	23.89	9.73	3.77	2.73	1.94	1.34	.94	77.02
1956	.95	5.18	22.86	20.08	14.70	12.47	6.53	3.39	2.36	1.90	2.00	20.03	112.45
1957	19.41	8.26	9.26	26.15	17.87	9.37	8.08	4.56	2.57	1.76	1.22	.91	109.42
1958	.89	5.43	12.20	8.75	9.86	5.16	3.20	8.19	4.53	2.09	1.53	1.09	62.93
1959	3.81	5.80	8.19	6.97	9.06	11.57	7.51	3.51	2.07	1.43	1.04	.82	61.77
1960	1.29	2.54	15.54	11.99	5.83	12.05	8.83	4.08	2.48	1.77	1.26	.90	68.56
1961	.69	4.57	7.29	11.81	17.08	8.48	4.08	2.74	1.86	1.29	.90	.63	61.44
1962	.51	3.51	5.11	27.07	13.27	7.25	4.57	2.68	1.99	1.61	1.27	.91	69.75
1963	.81	5.14	3.82	15.03	7.71	6.92	4.16	2.21	1.65	1.32	1.03	.83	50.62
1964	11.53	8.67	8.01	12.58	6.27	2.85	2.91	2.18	1.80	1.50	1.92	1.71	61.93
1965	1.33	2.76	2.16	16.01	12.49	4.72	2.38	1.66	1.18	.84	.60	.45	46.58
1966	.47	.98	9.40	17.39	31.03	23.83	11.88	5.56	3.37	2.34	1.61	1.10	108.97
1967	.79	.97	3.93	3.17	2.39	4.19	3.08	1.84	1.35	.99	.74	.60	24.04
1968	.49	1.13	7.07	6.26	7.47	15.38	7.72	3.35	2.48	1.91	1.41	1.01	55.67
1969	3.38	2.51	13.90	11.58	9.52	5.25	2.71	1.88	1.36	1.02	.98	1.26	55.36
1970	2.26	1.93	1.58	24.09	19.66	10.04	5.65	3.68	2.56	1.89	1.47	1.12	75.93
1971	.86	1.27	3.68	13.58	23.02	24.14	9.97	3.99	2.82	1.97	1.36	.94	87.60
1972	.72	1.79	1.39	1.46	12.93	7.38	3.07	2.10	1.47	1.03	1.31	2.12	36.78
1973	1.55	4.85	8.61	30.48	32.61	18.93	9.77	5.10	3.20	2.32	1.67	1.17	120.26
1974	.82	8.26	7.71	16.74	29.10	20.10	8.48	4.21	2.78	1.90	1.30	1.49	102.89
1975	1.54	7.00	13.73	23.60	22.74	42.35	19.66	6.76	4.56	3.14	2.15	1.49	148.72
1976	5.12	8.00	9.56	14.87	15.73	9.73	5.95	3.42	2.14	1.47	1.02	1.20	78.22
1977	5.14	3.47	9.37	25.09	17.99	15.51	8.03	3.73	2.49	1.71	1.21	1.03	94.76
1978	6.47	4.10	16.11	9.32	10.93	8.10	3.78	2.35	1.74	1.32	2.74	2.09	69.04
1979	3.78	9.14	10.56	12.68	14.86	15.08	6.74	2.96	2.02	1.39	.96	1.13	81.28
1980	1.00	1.74	5.92	18.62	41.26	18.28	5.69	3.86	2.69	1.88	1.55	1.31	103.81
1981	1.08	4.45	8.42	6.15	3.27	4.32	3.77	2.24	1.44	1.01	.72	.52	37.40
1982	1.55	1.44	1.06	1.21	1.29	1.27	1.11	.91	.73	.72	.72	.62	12.63
1983	1.57	6.78	12.11	8.09	6.58	18.84	9.31	3.30	2.25	1.58	1.23	1.01	72.64
1984	1.02	1.55	1.30	8.62	37.36	16.79	4.64	3.11	2.11	1.43	.97	.67	79.58
1985	4.69	4.06	12.17	16.28	8.40	6.01	5.25	3.03	1.85	1.30	.99	.82	64.84
1986	2.75	4.47	7.96	4.68	10.07	11.70	5.22	2.41	1.68	1.17	1.39	26.50	80.00
1987	13.74	10.13	6.51	9.74	30.62	37.26	15.22	5.55	3.85	2.82	2.10	1.58	139.12
1988	2.46	5.09	11.87	18.39	38.47	17.51	6.10	4.18	2.99	2.17	1.53	1.04	111.79
1989	.80	4.71	10.44	8.63	7.97	5.64	3.20	2.09	1.51	1.08	.79	.59	47.45
1990	.48	.46	4.11	18.55	16.59	13.93	6.28	2.76	1.87	1.30	.90	.63	67.86
1991	3.06	2.68	8.41	4.66	10.44	6.41	2.85	1.96	1.38	.96	.67	.49	43.96
1992	.41	.48	.59	2.93	13.78	10.63	4.22	2.23	1.56	1.08	.75	.54	39.17
1993	2.78	4.30	7.50	13.71	16.50	11.75	5.63	3.01	2.03	1.40	.98	.70	70.28
1994	.55	.48	.51	7.69	5.80	8.43	5.12	2.40	1.66	1.25	.92	.68	35.49

Runoff – TM02.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	11.84	15.78	12.93	11.95	36.02	105.90	48.27	15.70	10.81	7.47	5.11	3.53	285.32
1921	2.46	63.60	66.25	29.22	18.79	21.70	13.25	7.90	5.93	4.56	4.76	4.20	242.62
1922	22.87	74.92	80.83	104.26	131.50	55.78	20.29	13.60	9.90	8.28	6.84	5.05	534.09
1923	3.60	2.79	2.81	26.36	26.74	52.52	25.95	10.46	7.45	5.23	3.64	3.02	170.57
1924	17.69	65.11	94.67	67.27	75.99	196.86	95.48	30.79	20.71	15.21	10.95	7.93	698.67
1925	7.28	19.27	14.51	83.51	44.91	61.62	31.90	12.66	8.73	6.23	4.40	10.76	305.78
1926	8.30	31.37	27.83	52.56	86.79	73.81	30.88	14.32	9.78	7.01	5.50	4.26	352.42
1927	30.25	16.18	40.31	41.13	31.56	55.95	27.82	11.54	8.08	5.63	3.90	2.78	275.13
1928	3.06	4.70	17.86	76.90	40.39	74.14	40.04	15.65	15.60	18.28	12.16	43.30	362.08
1929	23.85	40.12	42.91	85.45	43.92	58.51	33.47	15.01	10.30	7.23	5.08	3.62	369.48
1930	2.95	2.99	22.41	71.18	43.79	22.89	17.94	11.65	7.64	6.37	5.35	4.03	219.20
1931	2.95	18.04	10.81	13.65	107.48	94.33	34.72	15.12	10.91	7.93	5.59	3.92	325.45
1932	2.99	11.21	18.48	18.28	24.18	22.82	12.60	7.82	5.69	4.19	3.12	2.24	133.62
1933	1.56	36.88	68.73	194.84	126.08	69.54	35.15	21.10	15.16	13.89	16.13	10.91	609.97
1934	12.07	59.46	111.92	55.87	57.80	37.69	18.87	12.58	9.05	6.45	4.53	3.18	389.46
1935	2.35	27.90	18.10	13.72	60.08	53.60	22.03	15.01	11.13	7.63	5.32	3.69	240.56
1936	3.87	102.56	62.39	75.18	90.93	42.14	17.99	12.05	8.23	5.61	3.83	2.66	427.43
1937	2.07	1.99	24.58	37.06	43.04	20.48	33.32	19.05	10.66	10.38	10.48	8.16	221.28
1938	20.67	14.95	54.90	66.99	162.10	106.16	37.55	19.10	13.41	9.83	7.85	6.53	520.04
1939	12.49	78.85	60.13	24.59	39.28	25.61	15.21	17.40	14.31	9.75	6.94	6.45	311.01
1940	5.38	7.93	44.58	82.55	83.36	36.59	16.97	12.47	9.15	6.62	4.84	3.51	313.95
1941	3.10	3.05	4.73	38.33	34.51	59.19	32.88	13.89	9.54	6.94	5.28	4.75	216.19
1942	14.76	64.18	89.18	58.50	29.69	55.33	122.86	57.86	20.24	22.73	36.33	19.82	591.46
1943	115.19	139.15	104.31	87.37	137.58	64.73	24.14	16.32	24.92	16.47	9.24	19.48	758.89
1944	25.91	23.84	13.96	14.04	61.72	136.61	60.55	19.76	13.49	9.32	6.39	4.35	389.93
1945	3.10	2.58	2.28	37.81	55.94	75.65	33.61	13.21	9.45	6.67	4.65	3.18	248.15
1946	21.13	36.87	20.98	11.34	28.67	67.70	33.66	13.07	9.00	6.33	4.44	3.63	256.82
1947	11.41	36.30	46.07	83.57	58.40	122.57	64.23	22.97	14.93	10.31	7.08	4.86	482.72
1948	5.33	6.78	7.01	23.93	32.53	44.26	26.29	12.69	8.52	6.08	4.28	3.29	180.98
1949	5.78	23.36	47.48	67.88	64.60	123.51	59.94	21.86	15.18	10.93	8.32	6.53	455.37
1950	7.00	6.16	64.36	36.31	30.80	36.46	20.48	11.16	8.01	5.85	4.86	5.23	236.68
1951	9.06	6.92	8.39	65.30	147.61	76.68	27.01	16.42	11.43	8.31	6.42	4.91	388.45
1952	4.94	18.68	55.46	45.24	99.49	61.14	27.02	16.21	11.35	8.16	5.84	4.24	357.78
1953	3.64	14.92	41.28	37.38	49.80	61.79	28.09	12.55	9.53	7.20	5.18	4.03	275.38
1954	7.77	48.17	43.68	114.57	150.66	74.08	29.14	18.30	13.21	9.41	6.53	4.45	519.99
1955	3.23	14.14	27.86	23.83	90.48	116.63	47.53	18.38	13.32	9.47	6.57	4.61	376.05
1956	4.64	25.28	111.60	98.06	71.79	60.91	31.86	16.55	11.53	9.25	9.78	97.77	549.02
1957	94.77	40.33	45.22	127.69	87.25	45.74	39.45	22.28	12.54	8.62	5.93	4.42	534.24
1958	4.34	26.51	59.58	42.73	48.15	25.21	15.65	39.97	22.14	10.19	7.47	5.34	307.27
1959	18.60	28.33	39.97	34.05	44.23	56.49	36.68	17.11	10.09	6.97	5.07	3.99	301.59
1960	6.31	12.40	75.86	58.56	28.46	58.83	43.10	19.91	12.08	8.67	6.15	4.42	334.75
1961	3.39	22.30	35.62	57.69	83.38	41.43	19.93	13.39	9.09	6.31	4.38	3.10	299.99
1962	2.47	17.15	24.96	132.14	64.76	35.41	22.34	13.09	9.72	7.84	6.21	4.44	340.53
1963	3.94	25.10	18.67	73.39	37.63	33.78	20.31	10.77	8.07	6.45	5.01	4.03	247.16
1964	56.29	42.35	39.12	61.41	30.59	13.93	14.20	10.64	8.77	7.30	9.40	8.34	302.34
1965	6.49	13.47	10.53	78.17	60.98	23.04	11.60	8.13	5.75	4.10	2.94	2.22	227.42
1966	2.27	4.78	45.91	84.92	151.51	116.33	58.03	27.15	16.47	11.41	7.88	5.39	532.04
1967	3.83	4.75	19.17	15.49	11.66	20.43	15.05	9.00	6.59	4.82	3.64	2.95	117.38
1968	2.38	5.51	34.51	30.54	36.49	75.10	37.67	16.37	12.12	9.30	6.89	4.91	271.80
1969	16.50	12.28	67.85	56.56	46.50	25.65	13.23	9.19	6.65	4.99	4.79	6.13	270.31
1970	11.06	9.43	7.70	117.60	95.97	49.01	27.61	17.96	12.51	9.25	7.18	5.45	370.73
1971	4.21	6.20	17.97	66.32	112.38	117.85	48.69	19.50	13.75	9.60	6.63	4.60	427.70
1972	3.53	8.74	6.77	7.13	63.13	36.04	14.99	10.26	7.20	5.05	6.39	10.35	179.57
1973	7.57	23.67	42.05	148.81	159.22	92.42	47.72	24.92	15.60	11.31	8.17	5.70	587.16
1974	4.03	40.34	37.62	81.74	142.06	98.11	41.43	20.56	13.57	9.25	6.34	7.27	502.32
1975	7.49	34.18	67.03	115.20	111.03	206.79	95.99	33.03	22.24	15.33	10.49	7.29	726.09
1976	24.97	39.08	46.70	72.58	76.78	47.52	29.05	16.72	10.44	7.19	4.99	5.88	381.88
1977	25.07	16.95	45.76	122.47	87.83	75.73	39.18	18.20	12.14	8.33	5.92	5.05	462.64
1978	31.58	20.01	78.66	45.50	53.36	39.54	18.48	11.45	8.48	6.44	13.39	10.19	337.09
1979	18.46	44.60	51.54	61.93	72.56	73.61	32.88	14.45	9.87	6.77	4.66	5.50	396.85
1980	4.90	8.50	28.91	90.89	201.45	89.23	27.81	18.87	13.16	9.18	7.56	6.38	506.83
1981	5.30	21.74	41.10	30.02	15.99	21.10	18.40	10.91	7.02	4.94	3.54	2.53	182.58
1982	7.57	7.04	5.20	5.89	6.29	6.20	5.39	4.45	3.56	3.53	3.51	3.03	61.66
1983	7.67	33.09	59.13	39.48	32.10	91.99	45.46	16.11	11.00	7.69	5.99	4.93	354.65
1984	4.98	7.58	6.35	42.11	182.39	82.00	22.67	15.17	10.32	6.99	4.75	3.26	388.56
1985	22.88	19.80	59.39	79.46	41.00	29.34	25.64	14.81	9.01	6.36	4.86	4.03	316.59
1986	13.41	21.82	38.88	22.84	49.15	57.14	25.50	11.76	8.21	5.73	6.78	129.37	390.59
1987	67.10	49.45	31.78	47.54	149.48	181.93	74.29	27.12	18.81	13.78	10.23	7.70	679.21
1988	12.01	24.86	57.94	89.80	187.84	85.50	29.77	20.38	14.58	10.57	7.46	5.10	545.82
1989	3.89	23.01	50.96	42.16	38.91	27.51	15.63	10.22	7.37	5.29	3.85	2.87	231.67
1990	2.36	2.23	20.06	90.56	80.97	68.03	30.69	13.49	9.13	6.33	4.40	3.09	331.34
1991	14.92	13.09	41.04	22.74	50.96	31.31	13.91	9.57	6.74	4.67	3.30	2.38	214.64
1992	1.99	2.32	2.86	14.28	67.30	51.88	20.58	10.89	7.59	5.25	3.64	2.64	191.24
1993	13.57	20.97	36.59	66.91	80.54	57.34	27.51	14.68	9.89	6.85	4.81	3.44	343.11
1994	2.66	2.33	2.47	37.57	28.31	41.17	25.00	11.71	8.13	6.13	4.48	3.31	173.27

Runoff – TM03.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.89	.55	.34	.39	4.24	4.23	1.57	.60	.41	.29	.21	.18	13.91
1921	.16	4.84	4.48	3.12	1.62	1.00	.63	.39	.28	.22	.21	.19	17.13
1922	.49	1.84	1.69	4.68	10.55	4.18	.96	.63	.45	.34	.27	.20	26.28
1923	.15	.14	.16	.53	2.93	3.50	1.44	.54	.37	.27	.19	.16	10.37
1924	.33	2.08	5.16	3.28	4.85	16.48	6.90	1.56	1.00	.70	.50	.35	43.19
1925	.31	.46	.43	6.59	3.37	1.28	.73	.44	.31	.24	.17	.29	14.62
1926	.42	1.48	2.54	3.57	4.40	5.15	2.13	.71	.47	.33	.25	.19	21.63
1927	.46	.36	1.96	2.18	1.47	3.63	1.66	.51	.35	.25	.17	.13	13.13
1928	.10	.10	1.92	2.01	5.09	6.92	2.91	.96	.67	.62	.47	1.13	22.90
1929	.90	1.79	5.83	5.97	2.54	2.98	1.59	.68	.48	.35	.27	.21	23.58
1930	.17	.14	.15	5.79	2.91	1.79	1.11	.54	.35	.26	.21	.15	13.56
1931	.12	.10	.09	.12	4.58	6.22	2.31	.71	.51	.38	.28	.20	15.62
1932	.14	.24	.66	.61	.46	.43	.39	.30	.22	.17	.14	.11	3.87
1933	.08	3.48	5.26	14.89	6.92	3.28	2.49	1.47	.82	.55	.52	.40	40.15
1934	.46	3.48	10.57	4.29	2.73	2.46	1.17	.61	.42	.30	.22	.15	26.85
1935	.11	.09	.17	1.17	2.96	3.39	1.36	1.36	.87	.43	.28	.20	12.40
1936	.18	4.54	2.20	7.01	7.81	2.93	.95	.63	.44	.30	.21	.14	27.34
1937	.11	.09	.67	3.95	2.14	.75	1.59	.90	.42	.38	.33	.27	11.60
1938	.55	.61	1.86	4.63	13.76	8.65	2.54	1.03	.72	.53	.40	.31	35.58
1939	.44	4.21	4.06	1.77	1.41	1.45	.78	.74	.73	.47	.31	.24	16.61
1940	.21	.32	.89	5.90	5.66	2.10	.99	.65	.42	.29	.21	.15	17.78
1941	.12	.12	.13	.85	3.74	4.26	2.08	.83	.47	.33	.25	.21	13.39
1942	.30	6.00	6.24	4.80	2.03	2.04	8.84	4.02	1.05	.87	1.91	1.08	39.18
1943	5.94	6.70	4.24	3.89	8.13	3.57	1.00	.64	.58	.46	.33	.52	36.01
1944	.72	.72	.42	.35	.64	6.59	2.91	.66	.43	.31	.21	.14	14.11
1945	.10	.08	.06	1.25	3.34	5.15	2.06	.61	.41	.28	.20	.14	13.67
1946	.26	1.88	.99	.37	3.51	4.79	1.92	.62	.42	.30	.22	.16	15.45
1947	.28	1.42	2.47	5.26	2.95	8.53	3.91	1.00	.64	.45	.31	.21	27.44
1948	.17	.17	.25	1.13	1.56	2.55	1.42	.57	.36	.26	.19	.15	8.79
1949	.15	.40	.70	1.15	1.74	8.98	3.88	.90	.62	.45	.33	.25	19.56
1950	.22	.21	4.96	2.38	1.35	1.19	.78	.46	.31	.23	.18	.20	12.47
1951	.25	.22	.29	4.59	6.53	3.16	1.16	.62	.41	.32	.27	.21	18.02
1952	.22	.29	1.90	2.61	8.81	3.89	1.12	.71	.47	.33	.24	.17	20.76
1953	.13	.28	.49	.91	6.92	3.82	1.13	.62	.46	.35	.25	.19	15.55
1954	.30	2.08	1.32	6.29	8.49	3.70	1.21	.71	.50	.35	.24	.17	25.37
1955	.12	.18	1.43	.83	3.98	7.29	2.80	.73	.50	.35	.24	.17	18.63
1956	.13	.52	8.55	7.59	3.96	3.92	1.98	.80	.52	.41	.38	5.97	34.73
1957	6.04	2.11	.87	7.01	4.01	1.71	1.71	.95	.48	.32	.23	.17	25.61
1958	.15	.70	3.15	2.18	3.31	1.72	.75	1.17	.79	.41	.28	.20	14.78
1959	.38	.75	.76	.73	3.25	3.95	2.02	.83	.46	.31	.22	.16	13.83
1960	.15	.27	2.94	1.53	.57	2.63	1.71	.72	.42	.30	.21	.15	11.62
1961	.12	.25	.52	5.92	4.53	1.73	.96	.60	.39	.27	.19	.14	15.62
1962	.10	.32	1.15	9.62	4.11	1.76	1.10	.58	.40	.32	.26	.19	19.91
1963	.15	.56	.36	3.81	1.90	1.67	1.04	.49	.33	.26	.20	.18	10.96
1964	2.04	1.55	3.10	2.06	.95	.51	.38	.30	.31	.27	.32	.31	12.10
1965	.26	.34	.32	5.65	3.51	1.08	.53	.36	.26	.19	.13	.10	12.73
1966	.08	.20	5.06	9.73	7.96	4.22	2.91	1.39	.67	.46	.32	.22	33.21
1967	.15	.12	.26	.32	.30	.36	.30	.22	.17	.12	.10	.08	2.51
1968	.07	.07	.25	.37	1.22	3.52	1.73	.62	.43	.32	.24	.17	9.01
1969	.45	.40	1.15	1.55	1.76	.95	.44	.29	.21	.16	.14	.24	7.73
1970	.37	.34	.27	3.87	3.61	1.71	.90	.59	.42	.32	.27	.21	12.88
1971	.20	.26	.68	1.43	3.22	5.89	2.40	.68	.47	.33	.24	.17	15.98
1972	.13	.24	.22	.25	5.31	2.56	.93	.59	.36	.25	.29	.42	11.57
1973	.32	.68	1.94	4.56	9.07	6.43	2.68	1.12	.66	.48	.35	.25	28.53
1974	.17	1.71	2.51	4.72	10.83	5.64	1.85	.95	.61	.42	.29	.37	30.06
1975	.32	.86	4.51	7.49	6.17	15.46	6.46	1.56	1.01	.69	.48	.33	45.33
1976	.67	.96	1.01	1.65	1.19	1.50	.95	.46	.30	.21	.15	.12	9.16
1977	.66	.79	.92	7.26	5.54	3.05	1.48	.72	.46	.32	.22	.18	21.60
1978	1.38	.90	3.32	1.91	3.79	2.58	1.04	.56	.40	.30	.45	.36	16.98
1979	.40	.75	1.24	2.10	5.99	4.68	1.60	.61	.42	.29	.20	.21	18.49
1980	.19	.35	3.19	8.56	17.51	6.77	1.50	.99	.68	.48	.36	.30	40.88
1981	.24	.64	.85	2.54	1.26	.77	.74	.46	.30	.21	.15	.11	8.28
1982	.17	.25	.21	.42	.40	.32	.27	.22	.17	.14	.13	.11	2.81
1983	.28	3.17	2.35	2.55	1.56	4.62	2.44	.79	.46	.32	.25	.21	19.01
1984	.21	.19	.17	2.56	10.80	4.39	.90	.58	.40	.27	.19	.13	20.79
1985	1.12	2.85	3.32	5.40	2.50	1.31	.98	.57	.37	.26	.20	.15	19.03
1986	.38	.80	2.03	2.11	5.61	5.15	1.83	.64	.43	.30	.26	9.74	29.30
1987	4.27	1.49	2.29	1.81	5.91	5.86	2.18	.79	.54	.42	.32	.24	26.11
1988	.22	.56	3.16	4.02	12.47	6.09	1.61	.86	.58	.42	.29	.20	30.49
1989	.15	2.11	1.43	.78	.93	1.26	.96	.49	.30	.21	.17	.14	8.92
1990	.11	.09	.86	7.72	5.48	2.24	.93	.51	.35	.24	.17	.12	18.83
1991	2.83	2.12	1.63	.95	2.50	2.14	.94	.47	.31	.22	.15	.12	14.39
1992	.09	.19	.34	.59	10.14	6.65	1.88	.74	.49	.34	.24	.16	21.84
1993	3.17	1.80	1.91	4.51	6.64	4.87	1.97	.81	.50	.34	.25	.17	26.95
1994	.13	.10	.09	1.55	1.19	2.70	1.43	.50	.32	.23	.16	.12	8.51

Runoff – TM04.INC

Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	24.64	11.43	5.86	14.12	72.48	49.38	17.09	8.68	6.24	4.43	3.09	4.56	222.00
1921	3.96	42.25	46.29	49.40	32.02	14.37	7.79	5.28	4.02	3.23	4.10	3.20	215.92
1922	6.59	17.92	11.15	40.80	60.74	30.81	11.58	6.96	4.80	3.53	2.82	2.15	199.85
1923	1.58	2.65	3.24	11.77	50.03	42.94	17.20	7.99	5.69	4.06	2.85	3.20	153.21
1924	8.90	26.76	52.08	39.01	44.70	125.98	63.46	20.06	12.10	8.47	5.96	4.29	411.77
1925	3.94	8.12	7.53	27.22	26.73	21.16	10.09	5.23	3.89	3.00	2.23	13.05	132.20
1926	16.01	31.92	48.63	62.06	45.03	40.87	20.57	9.41	6.27	4.39	3.23	2.39	290.77
1927	6.22	4.11	36.81	40.34	28.56	32.15	15.32	6.87	4.97	3.53	2.47	1.75	183.09
1928	1.45	2.05	40.72	39.77	44.58	43.69	20.53	9.72	8.95	10.18	6.47	21.82	249.93
1929	12.76	13.84	26.34	32.26	25.56	48.42	22.88	8.37	6.17	4.79	3.88	3.31	208.59
1930	3.00	2.50	4.25	46.95	29.30	29.14	17.29	7.75	4.89	3.82	3.01	2.22	154.13
1931	1.65	1.41	1.33	3.83	46.64	70.44	28.42	9.72	6.97	5.02	3.54	2.46	181.42
1932	1.83	10.59	18.76	16.29	9.65	7.53	6.54	4.31	2.87	2.23	1.90	1.46	83.97
1933	1.06	42.30	63.03	96.20	59.23	48.25	38.61	20.84	10.82	7.15	7.36	5.41	400.27
1934	10.39	59.29	92.85	38.15	45.52	41.49	17.80	8.66	6.00	4.27	3.03	2.14	329.60
1935	1.54	1.44	9.06	28.57	35.76	36.57	15.84	21.93	12.30	5.57	3.81	2.63	175.02
1936	3.16	47.40	27.72	52.37	68.84	32.78	12.62	7.90	5.40	3.69	2.52	1.73	266.12
1937	1.35	1.49	19.24	41.58	24.93	10.99	28.89	14.86	5.77	5.10	4.54	3.63	162.38
1938	15.11	13.59	32.25	49.90	113.44	77.72	27.00	12.75	8.96	6.68	5.05	3.93	366.38
1939	13.22	37.22	42.49	26.93	26.77	29.13	14.28	17.67	12.33	6.45	4.26	3.74	234.49
1940	3.02	8.72	16.97	42.57	49.43	22.68	17.00	9.81	5.23	3.57	2.49	1.73	183.23
1941	1.79	1.74	2.39	21.93	35.89	46.02	27.40	11.01	6.18	4.36	3.29	2.90	164.91
1942	5.71	59.51	62.08	58.96	28.70	34.13	68.78	37.48	13.80	13.26	30.74	15.37	428.52
1943	47.49	59.46	40.14	41.35	57.21	31.08	12.48	7.52	6.90	5.24	3.61	11.63	324.11
1944	8.10	6.44	4.52	7.13	9.65	50.21	24.75	7.67	5.13	3.57	2.46	1.68	131.31
1945	1.15	.92	.97	28.15	41.99	56.03	24.11	8.53	5.78	3.94	2.68	1.81	176.07
1946	3.69	22.46	12.00	5.35	40.26	48.84	20.29	7.95	5.52	4.00	2.86	2.09	175.32
1947	6.13	16.97	34.03	55.57	38.04	72.76	37.13	12.82	8.17	5.59	3.81	2.59	293.63
1948	2.13	2.96	8.07	25.30	27.24	34.67	18.53	7.89	5.17	3.64	2.57	1.94	140.12
1949	1.81	11.10	15.71	17.64	24.73	83.65	38.50	11.73	8.15	5.82	4.31	3.39	226.55
1950	3.12	3.11	47.84	24.46	24.95	20.32	10.07	5.76	3.99	2.81	2.41	2.62	151.44
1951	3.65	2.85	4.21	44.11	55.02	35.36	14.84	7.56	5.20	4.42	3.53	2.71	183.46
1952	4.07	7.77	36.74	34.58	65.90	32.25	12.90	8.37	5.50	3.76	2.60	1.81	216.24
1953	1.47	8.20	14.22	21.68	66.78	44.53	15.61	9.26	6.74	4.77	3.33	2.70	199.30
1954	4.41	27.68	24.36	60.20	78.86	44.60	17.82	9.80	6.92	4.86	3.36	2.28	285.16
1955	1.62	2.67	27.63	13.72	39.36	64.67	26.87	9.03	6.17	4.24	2.90	2.04	200.94
1956	1.66	16.89	73.91	66.29	40.38	42.96	24.13	10.78	6.80	5.04	5.28	44.81	338.95
1957	45.26	18.79	10.83	54.95	43.51	25.68	25.28	12.87	6.23	4.24	2.89	2.13	252.67
1958	2.01	17.61	30.00	26.66	31.87	17.04	10.09	21.08	11.27	5.00	3.55	2.49	178.66
1959	7.52	16.10	16.98	18.12	38.87	53.81	29.94	11.66	6.53	4.43	3.06	2.19	209.22
1960	1.96	8.18	27.61	16.37	8.77	28.71	21.12	8.86	5.11	3.62	2.52	1.87	134.70
1961	1.56	4.61	13.54	48.38	42.46	22.69	15.44	8.67	5.16	3.58	2.50	1.78	170.37
1962	1.31	16.01	25.69	66.84	33.34	29.31	16.21	7.47	5.28	4.14	3.26	2.33	211.18
1963	3.17	19.82	10.06	38.02	20.62	29.69	16.93	7.04	4.79	3.58	2.66	2.95	159.31
1964	30.13	26.48	27.01	22.15	11.22	6.08	5.20	4.07	5.54	4.40	5.55	5.43	153.28
1965	3.78	6.23	6.33	63.58	43.66	14.57	7.29	5.14	3.66	2.59	1.85	1.36	160.04
1966	1.21	9.30	38.49	70.80	61.93	50.72	45.46	20.43	9.22	6.27	4.30	2.92	321.05
1967	2.09	2.02	4.16	7.30	5.72	9.49	5.79	3.29	2.44	1.77	1.37	1.14	46.58
1968	.96	2.00	14.60	12.24	21.46	41.18	20.97	9.19	6.10	4.33	3.12	2.24	138.38
1969	14.60	8.90	26.03	26.63	28.60	15.50	7.15	4.82	3.44	2.46	2.57	6.07	146.77
1970	6.28	6.01	4.82	39.53	38.71	23.88	12.27	7.72	5.42	4.20	3.54	2.91	155.31
1971	3.89	5.59	16.21	27.54	37.15	54.14	24.15	9.12	6.52	4.64	3.26	2.28	194.48
1972	2.29	8.51	5.48	5.27	35.86	26.01	16.11	8.27	4.50	3.09	3.35	5.11	123.84
1973	3.78	18.61	33.95	64.63	75.29	58.52	35.25	16.01	8.96	6.51	4.74	3.33	329.60
1974	2.33	33.08	45.07	54.98	80.93	60.39	25.55	11.92	7.80	5.29	3.60	14.73	345.67
1975	8.48	22.07	55.13	68.83	70.01	103.13	52.20	20.50	12.32	8.16	5.56	4.02	430.40
1976	16.27	18.73	19.16	29.90	24.33	28.17	17.68	8.07	4.83	3.30	2.27	2.50	175.19
1977	14.65	17.73	21.79	63.29	59.00	42.52	21.60	10.36	6.55	4.47	3.16	2.76	267.87
1978	25.90	14.50	44.18	28.57	52.74	39.71	15.87	8.36	6.05	4.42	8.75	5.64	254.71
1979	4.50	13.68	24.85	37.00	51.10	35.73	14.82	7.60	5.26	3.62	2.50	4.19	204.85
1980	3.33	9.19	38.30	73.74	126.89	54.10	16.59	11.20	7.85	5.54	5.10	4.23	356.06
1981	3.34	20.02	21.80	29.34	16.50	18.70	14.88	7.35	4.28	2.97	2.11	1.55	142.85
1982	4.65	4.34	3.72	17.50	11.10	6.66	4.73	3.48	2.65	2.72	2.40	1.93	65.89
1983	11.72	31.62	31.51	28.96	24.08	44.74	23.81	9.16	5.86	4.10	3.35	2.74	221.65
1984	2.98	2.59	2.62	37.55	80.11	34.31	10.45	6.94	4.71	3.20	2.18	1.50	189.14
1985	24.35	37.33	40.29	51.09	31.56	23.78	17.50	9.04	5.30	3.70	2.75	2.18	248.87
1986	13.83	20.46	39.62	26.54	54.61	49.97	19.59	8.41	5.70	3.91	4.78	69.69	317.11
1987	34.47	26.37	23.40	24.60	74.75	72.96	28.83	11.64	8.30	6.44	4.94	3.66	320.35
1988	3.97	18.14	37.82	39.56	88.12	52.35	19.13	10.51	7.38	5.30	3.72	2.53	288.53
1989	1.89	27.63	25.02	18.06	18.54	18.31	11.18	5.96	3.92	2.75	2.07	1.63	136.96
1990	1.37	1.28	22.53	66.16	55.38	34.30	14.93	7.36	4.97	3.44	2.38	1.66	215.75
1991	30.11	23.74	27.42	16.89	44.10	35.34	14.01	6.99	4.80	3.28	2.28	1.63	210.59
1992	1.29	2.15	13.09	17.79	51.19	43.87	17.75	7.99	5.38	3.69	2.53	1.78	168.50
1993	19.52	18.71	29.41	45.99	55.68	41.48	19.23	9.36	6.08	4.16	2.91	2.05	254.58
1994	1.62	1.44	1.49	19.88	20.06	33.64	17.44	6.82	4.55	3.18	2.20	1.59	113.91

Runoff – TM05.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.31	1.89	1.18	1.10	2.52	16.51	7.12	1.31	.64	.42	.28	.23	35.52
1921	.19	28.08	22.00	6.69	2.85	3.48	2.21	.98	.61	.46	.64	.58	68.77
1922	3.67	12.15	11.71	27.76	74.77	25.42	2.39	1.41	1.18	1.06	.74	.49	162.74
1923	.55	.46	.66	3.89	3.95	12.76	5.80	1.29	.62	.40	.31	.50	31.19
1924	1.44	9.80	25.04	14.61	26.57	91.71	32.37	3.40	1.92	1.31	.86	.71	209.75
1925	1.08	2.20	1.99	56.62	22.34	4.17	2.48	1.19	.76	.58	.39	.70	94.50
1926	.93	1.59	2.11	5.13	22.46	32.04	10.70	1.68	.84	.67	.59	.38	79.11
1927	3.98	2.51	2.55	3.54	3.31	22.00	8.99	1.30	.61	.42	.30	.27	49.81
1928	.33	.32	1.29	3.61	28.92	47.86	17.50	3.63	2.11	1.90	1.30	3.22	112.00
1929	3.41	12.50	48.52	45.04	13.78	3.79	3.12	2.04	1.09	.69	.50	.37	134.84
1930	.30	.28	.50	35.85	15.82	4.43	3.00	1.46	.69	.55	.44	.25	63.57
1931	.31	.38	.33	.47	22.25	22.22	6.88	1.79	1.22	.86	.55	.33	57.59
1932	.23	.81	2.23	2.13	1.66	1.71	1.61	.99	.50	.44	.36	.20	12.87
1933	.13	14.17	18.93	95.96	36.86	6.31	4.92	3.82	2.16	1.40	1.72	1.18	187.59
1934	1.52	3.80	53.03	20.39	4.14	4.45	2.74	1.23	.69	.51	.36	.25	93.10
1935	.20	.20	.60	1.41	13.23	16.12	5.68	5.68	3.49	1.24	.56	.35	48.76
1936	.59	21.54	9.37	43.72	39.94	11.44	2.34	1.23	.73	.51	.36	.25	132.02
1937	.27	.30	1.98	20.56	10.36	2.88	3.11	2.17	1.28	1.46	1.23	.78	46.36
1938	2.19	2.45	5.51	21.51	71.18	42.09	9.41	2.19	1.38	1.14	.90	.72	160.68
1939	1.47	25.27	19.44	6.63	3.09	2.36	1.56	2.13	2.48	1.59	.75	.67	67.45
1940	.55	1.30	6.17	39.28	30.03	8.62	3.19	1.91	.93	.60	.42	.27	93.27
1941	.41	.56	.61	2.17	21.65	18.35	7.88	2.99	1.27	.74	.66	.57	57.87
1942	1.25	28.83	29.75	16.09	5.44	5.54	50.81	19.90	2.78	2.42	5.04	3.02	170.88
1943	34.79	35.31	22.20	18.03	51.22	19.22	2.66	1.35	1.95	1.80	.93	2.12	191.58
1944	4.17	4.09	2.11	1.35	4.10	39.18	15.05	1.69	.85	.58	.39	.25	73.80
1945	.19	.19	.16	2.01	12.81	20.66	7.48	1.40	.70	.45	.30	.20	46.54
1946	1.36	10.51	5.18	1.49	15.60	22.52	8.23	1.70	.87	.64	.44	.41	68.96
1947	1.30	9.63	10.01	24.08	11.75	44.01	17.57	2.53	1.25	.76	.51	.36	123.75
1948	.59	.85	1.04	2.67	5.75	9.48	5.34	2.02	.93	.54	.34	.42	29.95
1949	.76	2.03	3.80	7.21	7.77	41.41	15.93	2.28	1.35	.89	.69	.49	84.61
1950	.73	.91	25.60	11.27	3.78	4.22	3.25	1.65	.81	.53	.64	.93	54.33
1951	1.31	.89	1.37	25.03	36.93	14.45	3.87	1.70	.85	.89	.80	.51	88.62
1952	.79	1.26	3.68	10.42	52.86	20.53	3.87	2.16	1.11	.66	.49	.35	98.19
1953	.34	1.31	2.21	2.50	32.51	15.65	3.48	1.57	1.01	.70	.44	.51	62.23
1954	1.52	9.77	5.35	31.33	40.38	13.99	3.00	1.43	.84	.55	.37	.24	108.76
1955	.21	1.00	5.26	3.32	20.29	37.68	12.58	1.75	1.01	.66	.43	.32	84.52
1956	.35	1.56	45.54	40.06	18.89	16.47	7.12	2.07	1.02	1.16	1.46	38.20	173.89
1957	37.94	10.89	3.03	41.69	18.03	6.63	5.50	2.81	1.14	.61	.40	.51	129.17
1958	.69	3.11	18.16	11.43	18.16	8.50	2.87	5.01	3.18	1.27	.63	.37	73.38
1959	1.81	5.34	3.87	2.78	12.97	10.70	5.97	2.73	1.01	.52	.40	.32	48.42
1960	.66	1.31	18.01	8.20	2.23	13.60	8.00	2.97	1.36	.71	.43	.40	57.89
1961	.36	1.29	2.52	35.27	23.27	6.86	3.15	1.75	.83	.50	.36	.27	76.44
1962	.21	.93	3.91	60.37	22.63	4.02	2.89	1.41	.95	.97	.68	.36	99.33
1963	.36	.80	.86	19.69	9.01	3.68	2.77	1.30	.85	.73	.50	.66	41.21
1964	7.65	5.70	19.80	12.69	4.78	1.97	1.36	1.02	.96	.88	1.19	1.25	59.25
1965	.83	1.38	1.32	21.93	13.97	3.89	1.18	.60	.42	.33	.27	.22	46.34
1966	.22	.78	33.94	59.06	45.49	14.35	4.90	2.67	1.24	.72	.47	.30	164.16
1967	.27	.35	1.39	1.71	1.45	1.38	.93	.49	.30	.22	.28	.24	9.01
1968	.18	.29	.65	1.24	5.72	14.56	6.55	2.07	1.24	.75	.44	.29	33.99
1969	1.82	1.83	1.96	6.86	6.87	3.23	1.13	.50	.36	.32	.53	1.04	26.45
1970	1.73	1.42	.96	19.97	17.29	7.21	3.49	2.27	1.36	.98	.75	.44	57.88
1971	.67	1.15	4.29	3.82	13.80	29.90	10.70	1.62	.88	.58	.42	.27	68.10
1972	.36	1.03	.88	.97	37.80	15.11	3.00	1.85	.89	.52	1.33	2.34	66.09
1973	1.46	1.83	6.28	10.51	50.02	32.26	9.17	2.71	1.37	.97	.63	.38	117.60
1974	.24	4.02	4.73	17.95	63.54	23.44	4.31	2.45	1.20	.70	.46	1.10	124.16
1975	1.07	1.40	16.19	37.74	22.24	96.02	35.00	3.44	2.01	1.25	.81	.58	217.76
1976	3.05	5.01	4.30	4.19	3.16	3.29	2.29	1.03	.49	.32	.23	.35	27.73
1977	4.95	4.12	2.62	39.09	23.16	9.28	4.28	1.67	.77	.50	.41	.49	91.34
1978	4.87	3.56	11.17	6.68	9.80	6.61	2.98	1.39	.72	.66	1.83	1.50	51.76
1979	1.92	5.12	3.74	5.47	34.01	29.62	8.29	1.50	.80	.54	.38	.71	92.09
1980	.67	1.53	13.94	45.39	100.58	33.58	3.56	1.88	1.20	.85	.86	.82	204.87
1981	.57	1.00	2.59	12.79	5.49	2.12	2.40	1.47	.68	.42	.29	.19	30.00
1982	.70	1.40	1.03	.91	1.17	1.15	.82	.53	.34	.29	.27	.19	8.79
1983	1.04	17.87	10.42	12.55	6.29	22.90	11.23	2.76	1.13	.68	.71	.62	88.21
1984	.93	.84	.68	8.43	64.93	23.78	2.13	1.06	.67	.46	.32	.22	104.46
1985	1.93	11.27	13.74	28.51	11.35	3.75	2.81	1.43	.73	.50	.46	.38	76.86
1986	1.46	2.27	2.44	10.21	27.51	25.17	7.61	1.37	.69	.50	.72	60.49	140.43
1987	23.15	3.69	13.25	8.26	15.13	16.67	5.88	1.28	.80	.82	.62	.39	89.94
1988	.75	1.68	14.55	20.75	75.04	32.29	5.41	1.94	1.10	.75	.51	.32	155.07
1989	.33	9.73	5.85	2.80	4.38	7.13	4.83	2.04	.81	.47	.56	.44	39.36
1990	.29	.19	1.67	42.54	24.79	6.27	1.93	.86	.54	.41	.29	.20	79.97
1991	14.88	12.28	5.24	2.88	3.22	6.49	3.44	1.04	.48	.33	.28	.21	50.77
1992	.16	1.21	1.55	2.18	76.56	42.44	8.18	1.94	1.03	.69	.48	.33	136.74
1993	25.32	11.85	7.01	22.35	36.94	26.95	9.06	2.51	1.12	.69	.50	.33	144.63
1994	.33	.25	.26	9.55	6.04	10.87	5.65	1.62	.71	.43	.29	.20	36.20

Runoff – TM06.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.81	.66	.41	.39	.88	5.80	2.50	.46	.23	.15	.10	.08	12.47
1921	.07	9.86	7.72	2.35	1.00	1.22	.78	.34	.21	.16	.23	.20	24.14
1922	1.29	4.26	4.11	9.75	26.25	8.92	.84	.49	.41	.37	.26	.17	57.13
1923	.19	.16	.23	1.37	1.39	4.48	2.04	.45	.22	.14	.11	.17	10.95
1924	.51	3.44	8.79	5.13	9.33	32.20	11.36	1.19	.67	.46	.30	.25	73.64
1925	.38	.77	.70	19.88	7.84	1.46	.87	.42	.27	.20	.14	.24	33.17
1926	.33	.56	.74	1.80	7.89	11.25	3.76	.59	.29	.24	.21	.13	27.77
1927	1.40	.88	.90	1.24	1.16	7.73	3.16	.46	.22	.15	.11	.10	17.48
1928	.12	.11	.45	1.27	10.15	16.80	6.14	1.27	.74	.67	.46	1.13	39.32
1929	1.20	4.39	17.03	15.81	4.84	1.33	1.10	.72	.38	.24	.18	.13	47.34
1930	.10	.10	.18	12.59	5.55	1.56	1.05	.51	.24	.19	.16	.09	22.32
1931	.11	.13	.11	.17	7.81	7.80	2.42	.63	.43	.30	.19	.12	20.22
1932	.08	.28	.78	.75	.58	.60	.56	.35	.18	.15	.13	.07	4.52
1933	.04	4.98	6.65	33.69	12.94	2.22	1.73	1.34	.76	.49	.61	.42	65.86
1934	.53	1.33	18.62	7.16	1.45	1.56	.96	.43	.24	.18	.13	.09	32.68
1935	.07	.07	.21	.49	4.64	5.66	1.99	1.99	1.23	.44	.20	.12	17.12
1936	.21	7.56	3.29	15.35	14.02	4.01	.82	.43	.26	.18	.13	.09	46.35
1937	.09	.10	.69	7.22	3.64	1.01	1.09	.76	.45	.51	.43	.27	16.27
1938	.77	.86	1.93	7.55	24.99	14.78	3.30	.77	.48	.40	.32	.25	56.41
1939	.52	8.87	6.83	2.33	1.08	.83	.55	.75	.87	.56	.26	.23	23.68
1940	.19	.46	2.16	13.79	10.54	3.03	1.12	.67	.33	.21	.15	.09	32.74
1941	.14	.20	.21	.76	7.60	6.44	2.77	1.05	.45	.26	.23	.20	20.31
1942	.44	10.12	10.45	5.65	1.91	1.95	17.84	6.99	.98	.85	1.77	1.06	59.99
1943	12.22	12.40	7.79	6.33	17.98	6.75	.93	.47	.68	.63	.33	.74	67.26
1944	1.47	1.44	.74	.47	1.44	13.76	5.28	.59	.30	.20	.14	.09	25.91
1945	.07	.07	.05	.71	4.50	7.25	2.62	.49	.24	.16	.11	.07	16.34
1946	.48	3.69	1.82	.52	5.48	7.91	2.89	.60	.31	.22	.15	.14	24.21
1947	.46	3.38	3.51	8.46	4.12	15.45	6.17	.89	.44	.27	.18	.13	43.44
1948	.21	.30	.36	.94	2.02	3.33	1.87	.71	.33	.19	.12	.15	10.51
1949	.27	.71	1.33	2.53	2.73	14.54	5.59	.80	.47	.31	.24	.17	29.70
1950	.25	.32	8.99	3.96	1.33	1.48	1.14	.58	.29	.19	.23	.33	19.07
1951	.46	.31	.48	8.79	12.97	5.07	1.36	.60	.30	.31	.28	.18	31.11
1952	.28	.44	1.29	3.66	18.56	7.21	1.36	.76	.39	.23	.17	.12	34.47
1953	.12	.46	.77	.88	11.41	5.49	1.22	.55	.35	.25	.15	.18	21.85
1954	.53	3.43	1.88	11.00	14.18	4.91	1.05	.50	.29	.19	.13	.09	38.18
1955	.08	.35	1.85	1.17	7.12	13.23	4.42	.62	.35	.23	.15	.11	29.67
1956	.12	.55	15.99	14.06	6.63	5.78	2.50	.73	.36	.41	.51	13.41	61.05
1957	13.32	3.82	1.06	14.64	6.33	2.33	1.93	.99	.40	.21	.14	.18	45.34
1958	.24	1.09	6.37	4.01	6.38	2.98	1.01	1.76	1.11	.45	.22	.13	25.76
1959	.63	1.87	1.36	.98	4.55	3.76	2.10	.96	.36	.18	.14	.11	17.00
1960	.23	.46	6.32	2.88	.78	4.77	2.81	1.04	.48	.25	.15	.14	20.32
1961	.13	.45	.88	12.38	8.17	2.41	1.11	.61	.29	.17	.13	.09	26.83
1962	.07	.33	1.37	21.19	7.95	1.41	1.02	.50	.33	.34	.24	.13	34.87
1963	.13	.28	.30	6.91	3.16	1.29	.97	.46	.30	.26	.17	.23	14.47
1964	2.68	2.00	6.95	4.46	1.68	.69	.48	.36	.34	.31	.42	.44	20.80
1965	.29	.48	.46	7.70	4.91	1.36	.41	.21	.15	.11	.09	.08	16.27
1966	.08	.27	11.92	20.74	15.97	5.04	1.72	.94	.43	.25	.17	.11	57.63
1967	.10	.12	.49	.60	.51	.49	.33	.17	.10	.08	.10	.09	3.16
1968	.06	.10	.23	.43	2.01	5.11	2.30	.73	.44	.26	.16	.10	11.93
1969	.64	.64	.69	2.41	2.41	1.13	.40	.17	.13	.11	.19	.37	9.28
1970	.61	.50	.34	7.01	6.07	2.53	1.23	.80	.48	.34	.26	.15	20.32
1971	.24	.40	1.51	1.34	4.85	10.50	3.76	.57	.31	.20	.15	.09	23.91
1972	.13	.36	.31	.34	13.27	5.30	1.05	.65	.31	.18	.47	.82	23.20
1973	.51	.64	2.20	3.69	17.56	11.33	3.22	.95	.48	.34	.22	.13	41.28
1974	.09	1.41	1.66	6.30	22.31	8.23	1.51	.86	.42	.25	.16	.38	43.59
1975	.38	.49	5.68	13.25	7.81	33.71	12.29	1.21	.70	.44	.28	.20	76.45
1976	1.07	1.76	1.51	1.47	1.11	1.16	.80	.36	.17	.11	.08	.12	9.73
1977	1.74	1.45	.92	13.72	8.13	3.26	1.50	.59	.27	.18	.14	.17	32.07
1978	1.71	1.25	3.92	2.35	3.44	2.32	1.05	.49	.25	.23	.64	.53	18.17
1979	.67	1.80	1.31	1.92	11.94	10.40	2.91	.53	.28	.19	.13	.25	32.33
1980	.23	.54	4.89	15.94	35.31	11.79	1.25	.66	.42	.30	.30	.29	71.92
1981	.20	.35	.91	4.49	1.93	.74	.84	.52	.24	.15	.10	.07	10.53
1982	.25	.49	.36	.32	.41	.40	.29	.19	.12	.10	.09	.07	3.09
1983	.36	6.27	3.66	4.41	2.21	8.04	3.94	.97	.40	.24	.25	.22	30.97
1984	.33	.30	.24	2.96	22.80	8.35	.75	.37	.23	.16	.11	.08	36.67
1985	.68	3.96	4.82	10.01	3.98	1.32	.99	.50	.26	.17	.16	.13	26.98
1986	.51	.80	.86	3.58	9.66	8.84	2.67	.48	.24	.17	.25	21.24	49.30
1987	8.13	1.29	4.65	2.90	5.31	5.85	2.06	.45	.28	.29	.22	.14	31.57
1988	.26	.59	5.11	7.29	26.35	11.33	1.90	.68	.38	.26	.18	.11	54.44
1989	.12	3.41	2.06	.98	1.54	2.50	1.70	.71	.28	.17	.20	.15	13.82
1990	.10	.07	.58	14.94	8.70	2.20	.68	.30	.19	.14	.10	.07	28.07
1991	5.22	4.31	1.84	1.01	1.13	2.28	1.21	.37	.17	.11	.10	.07	17.82
1992	.06	.42	.54	.77	26.88	14.90	2.87	.68	.36	.24	.17	.12	48.01
1993	8.89	4.16	2.46	7.84	12.97	9.46	3.18	.88	.39	.24	.17	.11	50.77
1994	.12	.09	.09	3.35	2.12	3.82	1.98	.57	.25	.15	.10	.07	12.71

Runoff – TM07.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.64	.39	.15	.09	7.29	3.52	.74	.26	.13	.08	.05	.43	13.80
1921	.47	13.39	5.99	3.29	1.52	.61	.27	.11	.14	.14	.32	.31	26.57
1922	.45	.87	.75	1.05	4.48	1.81	.22	.06	.04	.10	.11	.06	10.00
1923	.05	.06	.08	.55	1.66	1.19	.46	.16	.09	.07	.06	.19	4.62
1924	.45	3.83	7.63	12.40	4.48	26.98	9.75	.61	.23	.13	.09	.24	66.81
1925	.54	.48	.30	6.44	2.67	.57	.29	.14	.12	.11	.07	.49	12.20
1926	.92	1.00	.91	.82	2.37	2.51	.91	.17	.06	.07	.11	.09	9.95
1927	.31	.32	.51	.68	.61	.74	.47	.18	.08	.06	.06	.13	4.16
1928	.27	.22	1.24	2.09	1.29	2.88	1.44	.38	.32	.51	.38	1.29	12.30
1929	1.07	3.06	1.71	6.97	3.10	4.04	1.79	.34	.12	.09	.10	.17	22.55
1930	.20	.16	.73	7.53	3.40	.83	.39	.15	.06	.08	.08	.04	13.66
1931	.10	.13	.51	.89	10.47	4.38	.68	.39	.27	.15	.08	.08	18.13
1932	.10	.15	.31	.21	.29	.53	.49	.24	.09	.13	.13	.06	2.73
1933	.04	5.10	6.70	13.75	4.90	1.39	2.02	.92	.29	.21	.36	.25	35.93
1934	.22	3.60	10.80	3.58	.51	.74	.60	.29	.14	.10	.07	.05	20.68
1935	.04	.08	.10	.39	4.50	2.31	.56	.73	.64	.27	.10	.05	9.76
1936	.12	3.82	1.90	1.64	4.38	1.91	.41	.14	.06	.05	.04	.04	14.52
1937	.06	.06	.50	1.57	1.15	.62	.51	.30	.28	.41	.32	.20	5.97
1938	.49	.48	3.42	1.72	6.82	3.53	.70	.29	.22	.20	.18	.17	18.23
1939	.24	5.63	2.73	.73	.46	.58	.44	.48	.59	.39	.16	.18	12.61
1940	.22	.42	5.47	2.65	1.22	1.02	.93	.52	.17	.09	.07	.05	12.82
1941	.08	.07	.23	.49	3.22	3.78	1.59	.46	.17	.09	.11	.14	10.45
1942	.25	7.89	4.81	8.45	3.24	.91	8.51	3.78	.75	.84	8.46	3.20	51.09
1943	5.50	5.01	2.47	1.29	5.05	2.24	.39	.11	.15	.17	.10	.54	23.02
1944	.61	.43	.22	.16	.30	5.37	2.18	.24	.08	.06	.05	.03	9.72
1945	.02	.02	.04	.49	1.34	1.27	.62	.20	.08	.06	.05	.03	4.23
1946	.41	2.90	1.40	.30	1.79	2.71	1.24	.32	.25	.24	.13	.11	11.79
1947	.24	3.46	1.94	6.24	2.56	1.26	.87	.37	.13	.07	.05	.05	17.24
1948	.17	.27	.39	2.62	2.36	1.58	1.15	.58	.21	.10	.07	.07	9.57
1949	.15	.41	.69	.45	.29	3.65	1.73	.51	.25	.12	.11	.10	8.46
1950	.16	.19	2.78	1.25	.40	.51	.45	.24	.11	.08	.38	.42	6.96
1951	.34	.17	.37	10.34	4.10	1.03	.76	.39	.18	.23	.23	.12	18.26
1952	.14	.34	.44	.58	5.12	2.21	.49	.24	.10	.06	.14	.13	10.00
1953	.09	.30	.60	.52	9.98	4.15	.63	.42	.31	.16	.08	.14	17.37
1954	1.21	7.17	2.93	13.22	10.22	2.50	.37	.14	.07	.05	.04	.03	37.95
1955	.12	.30	.50	.29	1.13	4.00	1.59	.25	.13	.08	.05	.08	8.52
1956	.11	.60	11.75	9.68	2.46	1.45	.93	.35	.13	.35	.47	8.91	37.18
1957	7.75	2.09	.34	.59	1.39	1.04	4.14	1.71	.23	.09	.06	.09	19.51
1958	.20	.58	2.39	1.35	1.32	.75	.31	.52	.44	.22	.11	.06	8.23
1959	.38	.63	.49	.51	.99	3.04	1.76	.63	.21	.08	.09	.09	8.88
1960	.23	.41	4.50	1.83	.41	.80	.93	.62	.29	.13	.07	.11	10.32
1961	.12	.25	.41	7.07	5.18	1.46	.52	.29	.12	.07	.08	.09	15.64
1962	.07	.35	1.43	5.61	2.16	2.29	1.15	.28	.17	.34	.28	.11	14.24
1963	.12	.33	.22	.60	.49	.56	.58	.30	.18	.16	.11	.14	3.80
1964	.61	.57	.41	2.99	4.01	1.27	.20	.12	.21	.27	.27	.28	11.21
1965	.21	.19	.18	6.63	2.94	.45	.18	.17	.13	.09	.09	.10	11.37
1966	.11	.28	1.02	13.16	6.43	3.48	2.16	.88	.29	.12	.07	.04	28.03
1967	.04	.08	1.35	.68	.21	.19	.13	.06	.04	.04	.08	.08	2.97
1968	.05	.05	.11	.41	.66	3.90	1.98	.68	.35	.17	.09	.06	8.51
1969	.46	.37	.43	.60	.73	.41	.14	.09	.10	.10	.25	.40	4.07
1970	.47	.37	.23	7.52	3.08	.48	.29	.29	.22	.19	.20	.14	13.47
1971	.26	.30	.70	1.39	1.27	4.17	1.75	.31	.14	.08	.09	.06	10.52
1972	.11	.55	.42	.32	1.18	.85	.75	.49	.18	.08	.34	.59	5.85
1973	.37	.62	.90	2.30	5.75	5.14	1.78	.43	.18	.12	.09	.05	17.72
1974	.03	.25	1.62	2.95	6.11	2.43	.59	.27	.11	.06	.05	.58	15.06
1975	.53	.65	2.57	7.06	6.00	7.58	2.82	.67	.33	.14	.08	.08	28.51
1976	.27	.49	.61	2.42	1.21	.63	.63	.35	.13	.07	.05	.18	7.02
1977	.55	.74	.61	6.74	2.80	2.79	1.47	.39	.12	.07	.09	.23	16.60
1978	1.25	1.13	5.89	2.35	6.15	2.59	.44	.23	.14	.15	.44	.50	21.24
1979	.33	.22	.29	.56	1.92	1.03	.35	.16	.08	.06	.05	.29	5.34
1980	.33	.64	8.66	7.43	15.46	5.09	.28	.11	.10	.10	.15	.23	38.59
1981	.19	.27	.30	1.14	.68	.38	.22	.09	.05	.05	.05	.06	3.48
1982	.52	.46	.60	3.77	1.55	.34	.22	.13	.09	.10	.10	.07	7.93
1983	.21	.62	2.84	1.67	.51	.49	.55	.30	.12	.08	.17	.17	7.74
1984	.21	.15	.08	3.44	7.87	2.61	.18	.05	.06	.07	.05	.04	14.79
1985	.55	1.08	.86	2.03	1.28	.91	.69	.30	.16	.14	.12	.08	8.20
1986	4.11	1.94	6.51	3.04	9.64	16.00	4.73	.23	.10	.10	.51	16.71	63.62
1987	6.11	.48	.55	1.14	3.65	3.28	1.29	.37	.22	.37	.30	.15	17.93
1988	.36	.44	1.89	1.26	18.46	6.73	.41	.16	.11	.09	.07	.04	30.01
1989	.09	3.47	3.49	1.20	.47	.52	.52	.30	.12	.07	.14	.13	10.51
1990	.10	.06	.64	7.57	5.20	1.49	.34	.09	.08	.09	.06	.06	15.79
1991	1.46	1.13	1.72	1.02	3.60	1.68	.36	.12	.05	.04	.06	.05	11.30
1992	.04	.16	.41	.42	.75	1.14	.77	.29	.10	.06	.05	.06	4.27
1993	.70	.97	3.29	4.17	4.49	2.82	1.07	.33	.12	.09	.10	.07	18.22
1994	.08	.07	.11	2.31	1.28	1.03	.68	.24	.09	.06	.05	.07	6.07

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	34.62	15.94	9.41	19.72	102.61	69.04	21.35	9.26	6.15	4.28	3.05	4.46	299.90
1921	4.11	70.20	73.65	53.18	28.04	18.93	9.73	5.01	4.78	3.79	4.24	3.27	278.93
1922	4.81	13.11	16.66	65.68	110.66	56.95	17.68	8.24	5.40	4.08	3.16	2.23	308.66
1923	1.57	8.32	5.51	16.70	56.38	47.02	18.57	7.55	4.93	3.43	2.49	2.93	175.40
1924	8.00	31.89	87.23	68.81	64.76	327.83	141.51	27.03	14.33	9.61	6.62	6.79	794.41
1925	5.98	6.39	10.94	39.30	38.25	30.86	13.91	5.88	4.35	3.45	2.48	10.36	172.15
1926	14.02	22.61	63.38	76.35	63.27	59.37	25.37	9.09	5.61	3.97	3.09	2.36	348.49
1927	9.59	5.61	24.79	62.57	34.21	30.64	15.48	6.35	4.25	3.00	2.13	1.63	200.24
1928	1.61	2.37	30.15	50.29	60.84	64.91	26.12	9.11	8.96	12.01	7.45	26.28	300.08
1929	15.51	17.91	30.04	61.50	53.90	113.62	46.35	10.79	6.95	4.89	3.53	2.78	367.76
1930	3.44	2.66	8.84	61.86	43.05	47.25	24.11	8.64	4.98	6.33	4.32	2.51	217.98
1931	1.96	1.75	3.21	14.18	138.42	154.75	50.53	12.65	8.40	5.74	3.90	2.79	398.29
1932	2.46	12.54	17.42	14.81	15.21	10.75	6.52	4.22	2.72	2.87	2.38	1.58	93.49
1933	1.20	68.16	133.08	187.68	83.67	75.62	58.65	25.90	11.66	7.58	8.29	5.81	667.30
1934	6.20	106.00	181.21	63.02	76.38	59.53	22.04	9.50	6.41	4.65	3.31	2.32	540.58
1935	1.65	2.28	7.51	40.78	49.25	38.70	15.96	17.31	10.91	5.16	3.20	2.15	194.85
1936	4.54	59.54	31.72	58.25	82.67	33.55	10.13	6.07	4.02	2.79	1.95	1.36	296.59
1937	1.19	1.47	25.94	50.69	28.49	12.30	33.06	16.78	5.89	5.87	5.05	3.70	190.44
1938	21.06	17.22	26.47	71.57	225.54	120.72	29.93	12.43	8.45	6.51	4.95	3.78	548.64
1939	8.57	31.00	37.66	23.47	34.03	40.42	19.34	16.49	13.42	7.56	4.35	3.64	239.96
1940	3.01	4.09	12.25	52.58	79.18	32.51	12.49	7.77	4.59	3.06	2.13	1.48	215.13
1941	1.48	1.46	1.57	18.70	50.79	81.32	37.65	11.55	6.17	4.09	3.13	3.15	221.07
1942	5.85	91.91	119.20	131.23	54.32	57.30	136.34	62.30	17.22	17.82	36.59	17.89	747.97
1943	93.56	109.83	53.65	43.58	71.86	34.14	11.24	6.31	6.27	4.69	3.05	11.25	449.43
1944	8.51	7.53	4.69	10.09	11.26	90.83	39.80	8.42	5.22	3.63	2.52	1.70	194.19
1945	1.19	1.04	1.12	35.37	51.98	76.72	30.95	8.31	5.17	3.52	2.43	1.63	219.41
1946	4.79	18.40	11.55	6.78	43.89	60.77	24.56	7.41	4.75	3.55	2.51	1.84	190.80
1947	7.33	13.84	43.71	101.00	60.98	103.73	46.84	12.73	7.46	4.95	3.35	2.30	408.24
1948	1.97	2.81	6.72	30.16	32.48	41.02	22.05	8.38	4.62	3.11	2.21	1.78	157.30
1949	1.75	14.86	16.59	17.54	26.72	147.92	60.73	12.75	8.27	5.64	4.63	3.71	321.12
1950	3.14	3.70	72.80	34.55	18.80	21.27	11.95	5.83	3.66	2.57	2.95	2.72	183.94
1951	3.28	2.49	4.03	78.07	81.60	39.28	15.04	7.27	4.54	4.18	3.45	2.54	245.78
1952	3.54	10.77	43.69	47.40	93.49	40.57	11.90	7.10	4.52	3.07	2.32	1.81	270.16
1953	3.00	12.30	21.25	19.65	106.17	64.48	18.64	9.43	6.48	4.37	2.96	2.57	271.31
1954	5.57	33.69	38.08	99.99	143.20	66.54	21.54	11.27	7.44	5.21	3.62	2.46	438.62
1955	1.82	2.63	19.73	10.83	60.27	97.24	35.92	8.72	5.51	3.76	2.59	1.92	250.93
1956	1.83	17.90	107.90	105.36	45.11	47.88	29.38	11.66	6.17	4.64	5.38	54.11	437.31
1957	51.38	19.04	13.52	102.22	88.38	34.40	21.54	12.39	6.35	4.10	2.79	2.12	358.22
1958	2.12	13.49	25.69	37.33	44.57	24.23	11.43	14.55	9.02	4.74	3.28	2.27	192.72
1959	4.38	14.52	27.33	17.47	42.96	85.90	41.78	12.73	6.31	4.05	2.85	2.09	262.37
1960	2.28	8.98	24.89	14.22	19.90	45.84	28.69	11.02	5.53	3.57	2.44	1.92	169.28
1961	1.63	8.27	14.63	60.75	64.52	48.50	25.02	10.81	5.94	3.95	2.78	2.01	248.80
1962	1.52	15.84	36.66	108.27	48.29	51.82	25.78	8.75	5.80	4.63	3.46	2.31	313.13
1963	8.16	30.71	15.81	54.43	28.30	30.18	19.13	8.00	4.81	3.57	2.56	5.02	210.68
1964	43.15	28.36	24.30	25.53	14.66	6.95	6.69	4.70	8.24	5.90	7.30	5.65	181.44
1965	3.85	5.88	5.92	99.73	55.85	15.08	7.07	4.82	3.50	2.54	1.88	1.44	207.55
1966	1.93	20.91	43.80	120.36	110.03	90.14	68.60	26.66	9.94	6.37	4.32	2.90	505.95
1967	2.21	3.57	6.81	11.64	10.59	20.23	11.45	4.85	3.16	2.25	1.78	1.41	79.93
1968	1.13	4.18	25.13	19.32	28.95	76.62	35.97	11.75	7.22	4.81	3.31	2.61	221.00
1969	11.71	9.80	33.65	31.37	33.15	18.41	7.75	4.69	3.28	2.34	4.93	9.54	170.61
1970	9.81	9.26	6.13	55.07	46.81	30.39	16.25	8.93	5.66	4.37	4.05	3.12	199.85
1971	5.15	5.69	12.08	35.72	62.73	90.39	36.61	11.11	7.12	4.81	3.36	2.31	277.09
1972	2.92	12.62	7.76	10.71	48.11	42.48	23.22	10.22	5.08	3.33	3.74	6.86	177.04
1973	4.58	21.02	37.75	131.53	142.95	117.76	62.24	22.57	10.83	7.56	5.36	3.64	567.80
1974	2.63	39.91	68.75	88.59	137.53	90.38	32.12	12.48	7.47	4.98	3.40	16.18	504.40
1975	10.24	20.97	91.94	133.47	126.60	192.82	78.03	21.94	13.07	8.25	5.51	4.54	707.36
1976	15.34	13.95	15.35	58.21	39.36	34.40	22.89	9.97	5.11	3.36	2.33	3.43	223.70
1977	17.76	16.11	18.78	95.80	82.79	57.59	29.13	11.73	6.18	4.08	3.01	2.65	345.60
1978	16.74	13.15	94.45	47.91	99.18	59.51	19.32	10.35	6.86	4.92	8.17	5.62	386.19
1979	4.96	11.60	22.36	44.10	61.36	45.76	20.29	8.45	5.00	3.39	2.39	6.42	236.09
1980	4.37	10.51	64.93	115.26	220.60	80.99	15.26	9.70	6.82	4.92	6.53	4.73	544.63
1981	3.28	20.73	34.12	32.21	18.41	23.87	18.03	8.13	4.24	2.95	2.14	1.76	169.87
1982	7.49	5.11	4.01	31.13	18.00	8.79	6.79	4.50	3.13	4.96	3.68	2.33	99.92
1983	10.66	28.35	33.58	32.62	30.03	74.72	34.51	9.76	5.82	4.07	3.92	3.05	271.10
1984	3.32	3.03	3.29	35.47	126.62	49.91	9.25	5.60	3.79	2.63	1.83	1.28	246.01
1985	26.35	38.51	42.29	77.06	50.72	29.26	20.13	10.03	5.35	3.66	3.49	2.70	309.56
1986	15.67	25.05	61.77	32.69	76.52	68.27	22.63	6.92	4.38	3.14	8.47	132.32	457.85
1987	57.20	26.07	17.52	24.78	167.87	148.38	49.08	15.20	11.10	9.08	6.51	4.47	537.25
1988	4.95	20.60	45.23	47.31	154.33	67.81	16.21	9.09	6.12	4.39	3.04	2.03	381.09
1989	2.13	32.87	29.97	19.95	19.12	18.25	12.54	6.48	3.70	2.54	2.24	1.84	151.63
1990	2.10	1.82	31.68	112.31	87.08	39.73	15.00	6.96	4.53	3.22	2.25	1.61	308.28
1991	34.89	22.96	61.86	30.40	73.19	39.98	12.55	6.61	4.21	2.87	2.05	1.46	293.02
1992	1.70	2.35	11.97	16.06	62.92	48.73	18.32	7.38	4.39	2.97	2.05	1.48	180.31
1993	12.31	16.06	34.58	49.99	57.78	42.70	17.57	7.10	4.24	2.92	2.20	1.61	249.06
1994	2.01	1.61	2.49	15.56	17.44	36.91	19.30	6.63	3.90	2.68	1.87	1.45	111.83

Runoff – TM09.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.39	.32	.18	.22	.46	3.68	1.53	.33	.20	.12	.08	.20	7.70
1921	.24	9.89	4.89	.99	.51	.27	.10	.06	.12	.14	.19	.18	17.58
1922	.25	.53	.61	.55	.37	.17	.10	.07	.05	.12	.14	.07	3.05
1923	.05	.09	.08	.26	.42	.45	.28	.14	.09	.07	.08	.18	2.18
1924	.31	2.13	2.05	1.58	1.01	12.93	6.39	1.08	.24	.13	.09	.15	28.10
1925	.30	.21	.07	.23	.26	.25	.19	.11	.12	.13	.08	.29	2.25
1926	.65	.58	.56	.61	.45	.39	.23	.09	.04	.04	.10	.09	3.85
1927	.26	.21	.45	.65	.33	.21	.15	.08	.05	.05	.06	.20	2.68
1928	.26	.15	.17	.50	.51	.54	.36	.17	.15	.40	.39	1.37	4.99
1929	.84	.42	.21	.27	.31	.67	.65	.33	.13	.08	.08	.10	4.10
1930	.13	.13	.11	.22	.17	.12	.14	.12	.07	.07	.07	.04	1.39
1931	.10	.08	.12	.22	.58	.57	.32	.27	.23	.13	.07	.06	2.75
1932	.06	.42	.70	.36	.48	1.59	.84	.24	.10	.12	.12	.06	5.10
1933	.07	5.28	2.20	7.76	2.90	.35	.28	.28	.20	.15	.20	.16	19.84
1934	.20	2.78	1.92	.51	.34	.42	.38	.26	.15	.10	.07	.04	7.17
1935	.03	.05	.11	2.07	10.01	3.46	.21	.27	.28	.15	.07	.06	16.77
1936	.10	.42	.42	.21	.31	.28	.13	.05	.04	.04	.04	.04	2.07
1937	.04	.13	.33	.38	.39	.24	.37	.32	.20	.30	.28	.16	3.14
1938	.20	.18	.19	.18	2.91	1.37	.36	.27	.18	.14	.15	.18	6.31
1939	.33	1.40	.94	.39	.33	.42	.28	.58	.82	.52	.20	.15	6.36
1940	.12	.17	.54	.54	2.74	5.09	1.93	.38	.14	.07	.05	.04	11.81
1941	.10	.10	.10	.39	.70	.87	.60	.30	.16	.11	.11	.12	3.64
1942	.13	1.12	.98	5.22	2.02	.45	7.02	2.92	.49	.46	5.77	2.20	28.77
1943	6.75	2.84	.52	.25	.51	.42	.17	.08	.10	.11	.07	.23	12.06
1944	.26	.20	.10	.06	.15	.76	.54	.23	.12	.08	.05	.03	2.59
1945	.02	.02	.05	.19	.28	.33	.24	.12	.07	.05	.04	.03	1.45
1946	.16	.34	.27	.19	1.94	1.20	.49	.20	.21	.23	.13	.11	5.47
1947	.24	.67	1.60	1.00	.61	.55	.46	.27	.12	.07	.05	.04	5.67
1948	.06	.12	.26	.48	.67	3.10	1.37	.31	.14	.08	.05	.07	6.70
1949	.11	.25	.46	.27	.10	.22	.26	.19	.12	.11	.15	.12	2.34
1950	.09	.08	.26	.52	.46	.42	.35	.20	.10	.07	.23	.34	3.12
1951	.27	.11	.29	15.00	5.42	.48	.27	.12	.07	.11	.13	.09	22.36
1952	.20	.28	2.48	.99	.48	.41	.23	.12	.07	.06	.12	.11	5.56
1953	.10	.35	.43	.25	.26	.27	.25	.29	.22	.12	.07	.16	2.77
1954	.38	.64	.67	5.50	2.22	.95	.63	.28	.13	.08	.05	.04	11.56
1955	.04	.05	.31	.22	.31	4.04	1.59	.17	.07	.05	.05	.08	6.99
1956	.08	.16	5.28	5.17	1.66	.76	.60	.31	.14	.15	.26	6.96	21.55
1957	6.85	1.79	.26	.36	.47	.34	.34	.26	.12	.07	.05	.05	10.95
1958	.09	.21	.19	.19	.50	.39	.24	.49	.44	.24	.14	.07	3.17
1959	.27	.48	.44	.26	.28	.55	.55	.30	.12	.07	.07	.09	3.48
1960	.15	.43	3.47	1.34	.26	.39	.38	.24	.12	.08	.07	.10	7.03
1961	.09	.12	.20	5.10	2.28	.82	.84	.52	.20	.09	.08	.06	10.40
1962	.08	.43	.55	.49	.30	.42	.41	.21	.12	.15	.13	.06	3.36
1963	.14	.48	.40	.50	.39	.32	.26	.15	.12	.12	.08	.21	3.16
1964	.66	.68	.35	.14	.08	.06	.06	.08	.20	.30	.39	.34	3.34
1965	.20	.16	.27	3.26	1.40	.20	.11	.12	.11	.08	.08	.08	6.07
1966	.08	.31	.39	4.25	6.21	2.46	.96	.57	.23	.12	.09	.05	15.73
1967	.06	.27	.40	.32	.17	.13	.12	.08	.05	.05	.06	.06	1.76
1968	.05	.08	.24	.20	.23	1.07	.69	.40	.27	.14	.08	.08	3.52
1969	.26	.20	.24	.34	.88	.48	.12	.05	.06	.06	.20	.41	3.29
1970	.41	.28	.19	.39	.32	.15	.10	.17	.16	.16	.20	.13	2.66
1971	.13	.21	.23	.37	.35	3.95	1.62	.28	.16	.10	.08	.05	7.52
1972	.09	.43	.31	.21	.42	.58	.55	.32	.13	.08	.25	.39	3.76
1973	.23	.25	.40	4.01	1.62	.31	.38	.29	.18	.16	.12	.07	8.03
1974	.04	.17	1.04	3.98	3.82	1.21	.32	.21	.12	.07	.05	.35	11.41
1975	.33	.56	3.77	2.49	2.41	4.91	1.74	.28	.16	.10	.07	.07	16.89
1976	.20	.28	.26	.79	.44	.24	.27	.18	.09	.06	.05	.08	2.95
1977	.55	.58	.46	.56	.36	.34	.48	.32	.13	.07	.07	.19	4.11
1978	.37	.32	2.36	1.30	.50	.32	.22	.18	.13	.12	.21	.19	6.21
1979	.12	.08	.13	.21	.17	.11	.08	.06	.05	.04	.04	.11	1.21
1980	.11	.20	4.83	6.61	2.25	.44	.17	.07	.08	.09	.13	.14	15.12
1981	.09	.37	.29	.29	.22	.20	.15	.08	.06	.06	.05	.04	1.91
1982	.24	.22	.14	.16	.11	.11	.15	.16	.12	.12	.12	.08	1.73
1983	.11	.44	.54	.32	.12	.14	.32	.26	.14	.11	.19	.16	2.85
1984	.17	.18	.20	.47	.67	.51	.21	.07	.05	.05	.04	.04	2.65
1985	.22	.57	.59	.41	.36	.27	.16	.08	.08	.09	.11	.09	3.02
1986	.20	.30	.30	.31	.49	1.05	.56	.15	.07	.06	.20	11.20	14.90
1987	4.18	.36	.21	.41	3.90	1.82	.45	.21	.21	.24	.17	.10	12.27
1988	.08	.08	.31	.37	.58	.41	.16	.07	.06	.06	.05	.03	2.24
1989	.05	.43	.54	.29	.12	.11	.18	.14	.08	.06	.09	.08	2.17
1990	.08	.05	.40	6.84	2.57	.21	.07	.04	.04	.06	.05	.04	10.44
1991	2.02	1.06	4.33	1.71	.44	.48	.40	.21	.09	.06	.05	.04	10.89
1992	.05	.10	.47	.56	.68	.61	.33	.15	.08	.06	.04	.06	3.20
1993	1.46	.87	.47	.44	.50	.62	.46	.23	.11	.08	.09	.06	5.38
1994	.07	.05	.18	.33	.21	.24	.20	.11	.07	.06	.05	.04	1.61

Runoff – TM10.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	3.64	2.23	.87	.52	37.76	19.34	4.41	1.50	.75	.48	.32	2.50	74.33
1921	2.73	81.68	36.58	17.87	8.26	3.44	1.55	.66	.83	.85	1.87	1.79	158.09
1922	2.59	4.93	4.37	6.02	25.88	10.38	1.23	.32	.25	.60	.65	.35	57.58
1923	.32	.31	.46	3.17	9.32	6.64	2.54	.92	.51	.39	.36	1.06	26.00
1924	2.55	22.62	45.80	78.20	27.65	157.01	56.57	3.43	1.29	.75	.51	1.41	397.80
1925	3.15	2.81	1.68	37.36	15.35	3.18	1.66	.80	.72	.63	.40	2.85	70.60
1926	5.37	5.83	5.28	4.69	14.44	14.11	4.98	.96	.34	.39	.65	.52	57.57
1927	1.80	1.85	2.97	3.91	3.47	4.18	2.66	1.00	.47	.36	.34	.77	23.78
1928	1.56	1.28	6.65	11.23	7.08	16.85	8.35	2.17	1.85	2.92	2.22	7.59	69.75
1929	6.12	17.94	9.92	41.56	18.28	21.77	9.74	1.91	.68	.50	.58	1.00	130.00
1930	1.19	.90	4.18	45.61	20.25	4.74	2.20	.83	.36	.46	.47	.25	81.44
1931	.58	.79	3.00	5.08	59.35	24.79	3.84	2.23	1.60	.89	.46	.47	103.09
1932	.56	.87	1.73	1.17	1.63	3.02	2.76	1.36	.52	.76	.74	.36	15.49
1933	.21	29.96	38.03	81.15	28.96	7.73	10.69	4.90	1.64	1.23	2.09	1.48	208.06
1934	1.28	18.87	61.51	20.58	2.86	4.09	3.38	1.69	.82	.56	.39	.28	116.30
1935	.25	.42	.56	2.23	27.85	13.91	3.19	4.21	3.70	1.55	.57	.30	58.73
1936	.71	24.01	11.49	9.85	24.14	10.56	2.36	.77	.34	.29	.24	.25	84.99
1937	.33	.36	2.89	8.46	6.40	3.58	2.80	1.63	1.62	2.36	1.85	1.18	33.46
1938	2.96	2.87	21.92	10.61	35.92	18.73	3.79	1.67	1.27	1.17	1.04	.99	102.95
1939	1.37	35.65	16.72	4.19	2.58	3.17	2.41	2.77	3.40	2.26	.93	1.06	76.52
1940	1.31	2.52	35.07	16.28	6.85	5.72	5.31	3.01	1.01	.50	.39	.28	78.24
1941	.47	.42	1.34	2.88	19.26	22.36	9.18	2.59	.96	.54	.65	.84	61.50
1942	1.45	47.70	27.67	49.27	18.99	5.19	48.83	21.64	4.27	5.25	53.21	19.86	303.34
1943	31.51	29.91	14.43	7.27	29.82	12.95	2.13	.57	.86	1.02	.58	3.20	134.26
1944	3.54	2.46	1.26	.91	1.64	30.94	12.55	1.34	.48	.36	.27	.19	55.94
1945	.12	.11	.23	2.84	7.31	7.02	3.46	1.15	.48	.34	.26	.19	23.51
1946	2.41	18.46	8.61	1.70	9.62	15.06	6.98	1.83	1.45	1.42	.74	.64	68.91
1947	1.40	22.21	11.86	33.85	13.92	6.75	4.74	2.04	.75	.38	.28	.28	98.46
1948	1.01	1.61	2.17	16.63	13.67	8.84	6.61	3.41	1.23	.57	.39	.43	56.57
1949	.90	2.37	4.07	2.61	1.62	19.01	9.27	2.96	1.45	.70	.63	.59	46.17
1950	.91	1.09	14.54	6.61	2.19	2.87	2.57	1.37	.66	.46	2.24	2.51	38.02
1951	2.03	.99	2.18	59.35	23.36	5.77	4.29	2.25	1.08	1.36	1.33	.67	104.66
1952	.81	1.95	2.45	3.18	27.93	12.25	2.83	1.37	.57	.37	.85	.80	55.36
1953	.52	1.78	3.35	2.86	59.98	24.76	3.69	2.49	1.81	.94	.46	.83	103.46
1954	7.83	44.39	17.76	80.15	60.96	14.55	2.05	.81	.41	.29	.24	.20	229.64
1955	.69	1.80	2.88	1.65	6.26	23.40	9.28	1.45	.74	.48	.32	.44	49.40
1956	.65	3.49	70.23	58.32	14.69	7.80	5.11	1.95	.72	2.09	2.77	54.21	222.02
1957	46.64	12.34	1.90	3.27	7.46	5.86	26.29	10.67	1.30	.50	.34	.55	117.11
1958	1.17	3.34	15.22	8.20	8.01	4.42	1.74	2.97	2.53	1.25	.62	.33	49.80
1959	2.20	3.62	2.74	2.93	5.58	16.10	9.57	3.59	1.18	.49	.52	.53	49.04
1960	1.35	2.37	28.56	11.42	2.33	4.59	5.36	3.58	1.68	.76	.42	.63	63.03
1961	.69	1.43	2.36	42.57	32.01	8.83	2.90	1.61	.69	.38	.48	.54	94.49
1962	.40	1.97	9.06	31.13	11.91	14.61	7.11	1.60	.96	1.99	1.69	.64	83.08
1963	.71	1.84	1.22	3.27	2.71	3.11	3.20	1.70	1.04	.92	.66	.83	21.22
1964	3.41	3.14	2.25	19.22	25.75	7.99	1.14	.72	1.20	1.52	1.53	1.58	69.46
1965	1.22	1.10	1.00	38.74	17.02	2.50	1.06	.98	.75	.50	.56	.57	65.99
1966	.65	1.60	5.62	78.09	36.76	19.89	12.31	4.98	1.62	.67	.41	.23	162.85
1967	.25	.49	8.96	4.30	1.18	1.03	.69	.33	.20	.20	.46	.50	18.60
1968	.30	.30	.64	2.39	3.89	24.67	12.16	3.96	2.01	.97	.54	.35	52.17
1969	2.66	2.14	2.43	3.34	3.99	2.22	.77	.52	.58	.60	1.46	2.28	22.98
1970	2.68	2.12	1.36	45.85	18.48	2.69	1.64	1.67	1.27	1.10	1.15	.81	80.82
1971	1.52	1.77	4.02	7.92	7.21	24.71	10.30	1.77	.79	.48	.50	.38	61.36
1972	.64	3.21	2.42	1.86	7.48	5.05	4.20	2.78	1.01	.45	1.96	3.48	34.55
1973	2.19	3.61	5.05	12.24	32.65	30.16	10.37	2.40	.99	.70	.53	.30	101.19
1974	.18	1.41	8.86	17.24	35.25	13.77	3.25	1.54	.62	.37	.30	3.33	86.12
1975	3.04	3.68	13.70	40.32	34.91	44.45	16.39	3.83	1.89	.82	.44	.45	163.92
1976	1.53	2.76	3.44	14.50	7.11	3.59	3.66	2.01	.73	.38	.30	1.01	41.02
1977	3.12	4.17	3.40	38.54	15.87	16.76	8.69	2.22	.72	.39	.53	1.37	95.78
1978	7.91	6.80	34.46	13.65	35.45	14.82	2.43	1.28	.79	.85	2.57	2.94	123.95
1979	1.96	1.29	1.64	3.09	10.20	5.52	1.91	.88	.47	.34	.28	1.70	29.29
1980	1.91	3.62	51.42	42.93	86.98	28.62	1.62	.64	.58	.58	.86	1.36	221.12
1981	1.10	1.55	1.70	6.27	3.78	2.09	1.23	.49	.27	.31	.30	.33	19.41
1982	3.04	2.66	3.53	23.27	9.36	1.92	1.22	.71	.52	.56	.61	.41	47.81
1983	1.20	3.50	17.75	9.99	2.88	2.67	3.07	1.69	.69	.48	.98	.97	45.86
1984	1.20	.86	.47	20.62	43.59	14.28	.98	.28	.34	.39	.30	.24	83.57
1985	3.11	5.96	4.67	11.01	7.09	5.18	3.88	1.70	.95	.82	.68	.44	45.48
1986	26.25	11.96	39.05	18.00	55.99	96.47	28.60	1.31	.60	.59	2.99	99.53	381.35
1987	36.25	2.70	3.13	7.27	20.22	17.79	7.20	2.18	1.27	2.19	1.74	.91	102.84
1988	2.13	2.50	10.34	6.94	108.51	39.42	2.29	.87	.65	.55	.38	.23	174.80
1989	.51	20.41	20.81	7.06	2.63	2.94	2.92	1.69	.70	.39	.83	.74	61.63
1990	.59	.37	3.78	44.17	30.24	8.52	1.90	.53	.46	.52	.37	.35	91.80
1991	9.19	6.73	9.41	5.71	19.06	9.06	2.03	.66	.31	.26	.37	.31	63.10
1992	.26	.97	2.42	2.42	4.31	6.49	4.39	1.66	.55	.34	.26	.37	24.43
1993	4.06	5.56	19.72	25.10	24.53	16.53	6.42	1.89	.67	.50	.61	.43	106.01
1994	.46	.40	.61	14.94	7.88	5.83	3.86	1.36	.52	.35	.28	.42	36.90

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	11.06	7.32	3.02	2.73	49.70	40.02	12.95	3.32	1.46	.99	.75	6.19	139.52
1921	6.98	123.28	84.86	26.87	30.09	18.12	6.09	2.28	2.26	2.17	7.01	6.67	316.66
1922	16.22	43.52	20.36	61.30	175.75	58.31	3.45	1.24	1.15	1.76	1.73	1.36	386.14
1923	2.12	1.86	3.20	27.75	21.02	35.22	15.37	3.48	1.73	1.22	1.12	4.06	118.16
1924	8.45	37.33	56.37	35.62	34.13	246.92	88.79	6.92	2.96	1.75	1.17	2.28	522.68
1925	6.10	9.93	6.46	160.35	60.46	7.21	3.78	1.89	1.90	1.83	1.18	10.39	271.48
1926	15.79	17.01	15.04	16.20	43.64	58.56	20.47	3.14	1.09	1.45	2.00	1.39	195.80
1927	9.38	8.22	11.94	12.60	11.70	33.61	15.74	3.89	1.80	1.12	1.02	2.08	113.10
1928	3.77	2.78	24.64	17.89	24.76	100.64	41.93	8.17	6.06	8.40	6.16	39.60	284.80
1929	21.61	49.42	49.35	74.56	29.46	8.76	6.16	3.42	1.69	1.33	1.56	1.88	249.20
1930	1.94	1.62	3.26	55.52	74.71	26.54	5.27	1.85	.87	1.25	1.34	.79	174.94
1931	1.77	2.50	3.45	4.65	106.83	46.53	7.58	4.20	3.60	2.84	1.79	1.43	187.19
1932	1.48	3.06	6.09	5.27	6.11	6.76	5.45	2.93	1.30	1.78	1.80	.96	42.97
1933	.58	49.11	69.03	276.32	94.66	8.65	9.83	10.27	6.06	4.25	8.08	5.80	542.64
1934	3.90	11.07	84.98	32.32	6.74	13.55	10.10	4.22	1.93	1.37	1.05	1.12	172.37
1935	1.22	.99	1.46	5.57	32.06	36.22	13.58	19.85	12.64	4.10	1.51	.98	130.18
1936	3.68	52.41	25.14	90.73	39.61	8.12	4.40	2.34	1.13	.80	.68	.86	229.90
1937	1.28	1.24	9.24	11.22	12.14	8.25	8.91	6.09	5.80	9.32	8.27	5.48	87.24
1938	9.69	11.26	54.28	35.46	50.99	39.06	12.35	4.17	2.86	3.49	3.51	3.15	230.26
1939	4.59	75.58	71.82	21.08	8.38	6.26	3.51	6.71	8.30	5.12	2.20	4.13	217.68
1940	5.52	9.06	59.02	74.80	65.40	22.79	10.41	6.47	2.35	1.32	1.06	.80	259.00
1941	1.13	1.34	3.68	16.14	98.27	62.72	21.35	8.66	3.95	2.11	2.74	3.82	225.92
1942	9.14	115.93	95.58	132.55	44.15	16.30	85.90	35.20	5.54	7.87	77.48	31.07	656.70
1943	43.19	24.70	28.96	24.69	106.67	40.50	3.86	1.09	3.99	4.68	2.34	16.21	300.90
1944	20.12	10.43	3.35	1.69	5.46	93.28	36.26	3.43	1.32	.99	.80	.70	177.84
1945	.62	.31	.14	50.64	46.71	61.30	21.99	2.89	1.15	.85	.69	.48	187.77
1946	6.92	44.28	20.95	6.06	43.93	31.01	12.87	4.86	3.78	3.78	2.14	1.96	182.55
1947	5.22	39.36	35.94	53.96	23.27	23.39	14.21	5.16	2.02	1.13	.85	.90	205.40
1948	3.71	5.13	3.47	22.41	32.49	33.23	18.36	7.71	2.95	1.46	1.00	1.71	133.63
1949	4.45	11.13	14.01	11.78	11.37	30.65	16.48	6.37	3.35	1.80	1.87	1.97	115.24
1950	4.02	3.31	6.90	8.41	11.34	11.04	7.94	4.19	2.14	1.58	4.26	5.33	70.45
1951	5.37	2.90	4.14	125.28	62.67	21.50	11.43	4.89	2.07	3.54	3.73	2.00	249.51
1952	3.07	5.90	4.23	18.83	122.92	48.59	10.12	5.31	2.04	1.07	1.73	1.61	225.42
1953	1.46	5.64	8.76	8.06	133.35	59.91	12.28	7.65	5.39	2.96	1.43	3.79	250.67
1954	17.88	82.24	39.60	129.28	156.76	45.54	4.95	2.12	1.21	.90	.73	.64	481.84
1955	1.77	6.48	9.17	5.00	120.24	103.54	25.70	4.60	3.26	1.81	1.02	1.35	283.95
1956	3.09	22.68	128.99	77.81	26.64	32.92	17.22	5.31	2.11	5.83	7.73	107.87	438.20
1957	73.25	18.04	5.73	37.51	22.27	15.81	22.01	11.07	2.99	1.23	.84	3.29	214.03
1958	5.77	9.62	29.82	24.26	66.72	25.78	4.02	9.33	8.23	3.66	1.64	.90	189.73
1959	8.51	12.46	11.12	11.78	40.69	22.35	16.25	9.25	2.95	1.31	1.37	1.50	139.55
1960	4.10	7.68	75.68	28.55	3.12	24.25	19.24	10.05	4.52	1.96	1.06	1.94	182.16
1961	2.21	7.51	11.21	68.06	43.73	12.33	5.65	3.68	1.73	1.00	1.21	1.56	159.88
1962	1.21	5.51	11.89	139.19	50.68	6.18	4.08	1.97	2.37	4.24	3.29	1.36	231.96
1963	1.55	4.68	3.09	12.54	7.78	5.85	5.01	2.56	2.59	2.67	2.09	2.75	53.15
1964	30.41	17.79	15.68	29.58	20.30	7.42	3.92	2.96	4.09	4.42	4.58	5.64	146.79
1965	4.60	4.30	4.10	112.82	52.41	8.65	2.85	2.59	2.11	1.35	1.41	1.55	198.74
1966	1.79	3.98	36.38	193.78	78.10	58.19	34.31	11.38	3.55	1.53	1.01	.68	424.68
1967	.97	1.45	7.95	6.64	3.46	2.67	1.70	.86	.59	.55	1.30	1.46	29.61
1968	1.03	1.12	1.65	5.39	8.90	68.65	32.83	11.67	6.50	3.01	1.59	1.01	143.35
1969	9.15	6.60	7.55	16.67	21.08	9.29	2.41	1.43	1.61	1.72	4.73	7.76	90.01
1970	10.92	8.65	4.52	165.68	64.05	7.46	4.34	5.72	4.66	4.01	3.84	2.49	286.34
1971	5.44	7.00	26.13	42.71	54.86	48.47	16.47	3.47	1.68	1.17	1.53	1.32	210.25
1972	2.68	8.26	6.75	5.71	27.72	13.15	25.48	13.46	3.15	1.25	6.96	14.14	128.71
1973	9.47	15.43	28.14	37.04	53.54	26.44	11.66	6.78	3.63	2.17	1.49	.93	196.72
1974	.67	7.96	11.04	59.34	123.40	48.98	11.70	4.89	1.85	1.04	.85	17.13	288.83
1975	11.85	28.89	80.28	103.29	82.74	112.48	46.20	14.38	6.97	2.67	1.30	1.20	492.25
1976	10.77	16.34	16.69	37.26	18.48	24.35	24.84	11.00	3.00	1.23	.86	4.70	169.52
1977	22.94	15.31	9.81	98.98	45.29	31.29	16.29	4.85	1.68	.95	1.49	4.99	253.88
1978	38.01	22.97	36.45	16.62	65.33	27.77	4.72	3.80	3.81	4.78	14.13	13.98	252.37
1979	7.80	4.74	7.48	34.24	41.47	17.14	4.69	2.07	1.30	.95	.82	5.41	128.10
1980	7.17	10.05	47.52	63.39	217.10	71.65	2.65	1.09	1.31	1.45	2.33	4.79	430.51
1981	4.45	7.12	8.31	19.04	9.75	6.16	4.01	1.56	.80	.90	.86	1.00	63.93
1982	12.10	8.98	3.62	5.75	4.61	3.91	2.94	1.84	1.38	1.35	1.34	.93	48.75
1983	9.85	44.18	86.01	67.75	19.91	16.39	11.61	4.49	1.76	1.36	5.07	5.71	274.10
1984	7.22	4.72	2.88	77.68	200.79	63.48	2.55	.64	.49	.56	.55	.69	362.26
1985	16.24	64.85	54.04	62.22	23.08	12.35	10.41	4.80	2.23	1.63	1.71	1.39	254.95
1986	5.45	8.30	24.29	17.19	215.47	141.98	29.38	3.35	1.35	1.15	6.25	173.47	627.64
1987	65.85	11.34	18.89	10.80	144.61	71.77	12.42	2.39	2.05	3.46	2.67	1.78	348.03
1988	4.17	9.91	23.15	36.14	164.07	62.74	8.86	3.94	2.41	1.77	1.14	.67	318.98
1989	1.89	53.62	24.39	5.30	6.44	10.40	9.13	4.58	1.79	1.02	1.80	1.59	121.94
1990	1.52	.88	4.70	73.84	83.69	30.00	6.38	1.63	1.26	1.47	1.04	.76	207.17
1991	57.25	27.45	19.41	11.61	37.43	16.76	3.11	1.19	.72	.61	.92	.83	177.29
1992	.70	1.77	4.33	8.68	27.85	25.16	11.75	3.98	1.42	.89	.77	1.44	88.74
1993	32.20	20.33	12.62	27.63	142.07	58.49	10.99	4.20	1.49	1.08	1.56	1.32	313.98
1994	1.91	1.25	1.20	4.51	6.47	8.71	6.90	3.82	2.06	1.33	1.13	1.39	40.67

Runoff – TM12.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	12.65	4.14	.74	.51	1.25	8.61	3.68	.77	.43	.26	.16	1.15	34.34
1921	1.21	36.44	22.10	4.40	1.38	1.21	.63	.35	.60	.63	.96	.80	70.71
1922	.74	1.58	1.62	2.44	8.82	3.59	.55	.25	.21	.26	.26	.16	20.47
1923	.16	.30	.39	.67	7.01	3.26	.64	.31	.24	.19	.19	.33	13.68
1924	.95	14.17	21.00	9.30	3.06	95.65	34.46	1.97	.72	.38	.26	.73	182.65
1925	1.28	.89	.57	2.35	2.09	1.32	.61	.32	.36	.34	.21	1.04	11.38
1926	2.03	1.97	1.86	1.81	2.83	3.07	1.44	.40	.16	.16	.26	.23	16.23
1927	.72	.68	1.01	1.25	.95	1.20	.86	.36	.18	.14	.14	.34	7.85
1928	.68	.58	1.07	14.25	6.28	5.70	2.67	.63	.70	1.41	1.15	11.41	46.51
1929	5.16	4.45	2.31	4.33	2.72	16.72	6.62	.82	.32	.24	.24	.36	44.27
1930	.42	.38	2.06	7.26	3.22	1.04	.73	.41	.21	.26	.26	.14	16.39
1931	.23	.22	.49	1.24	30.69	11.92	1.44	.98	.70	.39	.21	.24	48.74
1932	.29	.61	1.29	.77	.58	1.16	1.23	.70	.30	.50	.50	.23	8.17
1933	.10	12.85	7.96	21.83	8.17	1.53	2.06	1.98	1.07	.60	.92	.71	59.77
1934	.48	12.42	33.03	10.24	1.03	2.44	1.50	.52	.28	.22	.17	.14	62.48
1935	.10	.15	.12	.89	3.37	2.26	.97	1.32	1.17	.56	.24	.14	11.28
1936	.23	3.19	11.96	4.92	6.68	3.01	.79	.40	.21	.17	.14	.10	31.80
1937	.12	.15	1.08	8.47	3.82	.94	1.18	.92	.68	.98	.91	.47	19.72
1938	.36	.32	.35	.77	25.73	10.04	1.04	.49	.34	.35	.37	.37	40.52
1939	.40	1.60	1.27	.54	.34	.35	.40	.63	1.40	1.28	.58	.43	9.22
1940	.44	.38	1.09	1.76	2.08	11.31	5.21	1.19	.43	.22	.15	.12	24.39
1941	.33	.37	.23	1.17	18.49	12.35	3.71	1.25	.50	.28	.28	.29	39.24
1942	.31	10.92	8.08	4.49	2.61	1.88	27.86	11.18	1.62	1.13	12.21	5.01	87.30
1943	27.55	21.06	10.22	3.16	17.43	7.24	1.00	.34	.28	.28	.19	.88	89.63
1944	1.02	.74	.33	.16	.49	15.98	6.08	.51	.24	.17	.13	.08	25.93
1945	.05	.09	.33	.40	6.36	3.16	.92	.49	.26	.17	.14	.09	12.47
1946	.61	1.66	1.19	.53	4.41	11.64	4.52	.75	.53	.50	.30	.32	26.96
1947	.71	1.41	13.05	34.21	11.85	5.32	3.33	1.40	.55	.26	.16	.14	72.38
1948	.29	.46	1.58	1.48	1.57	3.67	2.56	1.11	.42	.22	.15	.21	13.72
1949	.29	.66	.64	.32	.22	23.53	9.21	1.23	.63	.33	.32	.39	37.78
1950	.46	7.67	33.36	11.60	1.55	1.97	1.75	.93	.44	.28	.56	.84	61.41
1951	.73	.35	.52	54.74	19.50	2.00	1.33	.52	.23	.40	.46	.33	81.10
1952	.57	.97	5.10	3.23	14.20	5.61	1.02	.56	.26	.17	.23	.21	32.11
1953	.27	.59	1.34	.94	2.40	1.87	1.07	.78	.52	.30	.17	.38	10.64
1954	1.30	12.69	5.28	9.85	18.13	6.10	.88	.50	.31	.21	.14	.10	55.48
1955	.10	.15	2.54	1.29	1.84	7.90	3.31	.53	.21	.16	.14	.19	18.38
1956	.16	.55	26.51	12.15	2.02	3.41	2.92	1.42	.50	.44	.77	24.23	75.09
1957	17.03	3.94	1.02	1.30	9.89	4.01	1.35	1.02	.44	.22	.15	.17	40.55
1958	.31	.85	1.33	1.15	1.37	.86	.61	1.02	.86	.50	.29	.14	9.28
1959	.89	1.58	1.29	.61	1.37	11.08	6.84	2.07	.60	.27	.20	.16	26.96
1960	.29	.73	1.91	1.15	1.10	1.59	2.20	1.48	.62	.32	.24	.30	11.95
1961	.27	.43	.64	5.54	15.22	6.17	1.90	1.08	.45	.23	.17	.14	32.26
1962	.11	.89	14.73	10.84	3.68	2.89	1.97	.90	.49	.46	.34	.16	37.47
1963	.29	3.52	1.92	2.04	1.18	1.24	1.51	.89	.49	.39	.25	.67	14.41
1964	4.32	6.03	2.42	.77	.56	.36	.26	.23	.54	.83	1.10	1.20	18.60
1965	.76	.55	.63	16.54	6.94	.92	.26	.23	.35	.33	.30	.23	28.04
1966	.27	1.29	5.55	13.61	22.64	8.13	10.40	4.69	1.06	.49	.28	.14	68.55
1967	.14	.24	.18	.53	.79	1.16	.94	.45	.21	.17	.22	.18	5.21
1968	.12	.23	.56	.93	.83	5.69	2.97	1.21	.79	.41	.22	.14	14.10
1969	.85	.77	1.09	.89	1.79	1.34	.53	.23	.20	.21	.73	1.59	10.21
1970	1.48	.99	.45	5.39	2.68	.81	.58	.61	.48	.46	.48	.29	14.71
1971	.38	.86	1.62	1.82	1.41	10.38	4.32	.81	.48	.29	.21	.14	22.72
1972	.25	1.35	1.01	.53	1.08	1.05	1.45	1.11	.46	.23	.84	1.34	10.69
1973	.78	1.01	1.27	4.23	12.22	15.24	5.57	1.27	.55	.37	.28	.17	42.97
1974	.14	.56	16.63	17.05	16.80	5.73	1.39	.72	.31	.19	.15	1.73	61.39
1975	1.38	5.40	5.70	10.74	14.44	21.38	6.94	1.03	.63	.33	.19	.27	68.42
1976	.72	1.06	.94	8.53	3.61	1.11	.88	.45	.22	.16	.14	.35	18.18
1977	2.36	2.08	1.60	22.50	8.64	2.02	1.79	.91	.35	.19	.24	.59	43.26
1978	1.42	1.26	12.87	5.28	8.66	4.10	1.11	.62	.36	.33	.81	.75	37.56
1979	.57	.62	.91	1.24	1.47	1.07	.73	.47	.27	.18	.14	.67	8.32
1980	.72	1.71	26.18	25.10	40.62	12.54	.59	.29	.25	.24	.40	.48	109.11
1981	.31	.43	.55	1.37	.95	.52	.34	.20	.16	.21	.17	.21	5.42
1982	1.13	1.04	.98	1.65	1.01	.59	.44	.41	.35	.35	.35	.21	8.51
1983	.44	.99	11.59	4.91	.80	1.34	1.99	1.21	.48	.28	.42	.36	24.81
1984	.72	.58	.26	13.32	7.03	1.67	.46	.16	.16	.17	.14	.12	24.80
1985	1.04	1.35	2.16	3.66	2.20	1.21	.69	.30	.30	.33	.31	.23	13.79
1986	5.73	3.04	5.05	6.16	23.24	37.80	11.01	.46	.24	.24	1.07	50.42	144.46
1987	18.15	1.17	1.57	9.38	23.53	8.73	1.71	.78	.53	.78	.64	.37	67.33
1988	.93	.89	3.21	2.00	47.16	16.79	.74	.32	.28	.25	.19	.12	72.86
1989	.21	9.77	10.41	3.18	.84	.92	.99	.66	.31	.19	.37	.32	28.19
1990	.25	.17	2.80	18.16	12.12	3.06	.57	.20	.23	.26	.17	.16	38.15
1991	5.61	3.23	2.43	1.72	1.77	1.40	.66	.27	.14	.13	.17	.14	17.67
1992	.12	.48	1.07	.91	1.50	2.20	1.54	.64	.25	.16	.13	.18	9.18
1993	1.95	2.23	10.18	12.47	4.43	7.91	3.53	.75	.32	.26	.29	.21	44.52
1994	.21	.19	.21	10.22	4.31	2.45	1.50	.50	.21	.16	.13	.21	20.31

Runoff – TM13.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	3.88	2.37	.83	.81	2.98	4.75	2.61	.97	.84	.52	.38	.46	21.40
1921	.53	6.22	8.63	3.36	1.48	1.20	.73	.49	.49	.48	.47	.45	24.52
1922	.57	1.77	1.93	2.56	3.45	1.85	.70	.51	.37	.36	.36	.27	14.70
1923	.21	.50	.56	1.57	1.92	1.57	1.33	.46	.37	.29	.23	.38	9.40
1924	.69	3.02	6.28	6.46	4.82	14.43	15.46	4.02	1.64	1.14	.81	.77	59.54
1925	1.05	.97	.57	.68	.97	.70	.37	.31	.32	.32	.25	1.33	7.85
1926	2.59	1.93	3.74	4.36	1.81	1.23	.90	.49	.35	.26	.24	.23	18.12
1927	1.18	1.24	2.45	4.92	3.02	1.12	1.01	.47	.36	.27	.21	.20	16.46
1928	.81	.88	1.25	2.85	2.63	2.83	2.34	.64	.68	1.06	.93	.93	17.82
1929	1.15	2.71	2.63	3.91	4.22	5.32	5.17	.99	.70	.51	.38	.29	28.00
1930	.35	.36	.32	1.16	1.19	.42	.62	.58	.31	.36	.38	.25	6.29
1931	.24	.25	.32	2.12	5.30	4.13	1.07	.66	.55	.40	.29	.25	15.60
1932	.26	2.09	3.41	1.71	1.87	2.18	.84	.47	.34	.34	.34	.24	14.10
1933	.20	5.63	7.18	8.57	7.78	1.72	1.55	1.23	.86	.66	.82	.73	36.93
1934	.60	3.56	7.86	5.22	3.23	3.52	1.25	.70	.55	.43	.32	.25	27.49
1935	.19	.16	.27	3.09	6.97	4.86	1.19	1.34	1.25	.53	.37	.27	20.50
1936	.32	2.42	2.59	.73	1.42	1.34	.46	.33	.25	.20	.16	.12	10.35
1937	.11	.21	2.00	2.98	1.53	.66	1.38	1.36	.44	.52	.54	.38	12.13
1938	1.87	2.00	1.79	1.85	7.03	7.59	1.41	.88	.68	.51	.40	.42	26.41
1939	.70	2.20	3.48	2.29	1.12	1.15	.84	2.01	2.35	.88	.50	.45	17.97
1940	.42	.60	3.50	3.75	5.32	7.99	4.13	1.25	.77	.55	.40	.29	28.96
1941	.37	.38	.42	2.85	4.98	4.57	2.80	1.01	.66	.49	.41	.36	19.31
1942	.43	2.96	4.99	6.23	4.61	1.35	6.91	7.33	1.66	1.73	5.31	4.73	48.23
1943	6.55	8.90	3.80	1.55	3.43	3.22	.81	.57	.45	.38	.30	1.63	31.58
1944	1.77	.64	.55	.37	.58	3.43	3.41	.66	.49	.36	.27	.19	12.71
1945	.14	.12	.14	1.23	2.22	1.59	.77	.42	.31	.23	.18	.13	7.47
1946	.31	1.44	1.51	.54	2.57	3.93	1.92	.61	.62	.58	.38	.30	14.71
1947	.62	2.39	4.05	4.45	3.31	2.70	2.29	.90	.55	.40	.29	.21	22.15
1948	.21	.27	.79	2.40	2.71	2.87	2.33	.68	.48	.35	.26	.24	13.60
1949	.25	1.48	2.83	1.79	.66	4.14	4.30	.88	.66	.50	.51	.48	18.50
1950	.35	.31	2.72	3.64	1.54	1.89	1.75	.56	.41	.30	.45	.57	14.49
1951	.51	.41	1.05	8.91	9.03	3.11	2.59	.84	.60	.48	.43	.35	28.32
1952	.49	.81	3.65	3.65	3.85	3.86	.86	.66	.47	.34	.35	.34	19.34
1953	.39	1.22	2.25	1.55	2.49	2.73	.85	.70	.58	.40	.30	.36	13.83
1954	.84	2.76	3.76	5.67	6.79	4.37	2.32	1.08	.71	.53	.38	.27	29.49
1955	.22	.20	2.31	2.43	2.56	6.18	4.33	.83	.58	.41	.30	.25	20.60
1956	.23	1.03	5.64	8.11	4.24	2.87	2.69	1.04	.64	.53	.66	5.15	32.84
1957	7.70	3.53	1.20	2.90	3.80	1.98	1.08	.93	.50	.36	.26	.20	24.44
1958	.21	.55	.83	.96	3.60	3.41	.83	1.88	1.76	.57	.44	.33	15.35
1959	.53	1.36	2.26	1.68	2.39	3.98	2.66	1.00	.54	.38	.29	.25	17.33
1960	.35	1.17	4.76	4.22	1.16	2.52	2.33	.86	.51	.37	.28	.27	18.81
1961	.27	.40	.73	5.49	7.66	4.84	3.17	1.39	.71	.50	.37	.29	25.83
1962	.25	2.26	3.18	2.17	1.41	2.48	2.54	.60	.45	.38	.32	.25	16.30
1963	.34	1.97	2.04	1.87	1.83	.88	.86	.46	.37	.32	.27	.76	11.98
1964	4.18	4.41	1.51	1.08	.72	.47	.39	.35	.81	.93	.73	.74	16.33
1965	.49	.43	.55	5.14	5.38	.92	.62	.50	.42	.33	.28	.25	15.31
1966	.27	2.24	2.97	5.99	9.74	7.67	5.22	2.80	1.01	.71	.51	.36	39.50
1967	.32	1.24	1.53	.81	.58	.58	.53	.34	.26	.20	.17	.16	6.73
1968	.14	.27	.70	.86	.84	4.06	4.12	1.02	.79	.51	.37	.32	14.02
1969	.97	1.01	1.29	1.63	2.46	2.22	.49	.35	.27	.21	1.09	1.72	13.71
1970	1.20	.73	.51	1.91	1.96	.53	.43	.48	.46	.37	.42	.38	9.40
1971	.49	.73	.78	1.38	1.57	5.73	5.69	.97	.73	.53	.40	.29	19.29
1972	.40	2.20	2.17	1.00	2.03	1.90	1.21	.84	.43	.31	.56	1.01	14.08
1973	.79	1.05	1.88	5.80	6.66	4.19	3.17	1.25	.71	.55	.44	.33	26.83
1974	.25	.68	2.35	5.22	6.42	3.56	1.03	.76	.53	.37	.27	2.19	23.62
1975	2.35	2.03	5.64	8.22	8.42	9.97	6.79	1.60	1.19	.81	.57	.42	48.00
1976	1.02	1.11	.64	2.36	2.28	.94	1.27	.85	.40	.29	.21	.27	11.65
1977	1.55	1.74	1.26	4.08	3.69	1.35	1.55	.97	.47	.34	.26	.37	17.63
1978	1.22	1.45	5.54	6.17	1.85	1.35	.91	.77	.71	.45	.68	.69	21.79
1979	.40	.35	.53	1.28	1.24	.58	.44	.32	.24	.18	.14	.36	6.06
1980	.43	.81	4.73	7.78	7.29	4.18	1.08	.77	.57	.45	.53	.54	29.17
1981	.35	.80	.90	1.32	1.27	1.54	1.59	.45	.33	.25	.20	.42	9.43
1982	1.47	1.33	.42	.73	.68	.58	.69	.45	.34	.31	.32	.27	7.60
1983	.43	2.20	3.17	1.88	.87	1.58	1.75	.67	.42	.33	.36	.34	14.00
1984	.49	.57	.53	2.70	6.39	4.53	.90	.61	.44	.32	.24	.18	17.91
1985	2.07	4.15	2.74	1.74	1.72	.90	.58	.42	.32	.27	.30	.30	15.50
1986	.78	1.03	.86	1.00	2.25	3.35	1.92	.51	.36	.27	.70	9.81	22.84
1987	10.14	1.51	1.08	2.29	8.66	9.57	3.41	1.19	1.07	.94	.65	.48	41.01
1988	.38	.44	2.32	2.66	2.57	2.35	.66	.46	.35	.27	.21	.16	12.84
1989	.19	1.99	2.27	.75	.60	.68	.68	.45	.31	.23	.31	.32	8.78
1990	.25	.25	3.83	10.55	8.09	1.81	.95	.66	.46	.35	.26	.21	27.67
1991	3.49	3.89	8.76	9.06	2.48	2.27	.99	.70	.49	.34	.25	.19	32.90
1992	.17	.29	3.32	4.13	3.43	3.14	1.07	.59	.44	.31	.23	.20	17.32
1993	4.09	4.58	2.13	2.59	2.51	3.17	2.11	.68	.49	.36	.29	.24	23.24
1994	.23	.21	1.27	2.07	1.10	.90	.90	.34	.27	.21	.16	.13	7.80

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.92	2.17	1.83	1.52	3.51	17.82	7.98	2.27	1.61	1.17	.86	9.03	52.69
1921	5.08	67.87	47.95	16.09	9.04	8.26	4.77	2.73	2.01	1.61	1.84	1.72	168.97
1922	2.97	4.99	5.03	20.13	10.07	3.12	1.98	1.36	.97	.77	.69	.58	52.66
1923	.49	.48	.47	6.63	8.01	4.89	2.55	1.73	1.33	1.01	.78	.79	29.16
1924	1.03	3.54	30.95	54.54	36.77	111.41	46.36	9.96	6.63	4.61	3.22	2.34	311.36
1925	3.09	3.41	2.13	28.20	12.65	3.75	2.66	1.92	1.51	1.24	.98	2.66	64.20
1926	4.08	3.77	2.86	2.53	26.42	17.51	5.54	2.60	1.78	1.30	1.10	.98	70.47
1927	1.72	1.49	8.72	8.38	4.11	4.18	2.81	1.78	1.35	1.04	.79	.69	37.06
1928	.91	.92	1.43	3.71	2.85	9.57	5.17	2.06	1.60	1.57	1.47	3.12	34.38
1929	2.73	16.92	10.39	29.54	17.89	6.53	3.50	2.45	1.77	1.30	1.01	.89	94.92
1930	.87	.81	3.30	35.64	17.32	5.43	3.28	2.22	1.59	1.17	.91	.69	73.23
1931	.58	.79	1.51	4.18	31.03	14.78	3.85	2.87	2.28	1.80	1.38	1.04	66.09
1932	.84	.79	1.63	1.28	1.48	3.54	2.55	1.52	1.10	.89	.78	.65	17.05
1933	.50	27.70	25.00	51.75	21.87	6.63	4.41	3.16	2.49	2.07	2.29	1.88	149.75
1934	1.76	2.01	29.00	13.51	4.32	4.82	4.10	2.58	1.77	1.33	1.00	.76	66.96
1935	.61	.49	.42	4.10	31.41	23.02	7.18	5.42	4.04	2.37	1.61	1.18	81.85
1936	1.01	22.38	10.00	5.40	24.00	11.82	3.61	2.35	1.65	1.18	.86	.66	84.92
1937	.55	.48	5.94	6.03	5.76	3.30	1.97	1.54	1.52	1.70	1.57	1.40	31.76
1938	9.51	5.23	24.16	12.82	33.54	15.11	4.03	3.11	2.41	1.94	1.65	1.64	115.15
1939	1.56	31.78	22.47	9.26	5.08	3.66	2.56	4.82	4.19	2.33	1.56	1.27	90.54
1940	1.20	2.78	15.30	8.27	7.41	4.67	8.20	4.66	2.07	1.43	1.08	.82	57.89
1941	.73	.72	5.01	15.85	19.13	15.56	6.92	3.08	2.19	1.65	1.29	1.12	73.25
1942	1.31	33.98	16.81	63.03	28.18	7.67	21.65	13.55	5.69	17.00	48.70	19.83	277.40
1943	25.49	36.48	22.88	9.19	31.76	14.45	4.13	2.79	2.13	1.75	1.40	3.68	156.13
1944	3.36	1.87	1.54	1.40	1.66	18.82	8.64	2.38	1.68	1.23	.90	.67	44.15
1945	.49	.37	.27	.99	.99	2.37	1.76	1.14	.86	.67	.53	.42	10.86
1946	1.42	27.33	12.21	2.85	20.51	10.81	3.49	2.30	1.85	1.58	1.30	1.03	86.68
1947	.97	8.84	6.48	9.43	4.58	2.49	1.99	1.60	1.24	.94	.72	.58	39.86
1948	1.14	1.46	1.56	19.09	12.31	4.75	3.60	2.54	1.77	1.31	.97	.76	51.26
1949	1.15	1.33	10.15	5.48	3.11	2.79	2.24	1.92	1.64	1.31	1.05	.87	33.04
1950	.80	1.08	3.32	2.31	1.42	1.52	1.41	1.26	1.03	.83	2.00	1.77	18.75
1951	1.41	1.15	4.74	31.41	13.29	3.68	3.10	2.43	1.93	1.80	1.55	1.24	67.73
1952	.99	2.15	1.61	3.66	38.23	16.95	4.75	3.26	2.26	1.62	1.55	1.35	78.38
1953	1.12	15.39	7.54	2.29	36.07	17.39	4.44	3.10	2.40	1.84	1.36	1.17	94.11
1954	7.20	48.00	20.22	45.46	35.02	11.69	4.87	3.39	2.39	1.68	1.19	.86	181.97
1955	1.03	1.57	1.99	1.43	1.93	3.97	2.48	1.41	1.15	.94	.74	.63	19.27
1956	.82	11.41	46.61	39.94	14.00	6.19	4.33	2.96	2.15	3.39	3.79	36.53	172.12
1957	34.05	11.27	3.93	4.01	9.10	7.16	22.67	10.30	2.94	1.99	1.42	1.08	109.92
1958	1.19	3.12	8.84	4.66	11.65	5.80	2.24	2.40	1.98	1.52	1.18	.92	45.50
1959	1.73	3.23	2.20	3.48	3.67	3.16	3.59	2.46	1.56	1.13	.91	.84	27.96
1960	1.09	4.01	17.42	7.50	2.47	9.92	6.78	3.41	2.20	1.63	1.23	.97	58.63
1961	.86	1.58	1.71	29.25	22.13	6.99	3.13	2.35	1.72	1.25	.96	.84	72.77
1962	.74	1.23	5.49	8.95	3.99	9.71	5.29	2.12	1.59	2.52	2.12	1.40	45.15
1963	1.07	1.26	1.14	12.63	6.32	2.58	2.06	1.64	1.33	1.15	.97	.97	33.12
1964	6.03	4.65	3.40	23.16	11.95	3.55	2.21	1.63	1.51	1.42	1.35	1.20	62.06
1965	1.14	1.19	1.16	30.50	13.61	3.07	2.26	1.83	1.48	1.16	.93	.81	59.14
1966	.77	1.15	3.01	51.48	23.40	38.04	19.03	5.87	3.64	2.51	1.77	1.26	151.93
1967	.93	1.30	1.64	1.23	.91	1.12	1.01	.82	.64	.51	.49	.55	11.15
1968	.51	.57	1.23	2.47	11.22	30.51	13.83	4.07	2.71	2.00	1.50	1.10	71.72
1969	2.35	1.78	1.78	2.83	12.15	5.69	1.90	1.46	1.18	.97	1.23	1.30	34.62
1970	1.80	1.89	1.44	23.95	10.81	3.80	3.25	3.18	2.38	1.80	1.58	1.40	57.28
1971	1.23	1.12	3.60	38.18	28.98	26.27	10.76	3.69	2.56	1.84	1.36	1.03	120.62
1972	.85	1.07	.95	1.11	30.90	13.56	4.41	3.14	2.07	1.46	1.73	2.72	63.97
1973	2.07	23.08	11.25	46.17	29.95	9.64	5.96	4.05	2.69	1.99	1.51	1.13	139.49
1974	.83	2.14	5.69	10.91	64.57	27.04	6.18	4.26	3.02	2.14	1.53	11.28	139.59
1975	6.05	4.88	12.21	57.42	44.73	44.51	19.00	6.60	4.42	3.11	2.23	1.63	206.79
1976	2.67	2.58	2.83	23.17	10.35	14.44	8.37	3.31	2.20	1.60	1.17	1.04	73.73
1977	4.88	3.39	2.78	51.04	23.72	10.81	6.77	3.54	2.36	1.68	1.27	1.62	113.86
1978	18.80	9.49	3.48	3.60	31.90	13.97	3.41	2.40	1.75	1.57	2.13	3.15	95.65
1979	2.35	1.90	1.92	4.47	11.12	6.92	2.91	1.82	1.32	.98	.73	.99	37.43
1980	1.59	3.75	19.90	33.52	61.35	23.52	5.71	3.99	2.91	2.22	1.78	2.06	162.30
1981	1.85	1.97	1.62	2.19	1.63	2.27	1.74	1.19	.88	.69	.55	.52	17.10
1982	15.40	7.17	1.97	3.68	2.43	1.68	1.40	1.21	1.06	.92	.81	.73	38.46
1983	1.22	22.78	17.51	41.04	17.28	6.98	5.82	3.47	2.27	1.71	1.89	1.66	123.63
1984	2.59	2.01	2.26	38.95	63.47	22.77	5.45	3.64	2.48	1.70	1.19	.86	147.37
1985	14.29	14.44	18.48	36.85	31.55	12.31	4.88	3.27	2.38	1.81	1.39	1.04	142.69
1986	.87	.85	3.34	3.60	18.59	38.14	14.79	3.78	2.59	1.83	1.77	45.95	136.10
1987	21.48	6.70	5.49	6.06	30.72	14.65	4.55	3.05	2.25	2.39	1.99	1.57	100.90
1988	2.78	2.58	15.76	14.08	60.39	26.08	5.85	3.91	2.77	1.99	1.44	1.03	138.66
1989	.84	40.53	19.64	4.94	3.30	2.60	2.52	2.00	1.50	1.11	.91	.81	80.70
1990	.73	.70	15.17	20.72	49.22	20.16	4.80	3.18	2.24	1.67	1.25	.94	120.78
1991	8.03	5.10	25.88	11.40	11.36	6.24	3.62	2.60	1.79	1.29	.98	.77	79.06
1992	.60	.71	.75	1.06	5.00	4.10	2.09	1.40	1.06	.78	.61	.52	18.68
1993	15.57	9.86	16.78	18.26	14.60	14.55	6.62	2.83	1.96	1.42	1.16	1.03	104.64
1994	.89	.75	1.12	2.64	1.77	1.57	1.34	1.20	1.10	.91	.72	.56	14.57

Runoff – TM15.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	5.25	5.25	6.65	4.77	18.53	16.56	6.80	2.13	.98	.68	.52	5.46	73.59
1921	6.33	96.39	86.15	25.21	8.14	6.62	3.12	1.42	1.78	1.83	3.87	4.30	245.17
1922	7.99	12.71	16.69	18.21	10.39	3.73	.97	.34	.41	.72	.80	.51	73.48
1923	.71	1.08	1.92	11.07	9.54	5.69	3.38	1.93	1.07	.72	.77	1.73	39.61
1924	2.74	12.24	39.00	41.97	38.81	222.66	77.11	4.08	1.56	1.03	.79	1.80	443.79
1925	4.89	6.15	3.04	13.09	7.38	3.52	2.10	1.18	1.70	1.74	1.01	4.45	50.25
1926	8.19	9.49	7.05	4.40	12.35	14.15	6.30	1.56	.57	.72	1.34	1.14	67.27
1927	2.36	2.36	6.95	12.16	7.54	6.23	3.95	1.80	1.01	.71	.64	1.14	46.85
1928	2.32	1.57	1.40	3.30	3.65	15.68	8.94	2.65	2.11	2.94	2.27	5.14	51.98
1929	4.93	12.17	9.63	21.29	12.79	6.10	3.46	1.60	.77	.68	.94	1.42	75.77
1930	2.06	1.48	3.79	49.45	23.05	6.45	3.02	1.15	.57	.66	.67	.42	92.77
1931	.95	1.26	1.87	3.77	51.48	23.40	4.26	3.03	2.80	1.75	.94	.83	96.33
1932	.84	1.21	3.95	2.80	3.09	4.29	2.99	1.31	.64	1.09	1.16	.65	24.02
1933	.55	17.49	24.59	67.71	25.72	6.48	3.86	2.46	1.95	2.24	3.48	2.40	158.91
1934	2.45	4.19	36.00	16.06	5.44	5.73	6.19	3.87	1.69	.96	.66	.57	83.81
1935	.63	.66	1.29	16.20	45.76	24.03	6.40	6.31	5.43	2.38	.97	.62	110.68
1936	1.88	42.19	17.02	10.69	33.37	15.43	3.48	1.07	.55	.50	.46	.61	127.23
1937	.74	.85	18.67	16.38	16.07	8.07	3.40	1.73	2.39	4.30	3.37	1.77	77.74
1938	8.61	6.93	34.79	16.83	31.13	14.22	2.82	2.02	1.74	1.90	1.79	2.08	124.85
1939	2.35	66.32	31.55	8.86	5.62	3.69	2.34	11.83	10.75	5.26	1.95	1.90	152.43
1940	2.49	4.34	34.51	17.19	8.34	7.19	13.11	7.28	2.03	.95	.73	.60	98.76
1941	.97	.97	4.30	38.78	32.65	17.68	6.55	2.14	1.14	.84	1.02	1.83	108.89
1942	2.78	39.70	30.31	87.01	33.11	4.81	24.55	17.76	6.91	14.56	77.30	28.54	367.33
1943	33.20	44.51	19.09	6.42	29.65	13.18	2.09	.60	1.54	1.93	1.12	5.02	158.36
1944	5.77	2.83	2.07	2.06	2.33	28.46	13.24	2.56	1.04	.69	.55	.39	61.98
1945	.32	.26	.19	2.24	2.35	3.55	2.52	1.02	.56	.49	.44	.40	14.33
1946	3.78	23.32	11.11	2.62	19.59	12.32	4.29	1.56	1.68	1.84	1.14	.99	84.25
1947	2.05	21.41	13.54	13.41	8.29	6.05	4.36	2.19	1.02	.68	.52	.69	74.20
1948	3.10	4.16	3.40	25.75	19.97	9.56	6.12	3.31	1.38	.84	.62	.78	78.99
1949	2.51	3.13	22.41	10.99	3.86	3.50	3.44	3.00	1.93	1.11	1.08	.88	57.82
1950	1.41	2.69	11.26	6.56	2.50	2.96	3.12	2.09	1.18	.93	3.95	4.32	42.96
1951	3.11	1.34	9.76	47.75	18.06	3.52	3.31	2.56	1.52	1.95	1.86	.95	95.68
1952	.96	3.40	3.93	7.01	60.59	24.18	4.37	2.27	1.06	.72	2.03	2.04	112.56
1953	1.20	6.11	5.00	2.68	42.06	20.77	5.38	4.30	3.31	1.72	.87	1.66	95.05
1954	11.61	74.75	27.66	84.75	51.85	12.30	3.07	1.28	.69	.56	.47	.38	269.38
1955	1.88	3.83	3.61	1.70	5.30	7.37	3.73	1.85	1.41	.93	.64	.96	33.21
1956	2.20	18.44	87.90	66.97	18.42	6.15	4.46	2.18	1.20	4.65	6.43	66.13	285.12
1957	61.17	16.67	2.15	4.02	6.24	6.42	20.17	10.07	2.22	.89	.59	.80	131.42
1958	1.96	4.73	7.17	5.11	11.66	6.25	2.24	2.90	2.49	1.66	1.18	.83	48.18
1959	2.94	5.69	4.57	5.07	6.76	6.19	6.46	4.06	1.56	.77	.92	1.30	46.28
1960	2.48	6.61	39.14	14.89	2.93	7.05	8.50	6.03	3.10	1.49	.80	1.09	94.10
1961	1.52	3.65	3.45	32.17	19.32	6.69	3.69	2.15	1.03	.66	.95	1.17	76.45
1962	1.04	3.33	18.93	14.13	4.94	11.90	7.73	2.73	2.03	5.84	5.03	1.76	79.39
1963	2.17	5.01	3.47	20.27	10.24	3.44	2.83	1.78	1.54	1.54	1.11	2.03	55.44
1964	29.52	15.24	6.30	16.54	10.50	3.33	1.15	.73	2.21	3.07	2.42	1.99	93.01
1965	2.82	4.80	2.80	36.57	16.20	2.28	1.25	1.58	1.30	.87	1.04	1.11	72.60
1966	1.29	2.13	5.27	59.33	30.05	41.70	19.39	4.77	1.67	.87	.65	.47	167.59
1967	1.08	4.55	5.48	2.94	1.23	2.01	1.70	.87	.55	.49	1.21	1.22	23.33
1968	.75	2.01	6.46	5.89	6.82	50.11	22.23	4.87	2.16	1.42	1.05	.68	104.45
1969	3.95	3.32	3.78	9.83	24.02	10.35	2.29	1.32	1.06	.98	3.39	4.71	68.99
1970	6.12	6.31	3.10	12.21	7.01	4.01	4.18	7.78	4.92	2.71	2.78	1.96	63.09
1971	7.59	6.57	35.67	39.82	29.65	47.68	16.77	2.34	1.52	1.13	.89	.66	190.30
1972	1.86	4.81	3.85	4.15	52.21	20.82	5.36	3.61	1.46	.74	2.62	4.58	106.08
1973	3.24	23.03	10.64	56.64	28.11	7.32	4.62	2.76	1.73	1.53	1.27	.76	141.66
1974	.57	3.94	25.28	24.01	86.41	31.44	5.00	3.19	1.47	.79	.64	9.85	192.58
1975	7.27	5.79	14.01	56.15	67.24	46.66	15.29	5.38	3.07	1.43	.82	.78	223.89
1976	7.55	6.41	9.62	25.90	10.96	9.74	7.16	2.92	1.17	.73	.58	1.70	84.44
1977	6.69	6.26	4.35	91.77	40.54	8.90	5.17	2.47	1.02	.66	1.03	2.68	171.53
1978	26.03	13.87	4.18	3.84	28.72	12.52	2.02	.96	.74	1.99	4.57	6.49	105.95
1979	4.46	2.68	4.00	16.62	12.17	6.87	3.32	1.30	.65	.52	.46	2.42	55.48
1980	3.75	4.85	14.77	47.56	45.47	13.20	2.04	1.10	1.67	1.81	1.90	2.80	140.92
1981	2.52	2.72	1.89	3.54	2.57	4.99	3.77	1.36	.62	.73	.71	1.16	26.59
1982	22.26	11.54	3.16	3.38	2.37	2.21	1.77	1.35	1.13	1.12	1.40	1.06	52.77
1983	2.05	33.06	66.46	143.78	46.26	10.66	8.11	3.49	1.49	1.28	2.36	2.37	321.37
1984	6.56	4.46	2.63	33.02	93.50	30.54	1.43	.38	.30	.34	.37	.53	174.06
1985	10.52	17.46	12.76	61.12	31.64	15.77	9.48	3.09	1.45	1.31	.93	.67	166.20
1986	1.26	1.54	21.03	15.44	14.98	38.63	15.40	2.35	.93	.71	1.82	132.95	247.04
1987	53.83	9.78	6.42	38.29	29.51	13.81	5.63	1.92	1.22	2.33	2.08	1.62	166.43
1988	4.69	5.35	16.07	10.52	58.43	23.10	2.65	1.01	.83	.84	.64	.42	124.54
1989	.96	74.42	50.56	12.40	3.95	3.23	4.70	3.47	1.46	.77	1.25	1.07	158.24
1990	1.37	1.15	5.76	18.12	53.96	20.78	2.85	1.20	1.19	1.15	.79	.82	109.14
1991	5.31	5.14	16.30	10.94	13.22	7.22	3.20	1.63	.75	.54	.62	.56	65.42
1992	.55	1.66	3.95	3.53	5.57	15.37	7.91	2.06	.77	.56	.72	1.02	43.66
1993	48.83	23.49	18.39	13.01	9.00	9.47	6.11	2.33	.86	.71	1.19	1.11	134.50
1994	1.01	.87	2.00	7.11	4.25	3.24	2.49	1.74	1.26	.87	.65	.49	25.99

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	9.30	4.55	2.70	2.57	3.51	16.00	7.40	1.96	1.10	.70	.47	2.04	52.30
1921	2.47	73.73	47.04	10.80	3.40	2.24	1.10	.78	1.41	1.48	2.13	2.06	148.63
1922	2.65	6.71	14.03	7.43	9.08	4.12	.99	.49	.41	.71	.75	.45	47.82
1923	.40	.74	1.25	2.98	6.35	4.18	1.73	.94	.69	.54	.57	1.14	21.51
1924	2.49	29.81	55.53	36.56	12.00	165.61	63.76	5.40	1.61	.93	.67	1.61	375.99
1925	3.34	2.98	1.40	7.67	4.68	2.35	1.38	.84	1.08	1.06	.65	2.78	30.21
1926	6.45	7.55	5.52	4.16	5.64	5.39	2.83	.93	.40	.43	.80	.70	40.78
1927	1.69	1.61	2.98	5.11	3.24	2.52	1.65	.81	.52	.43	.43	1.10	22.07
1928	1.80	1.21	1.46	9.26	5.62	6.96	4.44	1.73	1.55	2.89	2.47	11.50	50.89
1929	6.58	6.08	4.27	9.58	6.12	13.15	6.68	1.87	.77	.57	.62	.92	57.22
1930	1.29	1.04	2.12	15.75	7.59	2.33	1.48	.84	.48	.53	.52	.31	34.28
1931	.75	.70	1.41	2.53	48.98	20.16	2.98	2.20	1.88	1.15	.62	.67	84.04
1932	.65	1.94	3.72	2.05	2.20	5.49	3.43	1.33	.61	.94	.96	.49	23.81
1933	.43	24.92	21.12	81.50	29.17	3.71	3.00	2.57	1.74	1.39	2.07	1.55	173.18
1934	1.82	15.04	32.61	10.92	2.62	3.98	4.03	2.42	1.19	.75	.51	.35	76.23
1935	.27	.40	.64	18.50	41.65	15.28	2.27	3.17	3.05	1.47	.65	.43	87.77
1936	.86	10.07	10.58	5.18	6.59	4.59	1.92	.74	.40	.37	.32	.30	41.92
1937	.37	.76	5.13	7.34	9.82	4.61	2.91	2.08	1.79	3.05	2.56	1.29	41.72
1938	2.11	2.21	8.17	4.85	25.25	11.16	2.15	1.50	1.19	1.06	1.05	1.16	61.87
1939	1.61	21.66	11.06	3.41	2.06	1.92	1.41	3.73	5.54	3.68	1.48	1.43	59.00
1940	1.54	1.87	23.18	10.70	9.90	23.09	17.95	5.81	1.29	.65	.49	.34	96.81
1941	.63	.64	1.32	12.95	35.81	32.95	10.59	2.28	1.04	.70	.80	.96	100.66
1942	1.26	17.93	24.78	46.97	19.35	5.11	58.66	29.19	6.06	13.41	70.55	25.00	318.26
1943	54.64	42.39	14.78	4.52	17.08	8.03	1.56	.56	.89	1.04	.65	2.62	148.77
1944	2.74	1.95	1.45	1.16	1.50	20.84	9.30	1.72	.83	.56	.40	.27	42.70
1945	.19	.22	.44	1.41	3.97	3.17	1.72	.86	.51	.40	.33	.28	13.51
1946	2.46	11.45	5.49	1.54	7.92	11.89	5.61	1.69	1.64	1.70	.95	.81	53.15
1947	1.64	23.27	18.95	25.79	10.65	4.93	4.24	2.32	.98	.55	.40	.36	94.07
1948	1.04	2.09	3.08	16.75	10.94	12.22	7.18	2.97	1.24	.68	.47	.51	59.17
1949	.97	1.85	10.41	4.48	1.06	14.82	7.09	2.18	1.22	.78	.87	.76	46.48
1950	.85	4.18	22.23	9.68	2.89	2.93	2.62	1.58	.85	.60	2.61	3.23	54.26
1951	2.35	.98	2.25	95.58	34.67	4.05	2.88	1.56	.86	1.14	1.19	.75	148.27
1952	1.18	2.05	9.31	5.52	23.78	10.47	2.44	1.28	.68	.51	1.02	.95	59.19
1953	.75	2.63	3.15	2.18	11.69	6.89	3.08	3.07	2.30	1.17	.59	1.19	38.69
1954	7.42	34.41	14.40	65.36	39.36	10.18	3.18	1.45	.76	.51	.37	.27	177.67
1955	.66	1.28	2.88	1.71	3.17	18.25	7.68	1.27	.64	.48	.40	.61	39.04
1956	.78	3.42	82.85	75.17	19.26	4.54	4.36	2.52	1.08	1.85	2.77	70.72	269.32
1957	55.63	13.35	1.98	2.78	7.14	4.30	11.93	5.76	1.27	.60	.42	.46	105.64
1958	.89	2.38	5.83	3.98	20.17	8.37	1.73	2.99	2.67	1.54	.93	.50	51.96
1959	2.26	3.65	3.26	2.65	3.64	9.12	7.03	3.40	1.27	.63	.53	.57	37.99
1960	1.38	3.23	26.55	10.28	2.47	4.08	4.94	3.43	1.67	.87	.59	.80	60.29
1961	.85	1.31	1.67	23.76	21.41	8.60	4.73	2.75	1.12	.59	.67	.64	68.09
1962	.64	2.37	17.68	11.87	4.19	16.32	7.94	1.91	1.09	2.17	1.93	.77	68.88
1963	1.40	4.16	3.03	13.40	6.24	2.46	2.53	1.61	1.14	1.03	.72	1.44	39.14
1964	4.49	5.57	3.50	5.43	6.08	2.07	.58	.55	1.63	2.43	2.63	2.61	37.57
1965	2.42	5.76	3.72	27.50	12.03	1.81	.82	.90	.84	.65	.71	.65	57.81
1966	.71	2.22	3.81	37.94	43.50	28.70	14.75	5.54	1.84	.97	.66	.38	141.00
1967	.63	2.05	4.25	2.74	1.43	1.66	1.44	.80	.45	.38	.63	.61	17.06
1968	.41	.82	1.46	1.64	2.22	25.24	11.66	3.27	1.87	1.07	.69	.54	50.91
1969	2.33	1.87	2.85	3.21	10.50	5.25	1.21	.54	.52	.53	2.00	3.80	34.60
1970	3.62	2.87	1.70	9.67	4.77	1.55	1.25	8.45	4.49	1.80	1.75	1.14	43.05
1971	9.61	6.31	12.55	15.84	6.82	19.32	8.17	1.82	1.20	.82	.63	.41	83.51
1972	.85	3.37	2.73	2.32	10.37	5.81	3.47	2.32	1.00	.56	2.19	3.16	38.16
1973	1.84	2.39	2.74	21.35	17.46	13.95	6.26	2.19	1.20	1.03	.83	.47	71.70
1974	.33	1.77	34.98	37.77	26.47	8.23	2.51	1.62	.83	.51	.41	4.51	119.93
1975	3.66	4.95	13.05	16.97	22.32	49.33	17.52	2.89	1.68	.90	.55	.61	134.42
1976	2.65	3.37	3.48	9.42	4.90	3.28	2.76	1.46	.70	.49	.41	1.01	33.94
1977	5.83	5.99	3.89	42.06	16.37	5.49	4.52	2.37	.95	.52	.60	1.47	90.06
1978	15.47	7.64	16.95	8.18	10.39	5.48	1.93	1.23	.84	1.10	2.17	2.32	73.70
1979	1.64	1.37	1.81	2.85	2.56	1.66	1.20	.84	.53	.42	.34	1.34	16.55
1980	1.61	2.44	34.79	50.01	42.39	11.29	1.06	.58	.67	.75	1.04	1.18	147.81
1981	.82	2.02	1.85	3.72	2.60	1.79	1.17	.58	.40	.58	.56	.60	16.67
1982	6.39	4.51	2.71	5.80	2.52	1.20	1.39	1.22	.87	.88	.99	.69	29.16
1983	.93	3.10	30.96	53.34	16.02	2.55	3.93	2.70	1.21	.88	1.23	1.11	117.97
1984	6.70	3.68	1.60	13.80	43.34	15.31	1.35	.43	.35	.36	.31	.27	87.51
1985	2.57	4.39	4.50	98.89	35.49	22.22	17.07	4.60	1.28	1.02	.83	.59	193.44
1986	8.11	4.73	16.72	13.81	32.77	46.06	14.31	1.33	.60	.54	2.08	128.00	269.05
1987	46.85	4.23	3.49	8.39	26.84	15.52	5.00	1.75	1.30	2.12	1.75	1.06	118.29
1988	2.13	2.04	6.52	4.74	45.79	17.33	1.45	.66	.59	.56	.45	.29	82.54
1989	.60	17.91	55.92	19.06	2.06	2.13	3.27	2.31	.99	.55	.97	.84	106.61
1990	.79	.60	4.43	38.50	19.16	3.97	1.07	.45	.51	.56	.43	.66	71.15
1991	10.74	6.53	14.32	7.85	21.61	9.90	2.56	1.14	.53	.39	.43	.41	76.40
1992	.37	.89	3.90	3.74	4.40	14.96	6.73	1.43	.60	.43	.40	.77	38.63
1993	13.44	8.32	14.80	14.29	6.90	9.34	5.29	1.80	.77	.57	.78	.63	76.94
1994	.52	.50	1.47	15.76	7.12	3.29	2.41	1.19	.71	.55	.44	.44	34.40

Runoff – TM17.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	3.47	2.31	1.03	1.11	3.72	11.79	5.25	1.55	1.12	.68	.46	.79	33.28
1921	.98	28.03	17.89	4.73	2.25	1.56	.80	.49	.67	.71	.84	.75	59.69
1922	1.06	2.56	2.82	3.48	3.50	1.92	.89	.57	.38	.56	.60	.37	18.72
1923	.26	.65	.67	1.76	2.37	2.35	1.69	.75	.51	.38	.37	.75	12.49
1924	1.32	7.58	11.61	9.95	6.20	48.44	27.92	5.29	1.59	1.00	.69	.88	122.46
1925	1.53	1.31	.63	1.05	1.39	1.14	.72	.49	.56	.57	.37	1.60	11.37
1926	3.38	2.85	5.79	4.91	2.44	1.96	1.29	.59	.34	.28	.43	.40	24.66
1927	1.46	1.34	2.70	6.35	3.25	1.38	1.11	.55	.39	.30	.29	.59	19.71
1928	1.26	1.05	1.41	3.13	3.11	4.05	2.76	.93	.91	1.84	1.66	3.67	25.78
1929	2.78	3.64	2.57	5.24	4.20	8.98	5.92	1.38	.72	.52	.43	.42	36.80
1930	.58	.59	.52	1.38	1.28	.67	.91	.77	.40	.50	.50	.28	8.36
1931	.40	.39	.54	2.06	7.53	4.96	1.56	1.10	.91	.57	.35	.35	20.74
1932	.38	2.40	3.94	2.04	2.40	4.95	2.50	.88	.44	.56	.56	.32	21.37
1933	.30	17.91	10.30	27.63	12.75	2.03	1.84	1.66	1.14	.89	1.19	.99	78.64
1934	.97	9.60	13.61	5.61	3.18	3.49	1.86	1.10	.74	.54	.39	.28	41.37
1935	.21	.24	.47	7.24	27.53	11.09	1.42	1.66	1.58	.75	.42	.32	52.92
1936	.50	2.82	2.77	1.11	1.81	1.62	.67	.36	.27	.24	.20	.17	12.55
1937	.18	.47	2.17	3.05	2.12	1.15	1.93	1.74	.82	1.10	1.10	.67	16.51
1938	1.84	1.88	1.88	1.79	16.41	9.52	1.82	1.20	.87	.65	.60	.74	39.21
1939	1.34	4.63	4.75	2.65	1.70	1.92	1.34	2.77	3.60	1.97	.86	.69	28.21
1940	.62	.91	5.01	4.19	12.79	18.69	7.42	1.74	.80	.52	.38	.26	53.34
1941	.51	.53	.59	3.49	6.37	6.55	3.71	1.55	.87	.60	.57	.56	25.89
1942	.67	5.33	6.74	17.81	8.02	2.04	23.73	12.34	2.37	2.36	18.40	8.52	108.32
1943	22.22	14.41	4.21	1.72	4.31	3.29	.95	.54	.55	.53	.37	1.67	54.78
1944	1.87	1.07	.67	.44	.83	5.55	3.94	1.05	.64	.43	.29	.19	16.96
1945	.15	.15	.23	1.35	2.33	2.16	1.30	.65	.38	.28	.23	.16	9.37
1946	.62	1.86	1.79	.91	6.06	5.48	2.56	.96	.94	.96	.56	.45	23.14
1947	1.06	3.49	7.15	6.47	4.03	3.35	2.83	1.38	.68	.42	.30	.23	31.38
1948	.31	.51	1.24	2.85	3.50	8.92	4.68	1.27	.67	.43	.30	.34	25.02
1949	.46	1.67	3.09	1.98	.88	5.70	4.22	1.21	.79	.61	.77	.68	22.07
1950	.49	.44	2.88	3.79	2.27	2.46	2.12	.93	.52	.36	.85	1.23	18.34
1951	1.07	.59	1.41	42.46	18.69	3.44	2.42	.88	.55	.58	.62	.48	73.18
1952	.86	1.35	9.26	5.00	5.52	4.00	1.21	.75	.47	.35	.54	.52	29.83
1953	.59	1.75	2.68	1.74	2.72	2.68	1.35	1.26	.97	.57	.36	.64	17.32
1954	1.55	4.07	4.33	17.87	11.39	5.68	3.20	1.55	.86	.54	.36	.26	51.68
1955	.26	.28	2.28	2.06	2.71	15.38	7.03	.95	.52	.39	.30	.35	32.53
1956	.38	1.19	17.91	18.88	6.97	3.97	3.36	1.57	.80	.73	1.14	20.56	77.46
1957	21.53	6.57	1.48	3.10	3.83	2.27	1.71	1.31	.65	.41	.29	.25	43.39
1958	.39	.96	1.19	1.31	5.42	3.71	1.26	2.55	2.30	1.02	.65	.40	21.17
1959	1.00	2.10	2.73	1.92	2.49	4.62	3.49	1.57	.70	.44	.37	.40	21.82
1960	.66	1.87	12.97	6.25	1.46	2.78	2.71	1.32	.68	.43	.35	.46	31.94
1961	.43	.62	1.13	17.72	12.19	6.15	4.35	2.23	.96	.53	.43	.34	47.08
1962	.38	2.53	3.50	2.84	1.76	2.85	2.70	.98	.60	.64	.54	.31	19.62
1963	.58	2.49	2.32	2.52	2.15	1.49	1.33	.74	.57	.53	.38	1.08	16.19
1964	6.70	5.27	2.08	1.24	.79	.50	.45	.48	1.14	1.50	1.59	1.45	23.19
1965	.89	.72	1.02	13.38	7.37	1.11	.65	.64	.57	.43	.41	.38	27.57
1966	.43	2.28	3.04	16.97	23.67	12.95	6.73	3.36	1.23	.73	.51	.34	72.25
1967	.37	1.54	2.04	1.42	.90	.82	.73	.47	.31	.25	.28	.26	9.40
1968	.25	.45	1.15	1.22	1.33	7.72	5.11	1.79	1.24	.70	.43	.43	21.82
1969	1.36	1.24	1.55	2.01	3.91	2.63	.64	.35	.31	.29	1.27	2.33	17.90
1970	2.06	1.32	.87	2.24	2.11	.82	.58	.79	.75	.68	.85	.62	13.68
1971	.73	1.11	1.21	1.94	2.09	16.31	8.36	1.36	.87	.59	.44	.32	35.32
1972	.54	2.58	2.18	1.30	2.50	2.80	2.34	1.46	.64	.41	1.01	1.77	19.52
1973	1.21	1.44	2.35	15.95	9.17	4.86	3.57	1.66	.95	.77	.61	.38	42.91
1974	.28	.93	4.02	14.11	14.59	5.47	1.52	1.02	.62	.40	.29	2.27	45.52
1975	2.35	2.77	14.38	14.86	14.46	22.46	9.47	1.76	1.17	.74	.50	.42	85.35
1976	1.24	1.48	1.15	3.54	2.53	1.34	1.73	1.17	.54	.35	.27	.43	15.78
1977	2.35	2.55	2.07	6.03	3.92	1.90	2.38	1.54	.66	.39	.35	.73	24.87
1978	1.81	1.93	12.70	8.02	2.57	1.87	1.24	1.09	.89	.67	1.09	1.02	34.87
1979	.63	.48	.75	1.51	1.40	.82	.58	.41	.28	.23	.20	.58	7.87
1980	.63	1.14	15.64	21.66	12.67	4.48	1.14	.67	.56	.51	.74	.78	60.61
1981	.49	1.41	1.33	1.70	1.42	1.67	1.57	.61	.38	.31	.27	.49	11.64
1982	1.76	1.50	.68	1.00	.79	.79	.98	.79	.56	.54	.56	.40	10.35
1983	.63	2.64	3.55	2.31	1.08	1.60	2.09	1.16	.65	.51	.71	.64	17.57
1984	.82	.89	.92	3.41	9.14	5.10	1.09	.53	.39	.33	.25	.20	23.08
1985	1.95	5.15	3.60	2.30	2.15	1.40	.87	.51	.42	.40	.50	.46	19.70
1986	1.09	1.53	1.45	1.59	2.84	5.11	2.72	.71	.40	.34	1.03	37.55	56.35
1987	17.51	1.86	1.19	2.47	20.19	13.28	3.72	1.35	1.29	1.29	.88	.57	65.59
1988	.46	.57	2.36	2.75	3.57	2.71	.91	.50	.39	.33	.27	.17	14.99
1989	.28	2.34	2.77	1.32	.81	.89	1.02	.70	.43	.31	.48	.47	11.81
1990	.41	.35	5.19	27.49	12.47	1.80	.79	.48	.39	.37	.28	.24	50.25
1991	7.66	5.17	22.40	11.53	2.70	2.60	1.59	.93	.51	.34	.29	.22	55.93
1992	.24	.50	4.55	4.45	5.12	3.97	1.61	.79	.48	.34	.26	.28	22.59
1993	7.85	5.50	2.68	2.93	3.08	4.02	2.69	1.09	.60	.44	.42	.32	31.60
1994	.35	.28	1.30	2.28	1.34	1.31	1.18	.54	.36	.29	.23	.18	9.62

Runoff – TM18.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	3.43	2.24	.98	.93	3.76	6.43	3.79	1.34	1.15	.79	.59	.57	26.00
1921	.62	8.25	11.80	4.90	2.06	1.73	1.15	.76	.66	.62	.61	.59	33.75
1922	.74	2.11	2.38	3.53	4.61	2.48	1.09	.78	.58	.48	.45	.38	19.61
1923	.30	.49	.59	1.53	1.97	1.88	1.62	.74	.58	.45	.36	.44	10.97
1924	.77	3.90	8.55	9.00	6.52	20.27	22.06	5.92	2.45	1.69	1.20	.99	83.31
1925	1.22	1.27	.86	.80	1.12	.97	.61	.50	.46	.45	.38	.72	9.34
1926	2.32	2.55	5.08	5.77	2.33	1.76	1.37	.81	.58	.43	.36	.33	23.68
1927	.63	.73	2.54	5.88	4.13	1.33	1.20	.73	.54	.42	.32	.29	18.74
1928	.70	.82	1.11	3.06	3.20	3.81	3.43	1.01	.88	1.27	1.26	1.16	21.72
1929	1.44	3.84	3.75	5.15	5.61	7.58	7.39	1.53	1.06	.77	.57	.44	39.14
1930	.43	.45	.43	.91	.99	.60	.76	.75	.49	.46	.45	.36	7.08
1931	.31	.31	.39	2.22	6.68	5.72	1.57	.98	.79	.61	.46	.37	20.40
1932	.35	2.03	3.67	2.20	1.86	2.25	1.20	.72	.52	.44	.42	.35	16.00
1933	.28	7.02	9.03	11.86	10.99	2.41	2.10	1.77	1.29	.95	1.05	.98	49.71
1934	.81	4.53	10.67	7.41	3.87	4.20	1.79	1.07	.82	.65	.50	.38	36.72
1935	.29	.24	.31	3.87	9.34	6.80	1.74	1.49	1.41	.86	.57	.42	27.34
1936	.41	2.88	3.22	1.02	1.42	1.38	.72	.51	.38	.30	.24	.19	12.66
1937	.16	.22	2.00	3.21	1.92	.96	1.30	1.32	.69	.66	.69	.56	13.69
1938	1.69	1.89	1.99	2.05	9.50	10.30	2.05	1.29	.98	.74	.58	.54	33.60
1939	.80	2.59	4.30	3.01	1.52	1.54	1.22	2.15	2.64	1.38	.79	.62	22.54
1940	.56	.72	4.46	4.93	7.33	11.14	5.92	1.89	1.18	.82	.60	.43	39.97
1941	.43	.44	.50	3.61	6.77	6.59	4.08	1.53	1.02	.76	.62	.53	26.89
1942	.56	3.77	6.76	8.79	6.48	1.90	9.44	10.14	2.48	1.99	7.17	6.94	66.43
1943	8.65	11.92	5.39	2.17	4.62	4.42	1.24	.86	.65	.53	.42	1.07	41.95
1944	1.29	.85	.71	.50	.66	4.33	4.50	1.02	.75	.56	.41	.30	15.87
1945	.22	.18	.18	.87	1.99	2.01	1.18	.68	.50	.38	.28	.21	8.69
1946	.30	1.26	1.54	.77	3.11	4.85	2.59	.95	.77	.70	.54	.43	17.80
1947	.66	3.01	5.62	6.38	4.50	3.42	3.12	1.39	.87	.62	.45	.33	30.37
1948	.29	.33	.74	2.82	3.36	3.63	3.18	1.08	.74	.56	.41	.34	17.48
1949	.33	1.23	2.90	2.31	.92	5.35	5.69	1.35	.98	.75	.68	.64	23.13
1950	.51	.45	3.27	4.32	1.93	2.25	2.12	.89	.63	.47	.50	.63	17.98
1951	.67	.58	.83	11.97	12.83	4.16	3.46	1.29	.91	.70	.59	.50	38.49
1952	.57	.91	4.82	4.96	5.07	5.10	1.30	.97	.71	.51	.44	.42	25.78
1953	.47	1.05	2.37	2.00	3.12	3.44	1.24	.99	.85	.63	.47	.45	17.09
1954	.87	3.75	5.21	7.75	9.44	5.97	3.19	1.64	1.11	.82	.59	.43	40.77
1955	.33	.29	2.23	2.41	2.91	7.96	6.10	1.23	.85	.60	.44	.35	25.71
1956	.32	.76	7.32	11.45	6.00	3.96	3.71	1.59	1.00	.77	.82	6.71	44.41
1957	10.47	5.09	1.67	3.78	4.93	2.65	1.49	1.27	.80	.57	.42	.32	33.46
1958	.29	.62	.99	1.20	4.91	4.86	1.23	2.11	2.05	.91	.67	.52	20.34
1959	.59	1.26	2.50	2.18	2.89	4.93	3.66	1.58	.88	.61	.46	.38	21.92
1960	.44	.99	6.05	5.92	1.39	3.04	3.11	1.32	.80	.58	.44	.38	24.45
1961	.36	.46	.85	7.57	10.68	6.62	4.26	2.00	1.15	.78	.58	.45	35.77
1962	.37	2.29	3.37	2.57	1.76	2.89	2.99	.92	.67	.55	.47	.37	19.22
1963	.38	1.99	2.22	2.09	2.05	1.12	1.14	.75	.57	.49	.40	.65	13.86
1964	5.34	5.94	1.96	1.50	1.05	.73	.57	.50	.81	1.06	1.07	1.02	21.56
1965	.75	.61	.70	6.77	7.23	1.38	.91	.72	.60	.49	.40	.35	20.90
1966	.35	2.58	3.42	8.15	13.66	10.81	7.22	3.89	1.56	1.08	.77	.55	54.04
1967	.44	.93	1.34	1.09	.81	.77	.73	.55	.43	.32	.26	.23	7.90
1968	.21	.31	.74	1.04	1.17	5.68	5.87	1.56	1.18	.81	.59	.47	19.63
1969	.86	.96	1.20	1.57	3.07	2.84	.77	.55	.41	.32	.70	1.48	14.72
1970	1.60	1.07	.74	2.01	2.13	.80	.63	.64	.62	.52	.55	.53	11.85
1971	.58	.82	.98	1.49	1.78	8.11	8.19	1.51	1.11	.82	.61	.45	26.48
1972	.47	2.58	2.69	1.04	2.25	2.44	1.68	1.24	.70	.50	.61	1.13	17.33
1973	1.07	1.03	1.98	7.99	9.18	5.85	4.57	1.86	1.11	.84	.67	.51	36.65
1974	.38	.63	2.70	6.98	8.89	5.04	1.55	1.12	.81	.58	.42	1.77	30.88
1975	1.98	2.19	7.19	11.49	11.81	14.08	9.73	2.38	1.73	1.22	.86	.62	65.27
1976	.90	1.07	.89	2.99	2.98	1.12	1.53	1.24	.67	.47	.35	.34	14.56
1977	1.38	1.72	1.36	5.20	5.13	1.69	1.96	1.49	.79	.54	.41	.45	22.11
1978	1.02	1.43	7.65	8.34	2.43	1.95	1.37	1.07	.97	.71	.85	.87	28.67
1979	.62	.53	.65	1.21	1.30	.86	.66	.51	.39	.29	.23	.36	7.60
1980	.44	.74	6.22	10.90	10.20	5.94	1.64	1.16	.85	.65	.63	.64	40.01
1981	.51	.76	.92	1.34	1.28	1.43	1.51	.70	.50	.39	.30	.42	10.06
1982	1.34	1.36	.59	.84	.83	.74	.87	.71	.55	.48	.45	.40	9.15
1983	.48	2.64	3.93	2.45	1.28	1.64	1.87	1.03	.64	.50	.48	.46	17.39
1984	.56	.66	.69	3.48	8.67	6.40	1.38	.92	.65	.48	.35	.26	24.50
1985	1.66	4.68	3.92	2.04	2.03	1.29	.88	.65	.50	.41	.38	.38	18.83
1986	.69	1.04	1.13	1.30	2.94	4.36	2.62	.83	.58	.43	.65	13.34	29.91
1987	14.26	2.24	1.53	2.51	11.47	13.48	4.91	1.80	1.47	1.28	.98	.74	56.67
1988	.57	.57	2.83	3.31	3.51	3.33	1.02	.71	.54	.42	.32	.25	17.38
1989	.23	1.88	2.32	1.00	.81	.87	.90	.69	.50	.38	.37	.39	10.32
1990	.36	.35	4.64	14.11	11.24	2.42	1.41	.97	.69	.50	.38	.29	37.35
1991	4.06	4.62	12.07	12.55	2.92	2.60	1.44	1.00	.73	.52	.38	.28	43.18
1992	.24	.33	4.24	5.22	4.64	4.45	1.55	.93	.68	.49	.36	.29	23.41
1993	4.80	5.48	2.58	2.98	3.03	4.04	2.86	1.07	.75	.56	.45	.36	28.97
1994	.31	.28	.71	1.56	1.27	.92	.95	.56	.42	.32	.25	.20	7.76

Runoff – TM19.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	36.81	22.62	10.11	13.32	32.05	46.99	26.33	11.35	9.83	4.23	3.03	5.92	222.59
1921	6.83	48.76	73.23	36.71	22.25	17.76	8.07	4.29	5.21	4.87	4.74	4.48	237.20
1922	9.89	24.65	26.73	32.92	39.19	22.32	8.36	5.05	3.29	3.28	3.06	1.94	180.68
1923	1.49	9.80	11.22	19.40	26.42	22.79	16.38	4.77	3.54	2.54	1.97	5.48	125.78
1924	11.49	31.64	57.82	60.79	48.67	107.98	114.68	35.11	12.52	8.62	6.02	8.53	503.88
1925	15.22	14.38	7.04	12.35	19.73	11.54	4.07	3.04	3.20	3.02	1.88	13.16	108.65
1926	27.26	24.79	39.48	45.79	26.20	20.99	14.01	5.01	3.44	2.43	2.36	2.17	213.94
1927	13.21	13.98	24.00	48.80	30.07	15.88	14.84	4.57	3.37	2.42	1.81	1.86	174.81
1928	11.77	12.57	16.88	34.65	32.69	34.08	25.00	6.47	7.93	13.73	10.45	12.07	218.28
1929	17.29	30.01	28.81	37.97	44.10	49.94	42.83	8.56	5.78	4.14	3.02	2.26	274.70
1930	4.45	4.94	4.46	17.04	16.49	5.42	9.52	8.03	2.56	3.66	3.65	1.69	81.91
1931	2.04	2.42	5.94	24.76	49.99	41.01	13.98	6.35	5.13	3.25	2.27	2.28	159.43
1932	2.48	20.69	37.06	20.52	20.80	27.25	12.23	4.60	3.14	3.40	3.21	1.81	157.20
1933	1.61	44.20	62.44	72.89	62.70	20.43	20.01	13.82	7.80	5.42	8.76	7.61	327.71
1934	7.34	34.12	67.95	44.09	30.22	38.20	16.45	6.46	4.77	3.62	2.66	1.97	257.83
1935	1.49	1.54	5.62	32.27	62.12	45.52	14.43	14.85	14.05	4.49	3.04	2.19	201.61
1936	4.14	25.56	28.64	12.55	20.18	16.95	4.81	3.03	2.17	1.65	1.23	.94	121.86
1937	.82	3.71	22.78	34.98	22.16	9.83	16.40	15.51	4.01	5.47	5.46	2.93	144.06
1938	17.76	20.04	21.28	23.48	56.56	62.52	15.68	7.51	5.70	3.88	2.97	4.34	241.72
1939	10.54	25.66	37.58	29.71	19.82	19.75	12.85	18.97	22.94	9.00	4.01	4.37	215.22
1940	4.21	10.26	37.27	40.30	49.82	68.05	38.85	12.57	6.36	4.38	3.09	2.19	277.36
1941	5.36	5.72	7.76	31.87	49.50	46.40	30.26	11.43	5.80	4.07	3.48	3.12	204.76
1942	5.32	29.48	49.75	59.24	43.40	18.18	56.02	58.16	16.32	15.96	43.75	36.47	432.04
1943	49.46	72.85	39.34	21.20	35.68	30.74	7.46	4.84	3.92	3.23	2.22	15.06	285.99
1944	16.79	9.33	8.31	4.79	10.97	34.65	30.35	5.85	4.03	2.89	2.06	1.45	131.48
1945	1.08	.96	1.73	16.36	29.08	24.35	13.05	4.43	3.00	2.13	1.53	1.10	98.79
1946	5.92	19.81	20.78	8.91	26.02	40.77	20.83	5.85	6.81	6.25	2.82	2.34	167.12
1947	9.96	28.99	43.45	47.94	38.82	32.58	26.31	10.84	5.06	3.51	2.45	1.76	251.67
1948	2.16	3.63	14.20	31.44	32.96	33.06	23.97	6.93	4.32	3.06	2.17	2.28	160.17
1949	2.47	16.86	33.41	22.80	11.03	38.02	37.00	8.35	5.65	3.79	4.82	4.59	188.79
1950	2.61	2.88	27.17	40.56	22.68	23.72	19.58	5.61	3.66	2.60	5.99	7.17	164.22
1951	5.57	4.41	14.48	73.76	73.65	33.63	24.64	7.23	5.04	4.24	3.67	2.68	253.00
1952	7.38	15.21	38.32	36.47	37.23	34.85	8.52	5.95	3.73	2.62	3.07	2.95	196.30
1953	5.22	17.30	29.45	20.06	26.47	30.21	10.98	7.63	5.88	3.12	2.19	4.38	162.88
1954	13.30	32.07	41.04	54.62	62.34	44.85	26.31	11.83	6.40	4.36	3.06	2.16	302.34
1955	1.84	1.92	22.77	24.00	25.50	56.08	37.03	7.12	4.86	3.36	2.36	2.03	188.86
1956	2.14	14.11	52.62	71.23	44.80	33.62	29.04	11.95	5.66	4.60	7.50	41.38	318.65
1957	62.45	31.42	15.31	33.82	41.15	22.42	14.50	12.18	4.39	3.06	2.16	1.63	244.49
1958	2.07	11.46	18.57	19.99	39.51	32.19	10.55	20.45	16.84	4.71	3.50	2.60	182.45
1959	8.17	20.16	29.62	23.72	27.28	40.07	30.74	13.84	5.12	3.52	2.56	2.26	207.06
1960	4.90	16.74	46.77	37.52	16.32	30.97	26.10	10.39	4.55	3.17	2.31	2.56	202.31
1961	2.49	6.79	16.47	52.08	67.21	47.32	34.13	16.37	6.40	4.35	3.17	2.42	259.19
1962	2.36	22.23	35.82	30.54	19.16	25.10	25.14	5.85	3.97	3.32	2.75	1.92	178.16
1963	5.26	22.37	22.79	23.00	21.38	14.42	14.14	4.76	3.40	2.84	2.08	10.42	146.85
1964	39.04	42.53	24.34	18.95	10.93	5.12	4.04	3.55	10.41	11.45	8.44	8.64	187.43
1965	4.21	4.72	9.82	46.33	46.32	9.57	5.24	4.54	3.57	2.49	2.14	1.93	140.89
1966	2.40	23.10	35.32	55.99	81.01	66.95	48.69	25.61	8.55	5.87	4.13	2.89	360.51
1967	2.92	15.62	23.31	16.30	10.07	9.47	8.21	3.21	2.19	1.59	1.28	1.14	95.31
1968	1.13	5.42	15.72	18.94	18.21	41.19	37.04	11.36	7.76	4.05	2.83	2.73	166.37
1969	12.93	13.45	17.21	25.77	30.17	22.58	5.11	3.50	2.52	1.89	11.51	20.63	167.28
1970	17.06	10.17	7.17	22.76	22.31	6.23	4.45	5.65	5.07	3.02	3.79	3.19	110.86
1971	7.18	13.13	14.89	22.01	25.18	52.12	46.12	8.82	6.22	4.22	3.05	2.21	205.12
1972	6.13	25.46	22.78	15.61	28.72	26.14	19.20	11.16	4.09	2.88	7.65	15.30	185.12
1973	10.63	14.56	27.62	55.11	60.41	43.61	34.83	15.00	6.42	4.87	3.71	2.71	279.49
1974	2.07	11.77	30.41	51.16	59.69	34.58	10.86	6.94	4.33	3.01	2.11	18.50	235.41
1975	19.96	21.02	52.96	72.09	73.06	81.72	54.03	13.93	10.03	6.14	4.21	3.19	412.35
1976	12.92	15.22	10.93	28.95	24.65	14.30	20.88	11.70	3.82	2.62	1.91	3.14	151.03
1977	16.94	20.80	19.78	43.50	36.50	19.26	23.15	13.22	4.51	3.08	2.29	4.81	207.85
1978	15.83	20.58	50.15	57.18	27.94	21.49	12.17	9.82	8.88	3.95	8.43	8.29	244.70
1979	3.47	3.65	9.95	21.57	18.96	8.80	5.00	2.87	2.06	1.48	1.11	6.18	85.11
1980	6.74	12.60	46.78	68.98	65.59	37.76	9.85	6.58	4.76	3.59	6.08	6.16	275.47
1981	2.72	12.42	15.66	19.28	17.19	17.81	18.31	4.55	3.03	2.20	1.63	6.80	121.60
1982	18.96	14.74	5.79	15.17	13.20	10.54	11.70	4.86	3.02	2.67	2.58	2.02	105.26
1983	6.70	25.89	36.59	28.68	15.45	19.02	21.58	8.01	3.75	2.81	3.19	2.99	174.67
1984	7.48	9.26	9.19	30.69	58.43	39.37	8.23	5.03	3.51	2.51	1.81	1.34	176.85
1985	18.51	40.38	32.62	25.72	25.29	14.13	6.89	4.09	2.93	2.31	2.80	2.72	178.38
1986	11.10	16.82	16.62	21.12	29.74	36.35	20.81	5.17	3.57	2.56	9.77	72.94	246.57
1987	72.06	12.81	9.90	24.51	71.58	78.04	31.95	10.04	10.47	9.32	4.93	3.45	339.05
1988	3.00	6.56	27.09	33.27	32.07	25.37	6.97	4.23	3.09	2.31	1.71	1.23	146.89
1989	1.92	20.28	26.50	14.07	10.30	11.25	10.14	4.22	2.49	1.79	3.16	3.27	109.41
1990	2.21	2.71	34.07	85.93	68.95	20.67	8.18	5.46	3.82	2.78	2.01	1.54	238.34
1991	29.13	35.34	68.75	68.98	25.44	24.48	9.77	5.86	3.81	2.65	1.90	1.40	277.50
1992	1.46	5.35	33.42	43.68	38.94	35.38	14.49	5.64	3.96	2.80	1.97	1.72	188.82
1993	33.14	40.26	26.07	33.02	32.07	35.45	22.68	6.95	4.49	3.21	2.49	1.95	241.77
1994	2.28	2.14	15.62	28.69	16.08	14.03	13.85	3.66	2.63	1.93	1.42	1.06	103.38

Runoff – TM20.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	12.96	12.56	6.87	3.98	14.96	18.73	7.58	4.07	2.85	1.97	1.49	1.98	90.00
1921	3.12	42.39	35.27	12.44	5.63	16.41	8.45	3.46	2.81	2.20	2.19	1.70	136.06
1922	7.01	10.16	17.79	17.39	24.02	15.12	5.74	3.04	2.10	1.46	1.05	.77	105.64
1923	.60	5.89	4.31	16.94	7.75	3.50	2.37	1.55	1.17	.87	.72	1.70	47.38
1924	2.71	18.38	28.97	23.76	11.14	77.85	44.98	12.98	6.80	4.68	3.28	11.34	246.88
1925	11.41	5.11	2.89	33.78	17.58	8.74	4.82	2.77	2.25	1.81	1.35	6.29	98.80
1926	4.36	2.76	8.48	6.79	11.95	11.56	4.81	2.22	1.57	1.14	1.26	1.09	58.00
1927	7.11	3.64	9.98	23.24	11.84	17.40	8.39	3.11	2.23	1.59	1.16	1.10	90.81
1928	4.14	2.52	7.22	12.84	6.39	15.26	8.67	3.42	3.77	4.81	2.97	10.35	82.38
1929	7.62	15.57	7.64	18.33	15.67	23.22	10.44	3.70	2.57	1.81	1.34	1.08	109.00
1930	1.05	1.74	12.13	11.41	6.73	6.66	4.16	2.24	1.51	1.76	1.39	.97	51.75
1931	1.09	1.00	1.39	8.50	30.80	15.34	4.55	3.03	2.29	1.68	1.21	1.66	72.54
1932	1.36	11.98	19.25	7.75	14.55	9.40	3.72	2.33	1.65	2.07	1.57	1.05	76.68
1933	.84	30.06	24.48	37.02	17.05	18.94	12.59	6.70	4.00	3.86	4.31	2.86	162.72
1934	3.30	25.25	27.91	10.85	12.30	10.53	5.30	3.02	2.47	1.97	1.49	1.13	105.52
1935	.86	.76	.87	6.15	19.50	13.47	4.66	3.62	2.47	1.60	1.16	.87	56.01
1936	1.91	16.24	8.71	11.40	17.13	9.30	3.65	2.16	1.55	1.18	.90	.67	74.81
1937	.61	1.57	8.48	20.44	15.96	7.05	8.31	4.45	2.21	2.82	2.15	1.55	75.61
1938	11.54	7.17	32.45	20.23	36.47	20.98	7.31	4.54	3.32	2.41	1.84	2.22	150.49
1939	3.19	14.32	9.11	12.60	10.89	14.63	7.48	7.82	6.06	3.25	2.07	2.52	93.93
1940	2.41	9.89	25.81	20.50	39.05	21.79	7.86	4.48	3.02	2.14	1.57	1.13	139.67
1941	1.70	3.57	3.21	22.50	19.27	20.12	9.73	3.97	2.74	2.03	1.72	1.50	92.06
1942	1.88	17.88	20.97	33.02	18.82	8.06	42.20	23.44	7.38	8.21	19.01	9.04	209.92
1943	45.05	25.71	18.36	11.64	21.07	21.79	8.84	3.65	2.83	2.17	1.58	13.70	176.39
1944	6.92	3.30	2.18	3.78	8.44	20.90	9.15	2.98	2.13	1.52	1.08	.79	63.17
1945	.61	.49	1.27	6.59	8.99	13.19	5.73	2.13	1.52	1.09	.80	.58	42.99
1946	1.06	9.09	6.18	3.27	18.65	14.40	5.35	2.72	2.35	1.96	1.59	1.23	67.84
1947	2.15	12.57	17.15	12.70	11.12	16.26	8.89	3.72	2.43	1.71	1.22	.91	90.83
1948	1.05	1.74	6.21	11.97	14.68	15.88	6.85	2.99	2.27	1.66	1.20	1.22	67.72
1949	1.13	5.98	17.53	8.73	4.73	21.75	14.74	6.10	3.34	2.50	3.12	2.24	91.89
1950	1.56	2.04	13.17	29.02	22.26	9.71	5.27	3.36	2.25	1.60	4.03	3.09	97.36
1951	2.85	1.85	9.64	38.47	26.39	11.60	5.72	3.59	2.62	2.09	1.94	1.64	108.38
1952	2.53	6.75	17.25	8.75	25.36	12.19	4.06	2.92	2.06	1.47	1.51	1.34	86.17
1953	2.07	3.15	9.44	6.55	22.63	11.41	3.91	3.60	2.60	1.81	1.30	1.68	70.16
1954	8.89	9.79	5.90	27.04	21.83	8.57	4.43	3.11	2.26	1.65	1.20	.94	95.62
1955	.95	.98	19.62	8.98	21.08	20.61	7.81	3.28	2.30	1.61	1.17	.97	89.37
1956	1.36	7.74	35.76	46.26	21.63	23.26	12.57	5.26	3.54	2.61	2.84	21.64	184.45
1957	19.82	8.58	7.48	19.79	16.12	6.71	9.05	4.96	2.37	1.70	1.22	.96	98.76
1958	1.10	4.25	24.13	16.05	16.70	10.16	5.12	20.54	9.95	3.34	2.41	1.79	115.55
1959	2.20	4.75	8.46	5.79	13.54	7.73	9.89	5.09	2.21	1.57	1.17	1.08	63.49
1960	1.72	5.30	20.42	9.85	8.62	15.17	8.40	3.45	2.20	1.62	1.24	1.26	79.26
1961	1.12	7.72	10.56	23.49	16.48	16.83	10.85	4.68	2.75	1.93	1.46	1.15	99.04
1962	.95	10.79	15.89	18.52	7.89	23.42	11.21	3.62	2.62	3.20	2.32	1.48	101.91
1963	7.61	10.85	5.51	25.28	12.29	10.30	7.02	3.39	2.62	2.09	1.62	4.99	93.59
1964	17.18	16.31	11.94	15.45	8.20	3.35	2.44	1.90	7.07	4.11	3.50	3.33	94.76
1965	2.28	2.33	2.98	28.50	16.56	4.95	3.06	2.60	2.05	1.55	1.39	1.20	69.46
1966	1.29	11.95	19.27	30.34	38.02	29.53	24.01	10.51	4.66	3.23	2.28	1.60	176.69
1967	1.86	6.58	7.15	12.82	7.55	4.38	2.74	1.88	1.38	1.00	.84	.81	48.99
1968	.84	2.04	8.11	6.98	8.65	29.60	14.24	5.44	3.60	2.53	1.90	1.67	85.60
1969	8.99	5.13	18.73	13.87	9.97	4.84	2.49	1.81	1.36	1.06	8.28	6.72	83.24
1970	6.86	4.03	3.23	4.15	3.34	4.11	2.79	2.61	1.94	1.78	2.85	2.00	39.70
1971	4.63	4.06	3.59	8.06	13.79	26.41	11.21	3.88	2.88	2.08	1.52	1.11	83.22
1972	1.26	10.13	5.08	4.39	23.89	15.88	13.62	6.47	2.84	2.02	2.64	4.66	92.87
1973	2.93	7.83	8.04	26.64	22.75	21.65	11.17	4.71	3.15	2.44	1.88	1.38	114.58
1974	1.17	7.22	9.55	28.40	30.37	12.85	5.73	3.70	2.46	1.72	1.22	9.55	113.93
1975	4.79	8.50	28.20	33.62	33.24	46.20	19.55	6.92	4.90	3.41	2.43	2.36	194.13
1976	9.93	5.20	3.44	13.16	6.36	9.77	6.18	2.72	1.79	1.31	.98	2.27	63.13
1977	3.40	2.78	13.93	22.01	13.65	11.95	13.63	6.21	2.74	1.93	1.42	2.28	95.93
1978	6.46	8.98	29.89	21.19	8.42	4.89	3.32	3.50	2.51	1.99	2.63	2.05	95.83
1979	1.78	1.55	2.14	8.59	8.58	9.42	4.36	2.01	1.45	1.04	.77	3.87	45.55
1980	2.28	6.39	13.99	23.66	39.29	16.49	5.44	3.87	2.76	2.01	2.60	1.94	120.71
1981	1.39	6.80	4.60	5.46	3.18	22.45	10.73	3.22	2.26	1.62	1.18	.92	63.82
1982	1.67	1.38	4.07	3.52	1.83	1.94	1.69	1.32	1.02	1.00	.98	.86	21.27
1983	2.10	14.96	13.33	12.56	6.72	14.47	7.37	2.89	2.07	1.55	1.24	1.03	80.31
1984	2.05	1.42	1.79	18.46	43.01	18.49	5.30	3.45	2.42	1.78	1.30	.96	100.43
1985	14.52	9.62	17.87	31.16	17.72	7.64	5.84	3.58	2.25	1.64	1.71	1.40	114.95
1986	6.05	12.61	21.54	28.43	29.76	26.45	10.89	4.58	3.20	2.31	3.76	50.72	200.30
1987	24.55	9.79	7.79	6.80	35.72	34.36	13.06	5.43	5.00	3.58	2.47	1.86	150.42
1988	4.11	19.94	24.44	18.58	36.49	20.50	6.92	3.93	2.76	1.96	1.40	.98	142.03
1989	.99	34.07	23.66	13.10	6.43	23.08	11.02	3.51	2.42	1.69	1.41	1.19	122.59
1990	1.37	1.15	6.72	35.78	30.54	13.67	5.54	3.19	2.22	1.58	1.14	1.04	103.96
1991	21.22	21.51	15.54	6.67	13.92	7.09	2.84	2.05	1.44	1.02	.74	.57	94.63
1992	.53	.66	1.87	3.98	19.79	16.40	6.09	2.83	1.98	1.40	.99	.73	57.27
1993	3.98	3.14	5.39	29.14	13.97	5.75	3.69	2.43	1.73	1.33	1.10	.87	72.54
1994	1.62	1.11	1.18	15.88	7.27	15.02	9.09	3.37	2.17	1.62	1.22	.91	60.47

Runoff – TM21.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	12.02	11.56	7.31	3.97	12.80	15.56	5.90	3.58	2.20	1.32	.99	1.75	78.96
1921	3.78	30.68	26.37	9.37	4.23	13.52	6.62	2.34	2.06	1.52	1.83	1.24	103.58
1922	6.84	9.66	15.19	14.89	19.18	12.55	4.53	2.14	1.47	1.02	.72	.53	88.72
1923	.42	6.39	5.31	14.46	6.18	4.12	2.26	1.12	.83	.62	.51	1.90	44.12
1924	3.47	15.02	22.51	19.15	10.30	53.82	31.57	8.79	4.21	2.92	2.06	9.93	183.74
1925	9.89	4.30	2.53	25.51	14.61	8.10	3.84	1.96	1.68	1.29	.92	6.28	80.89
1926	4.03	2.33	8.30	7.72	10.86	10.47	4.05	1.62	1.13	.82	1.19	.86	53.38
1927	7.24	3.46	9.61	19.10	10.83	14.46	6.41	2.16	1.55	1.09	.80	.93	77.65
1928	4.84	2.69	7.42	11.88	5.74	12.77	7.29	2.62	3.30	4.52	2.29	8.99	74.33
1929	7.59	13.20	6.31	15.33	13.61	18.35	7.74	2.53	1.76	1.22	.91	.75	89.29
1930	.91	1.76	10.83	10.62	7.50	6.93	3.87	1.72	1.07	1.68	1.12	.64	48.64
1931	1.09	.93	1.54	8.62	23.65	12.81	3.71	2.23	1.61	1.13	.81	1.42	59.54
1932	1.10	10.60	16.28	6.28	12.43	9.19	3.34	1.68	1.17	2.02	1.29	.70	66.07
1933	.64	22.92	19.71	27.86	12.81	15.03	10.86	5.49	2.78	3.33	4.20	2.33	127.97
1934	3.41	19.41	21.71	8.49	10.80	9.53	4.51	2.19	1.91	1.40	1.00	.75	85.12
1935	.58	.68	.90	6.68	16.20	11.43	3.80	3.19	1.93	1.08	.76	.59	47.81
1936	2.42	13.63	8.33	10.62	14.61	8.89	3.20	1.54	1.11	.85	.63	.47	66.29
1937	.54	1.96	8.50	17.09	13.66	6.34	7.31	3.53	1.54	2.49	1.64	1.02	65.62
1938	10.11	7.33	24.62	16.28	27.10	16.20	5.61	3.30	2.26	1.59	1.23	1.79	117.41
1939	3.74	12.37	9.05	11.50	9.92	12.63	6.23	6.86	5.15	2.34	1.34	2.41	83.53
1940	2.23	9.12	20.51	16.80	28.89	16.72	6.11	3.08	1.99	1.41	1.04	.75	108.63
1941	1.71	4.79	4.10	17.97	15.75	16.24	7.68	2.82	1.82	1.36	1.25	1.09	76.59
1942	1.78	14.77	17.41	25.31	15.08	7.58	30.13	16.99	5.11	6.83	14.38	6.36	161.74
1943	32.19	19.34	15.20	10.56	17.03	17.43	6.68	2.50	2.13	1.55	1.08	11.54	137.24
1944	5.74	3.07	1.71	5.19	8.73	16.82	6.95	2.06	1.46	1.03	.73	.52	54.02
1945	.42	.35	1.92	7.35	8.82	11.48	4.65	1.56	1.10	.78	.55	.41	39.39
1946	1.22	8.79	7.13	3.76	15.18	12.40	4.49	1.94	1.91	1.49	1.09	.85	60.24
1947	2.49	11.17	14.82	11.76	10.49	13.85	7.77	2.91	1.67	1.17	.82	.62	79.55
1948	1.06	1.77	6.46	11.13	12.77	13.54	5.58	2.23	1.61	1.14	.82	1.12	59.24
1949	.95	6.30	15.07	7.88	5.45	17.27	11.85	4.89	2.36	1.79	2.76	1.69	78.26
1950	1.03	1.94	11.74	22.76	17.92	8.88	4.57	2.42	1.49	1.05	4.87	3.10	81.77
1951	2.69	1.45	9.42	29.01	20.53	10.10	4.69	2.52	1.77	1.51	1.57	1.19	86.44
1952	2.87	6.85	14.74	8.00	19.64	9.22	3.02	1.99	1.36	.96	1.33	1.05	71.04
1953	1.98	4.09	9.30	7.44	18.12	8.96	3.06	2.98	1.88	1.15	.81	1.62	61.37
1954	8.30	9.13	6.76	21.29	17.46	6.90	3.47	2.19	1.51	1.09	.79	.63	79.53
1955	.82	.92	16.25	7.25	16.98	16.85	6.01	2.26	1.59	1.10	.80	.72	71.56
1956	1.38	7.85	27.07	33.82	16.76	18.11	9.66	3.67	2.30	1.75	2.41	16.62	141.38
1957	15.67	7.27	7.32	16.46	13.77	5.70	8.02	4.01	1.65	1.17	.83	.69	82.56
1958	1.06	5.15	19.38	13.54	14.18	9.71	4.70	15.73	7.23	2.18	1.59	1.18	95.63
1959	2.04	5.33	8.43	6.81	12.16	7.11	8.72	4.07	1.52	1.07	.79	.89	58.94
1960	1.75	5.80	16.89	8.11	8.27	13.08	7.68	2.82	1.51	1.11	.85	1.14	68.99
1961	.86	7.91	10.42	19.11	14.04	14.18	9.42	3.71	1.92	1.34	1.04	.82	84.78
1962	.76	10.00	14.14	15.88	6.63	18.35	8.43	2.47	1.79	2.89	1.79	.95	84.09
1963	7.67	10.27	5.24	19.80	9.59	9.32	6.43	2.60	2.05	1.50	1.08	5.30	80.85
1964	14.00	13.56	10.79	13.46	7.47	2.74	1.98	1.44	6.55	3.48	3.29	2.90	81.65
1965	1.79	2.13	4.00	22.11	13.56	3.94	2.41	2.15	1.46	1.02	1.09	.87	56.54
1966	1.19	10.65	16.29	23.60	28.28	22.37	18.36	7.54	3.05	2.11	1.49	1.05	135.98
1967	1.50	6.61	7.55	11.69	7.83	5.22	2.63	1.39	.97	.70	.61	.60	47.29
1968	.74	3.23	8.52	7.62	8.74	22.58	10.77	4.23	2.51	1.62	1.22	1.28	73.07
1969	8.37	4.72	15.52	12.24	9.19	4.19	1.86	1.31	.99	.76	7.78	7.03	73.96
1970	6.66	3.74	3.71	5.45	3.69	4.94	2.86	2.35	1.45	1.42	2.76	1.54	40.57
1971	5.03	4.69	4.70	8.45	12.42	20.53	8.23	2.90	2.03	1.39	1.02	.75	72.13
1972	1.26	9.48	4.67	5.59	19.00	12.92	11.27	4.93	1.93	1.38	2.53	5.06	80.01
1973	2.75	7.75	8.26	21.02	18.30	17.35	9.60	3.68	2.15	1.68	1.30	.95	94.79
1974	.97	7.58	9.46	22.22	23.33	10.86	4.80	2.62	1.63	1.12	.79	8.85	94.25
1975	4.19	8.31	22.19	25.69	25.13	33.27	13.61	4.74	3.20	2.17	1.55	1.97	146.03
1976	8.95	4.52	4.35	12.11	5.42	9.12	5.47	2.02	1.22	.88	.66	3.14	57.86
1977	4.44	2.78	12.12	18.14	11.76	10.63	11.47	4.80	1.90	1.33	.98	2.49	82.84
1978	6.55	8.77	23.12	17.27	7.98	4.27	2.49	3.06	1.87	1.46	2.10	1.52	80.46
1979	1.40	1.21	2.35	8.57	8.42	8.69	3.71	1.49	1.05	.74	.55	4.87	43.04
1980	2.46	6.48	12.70	19.27	29.19	12.00	3.93	2.61	1.82	1.32	2.49	1.57	95.83
1981	.93	7.01	5.08	6.16	3.30	17.69	8.28	2.23	1.50	1.07	.78	.62	54.65
1982	1.67	1.28	5.00	4.46	1.88	1.96	1.59	.98	.69	.82	.73	.62	21.67
1983	3.10	12.96	12.08	11.64	6.42	12.31	6.00	2.06	1.42	1.05	.86	.73	70.64
1984	2.96	1.55	2.09	15.38	31.59	13.31	3.54	2.19	1.56	1.16	.85	.62	76.79
1985	12.46	9.13	15.12	24.15	14.41	6.94	5.71	2.90	1.52	1.11	1.52	1.07	96.04
1986	6.06	11.23	17.65	22.36	22.92	20.44	8.04	3.09	2.15	1.56	4.27	35.57	155.33
1987	17.90	8.50	7.92	7.52	26.56	25.46	9.57	3.76	3.79	2.45	1.54	1.19	116.16
1988	4.84	16.21	19.51	15.57	27.27	15.92	5.20	2.65	1.87	1.32	.93	.65	111.95
1989	.91	25.50	18.88	11.86	5.62	18.07	8.23	2.36	1.62	1.13	1.09	.87	96.16
1990	1.32	.92	7.16	27.17	23.32	11.47	4.32	2.18	1.51	1.08	.77	.85	82.07
1991	16.75	17.43	13.47	5.71	12.00	5.85	2.06	1.46	1.02	.71	.51	.39	77.35
1992	.43	.68	3.26	5.75	16.25	13.64	5.01	2.01	1.36	.94	.66	.49	50.49
1993	4.70	3.33	5.90	22.64	11.02	5.83	3.20	1.67	1.15	.89	.76	.60	61.68
1994	1.84	1.01	1.34	13.79	5.98	12.60	8.42	2.82	1.50	1.13	.83	.62	51.89

Runoff – TM22.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	8.77	9.35	5.95	3.85	12.25	20.89	8.58	3.43	2.20	1.41	.99	2.08	79.75
1921	4.01	62.38	46.80	12.47	3.83	11.43	5.95	2.18	2.23	1.94	2.35	1.93	157.48
1922	5.23	10.13	16.80	23.53	24.42	11.90	4.08	1.65	.91	.81	.75	.59	100.82
1923	.49	3.54	3.71	13.90	7.00	3.94	2.33	1.25	.87	.67	.71	2.14	40.56
1924	3.85	26.27	34.29	25.74	11.68	132.01	56.98	7.84	2.69	1.79	1.30	5.87	310.32
1925	7.84	4.62	2.47	29.44	14.05	6.25	3.61	1.88	1.81	1.53	.94	4.61	79.04
1926	5.64	4.57	6.89	6.50	9.42	9.29	4.76	1.85	.92	.74	1.51	1.35	53.44
1927	4.92	3.28	6.87	21.64	10.96	14.39	6.73	2.04	1.24	.85	.77	1.25	74.92
1928	3.87	2.87	4.67	9.49	5.95	13.35	8.24	3.34	3.39	5.15	3.45	7.09	70.86
1929	7.41	14.35	6.95	14.85	11.39	33.77	13.91	2.54	1.29	.95	.94	1.09	109.43
1930	1.58	2.22	8.08	8.07	6.01	5.58	4.14	2.15	1.03	1.64	1.46	.73	42.69
1931	1.19	1.17	1.54	5.79	48.52	21.88	4.37	2.72	2.10	1.28	.76	1.41	92.72
1932	1.59	8.80	18.26	7.41	10.52	8.43	3.94	1.73	.94	1.90	1.67	.82	66.00
1933	.77	33.94	24.18	53.94	20.80	14.40	10.22	6.11	3.30	3.04	4.24	3.09	178.03
1934	3.36	23.97	37.95	12.95	7.05	7.72	5.26	3.04	2.92	2.38	1.40	.81	108.81
1935	.63	.79	.98	4.91	36.71	18.60	4.53	3.90	3.12	1.65	.86	.69	77.38
1936	2.17	18.34	9.83	7.45	14.22	8.89	3.17	1.20	.85	.80	.62	.52	68.05
1937	.77	1.95	6.07	19.04	13.90	6.39	6.89	4.32	2.07	3.06	2.72	1.56	68.75
1938	7.81	6.35	30.66	16.21	50.71	22.85	5.17	3.22	2.09	1.49	1.30	2.18	150.06
1939	4.11	14.08	12.32	10.72	8.60	13.01	7.05	11.00	9.08	4.62	1.92	2.38	98.89
1940	2.85	7.34	31.81	18.95	35.91	18.13	6.62	3.21	1.45	1.03	.82	.62	128.74
1941	1.64	3.53	3.19	19.91	16.19	26.26	12.00	3.61	1.94	1.42	1.61	1.65	92.93
1942	2.40	18.13	27.09	33.83	14.99	6.46	70.35	30.64	5.87	6.41	30.97	12.78	259.91
1943	67.19	29.72	13.39	8.10	18.96	18.50	6.41	1.75	1.65	1.49	.95	9.62	177.72
1944	6.26	3.56	1.67	2.96	5.80	25.41	11.00	2.39	1.29	.86	.62	.44	62.26
1945	.42	.30	1.25	5.43	7.93	11.77	5.45	1.70	.93	.68	.52	.40	36.79
1946	1.31	5.73	5.61	4.07	20.45	13.70	5.90	2.69	2.49	2.52	1.56	1.20	67.24
1947	2.58	13.23	16.22	10.71	8.79	18.02	10.27	3.93	1.80	1.00	.68	.60	87.83
1948	1.23	2.08	4.56	8.63	12.28	14.85	7.49	3.16	1.72	1.05	.75	1.16	58.95
1949	1.33	4.24	15.72	8.37	4.55	19.06	11.98	5.46	2.71	1.79	2.87	2.18	80.26
1950	1.31	1.74	9.73	28.18	19.35	8.13	4.55	2.46	1.24	.83	3.89	4.40	85.82
1951	4.07	2.06	6.14	58.03	30.64	9.82	4.81	2.49	1.52	1.47	1.77	1.38	124.21
1952	2.53	5.36	15.47	8.48	30.29	13.09	3.05	1.74	1.05	.77	1.53	1.65	85.02
1953	2.38	3.56	6.37	5.94	21.11	10.51	3.59	3.43	2.51	1.41	.84	1.74	63.39
1954	7.12	8.52	6.13	31.23	20.30	7.21	3.96	2.59	1.59	1.03	.71	.78	91.17
1955	1.24	1.43	16.64	7.33	17.86	23.36	8.76	2.26	1.23	.86	.73	1.00	82.69
1956	1.74	6.20	52.98	61.56	21.14	19.92	10.71	3.67	1.82	1.51	2.44	27.40	211.09
1957	32.50	12.28	5.64	16.50	13.11	5.86	6.74	4.48	1.91	1.04	.69	.83	101.57
1958	1.28	4.33	24.15	14.42	28.62	14.00	5.05	30.65	13.28	2.65	1.63	1.15	141.23
1959	2.10	4.32	6.32	5.36	11.69	7.91	8.67	5.30	1.98	1.01	.87	1.24	56.76
1960	2.20	4.87	22.08	10.64	7.20	13.96	9.58	4.15	1.81	1.19	.99	1.51	80.18
1961	1.55	5.67	7.79	33.50	17.62	14.61	9.85	4.39	1.89	1.02	1.07	.95	99.93
1962	.95	8.63	13.92	16.37	7.03	29.85	13.01	2.55	1.54	3.05	2.56	1.16	100.63
1963	4.84	8.12	4.87	25.86	11.81	6.82	5.90	3.05	2.22	1.93	1.26	3.73	80.41
1964	15.90	13.84	8.64	11.28	6.51	2.35	1.49	1.34	5.32	5.22	4.85	4.22	80.95
1965	2.99	2.72	3.41	26.87	14.20	3.43	1.82	2.07	1.73	1.13	1.34	1.24	62.94
1966	1.52	8.32	16.46	37.91	48.00	32.10	21.89	8.29	2.45	1.52	1.12	.72	180.30
1967	1.47	5.74	6.57	10.53	7.21	4.90	3.13	1.68	.92	.66	.99	1.19	45.00
1968	1.28	2.73	6.49	6.44	7.13	40.60	17.73	5.18	3.16	1.93	1.40	1.46	95.54
1969	6.50	5.48	16.66	10.96	7.44	4.11	1.80	1.14	1.04	.91	5.29	7.41	68.74
1970	7.72	4.80	4.14	5.07	3.98	4.21	3.26	3.26	2.38	2.23	3.53	2.47	47.06
1971	4.10	4.56	4.55	6.93	12.14	38.93	14.82	2.94	1.92	1.29	.94	.63	93.74
1972	1.25	6.29	3.80	4.38	34.00	17.23	11.94	6.26	2.14	1.20	2.44	4.88	95.80
1973	3.68	5.88	6.36	34.92	23.73	20.35	10.79	4.25	2.34	1.86	1.36	.78	116.30
1974	.80	4.69	6.74	26.93	34.68	13.38	4.42	2.33	1.15	.76	.60	6.36	102.84
1975	5.00	6.95	36.66	46.47	41.90	68.07	23.46	3.90	2.34	1.46	1.09	1.69	239.00
1976	6.87	4.78	3.75	10.03	5.30	7.01	6.25	3.06	1.34	.83	.75	2.58	52.55
1977	4.63	3.95	15.93	30.87	14.21	9.10	12.25	6.24	2.16	1.19	.98	2.49	104.00
1978	6.44	8.40	43.67	23.07	7.90	4.83	2.95	3.28	2.45	1.96	2.78	2.38	110.10
1979	1.91	1.43	1.97	5.68	6.60	6.76	3.68	1.58	.87	.63	.55	3.66	35.33
1980	3.19	5.66	12.05	21.67	38.15	14.39	3.26	1.96	1.43	1.14	2.30	2.40	107.60
1981	1.46	4.99	4.44	4.90	3.54	21.61	10.41	2.54	1.27	.89	.70	1.10	57.85
1982	3.31	3.02	4.16	3.69	1.88	2.34	2.42	1.62	1.00	1.26	1.50	1.19	27.38
1983	2.54	18.80	12.57	9.91	6.39	12.23	7.25	2.77	1.49	1.17	1.21	1.05	77.39
1984	2.75	2.22	2.13	22.52	71.45	26.01	3.13	1.31	.93	.84	.65	.58	134.53
1985	11.33	9.89	20.29	30.34	14.07	5.82	4.56	2.40	1.28	.99	1.45	1.27	103.70
1986	4.34	9.56	18.85	25.91	28.02	29.65	10.95	2.63	1.67	1.51	4.09	109.91	247.09
1987	42.68	7.45	5.90	5.51	50.54	44.72	13.36	3.50	3.45	2.80	1.76	1.25	182.93
1988	3.30	17.03	22.45	14.51	37.88	17.46	3.87	1.69	1.17	.93	.69	.48	121.46
1989	1.04	32.96	19.84	8.71	5.54	21.35	10.10	2.55	1.28	.87	1.37	1.41	107.01
1990	1.93	1.73	5.65	41.56	31.26	11.71	3.92	1.68	1.11	.88	.70	1.01	103.15
1991	19.07	18.37	10.71	4.23	9.63	5.96	2.36	1.19	.71	.54	.52	.53	73.80
1992	.92	1.38	2.91	4.02	17.85	14.23	5.95	2.42	1.25	.79	.71	.75	53.19
1993	4.43	4.31	5.96	28.27	12.74	5.83	4.17	2.12	1.11	.97	1.15	.85	71.91
1994	1.76	1.14	1.46	12.41	5.56	10.17	7.19	3.04	2.12	1.75	1.13	.74	48.46

Runoff – TM23.INC

Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	3.98	1.65	.69	.98	4.37	6.27	2.05	.39	.22	.15	.11	.61	21.47
1921	.96	13.69	11.80	3.01	.76	.77	.42	.22	.45	.40	.56	.46	33.50
1922	1.68	5.48	3.87	8.44	4.46	1.22	.44	.16	.08	.15	.16	.11	26.25
1923	.10	.27	.38	1.76	1.37	.90	.42	.21	.14	.09	.12	.52	6.28
1924	.90	8.86	8.41	7.13	4.79	25.65	9.22	.69	.23	.19	.14	.49	66.70
1925	1.10	.74	.42	.66	.70	.95	.55	.23	.30	.26	.13	1.98	8.02
1926	2.60	1.51	2.47	1.48	1.64	3.17	1.24	.22	.09	.09	.36	.30	15.17
1927	.72	.52	4.52	5.66	1.76	1.51	.77	.26	.14	.09	.12	.32	16.39
1928	.68	.49	.45	2.97	1.52	4.02	1.73	.32	.44	.95	.64	.88	15.09
1929	1.82	3.28	1.32	3.79	1.79	10.08	3.81	.34	.14	.12	.17	.28	26.94
1930	.52	.58	.72	2.08	1.05	.65	.62	.32	.12	.28	.26	.11	7.31
1931	.30	.24	.38	2.09	12.89	6.81	1.18	.58	.46	.21	.09	.23	25.46
1932	.32	3.68	5.79	1.82	3.58	1.94	.62	.23	.10	.39	.34	.13	18.94
1933	.17	8.33	6.94	13.18	4.45	2.47	1.59	.90	.44	.39	.63	.46	39.95
1934	.58	5.43	10.64	3.22	1.03	1.98	1.13	.55	.79	.59	.25	.11	26.30
1935	.13	.20	.24	3.68	12.70	6.22	1.06	1.53	.88	.27	.11	.12	27.14
1936	.47	6.99	2.79	.64	4.30	1.96	.38	.12	.09	.10	.08	.10	18.02
1937	.20	.48	2.21	4.56	3.73	1.20	2.74	1.18	.29	.67	.58	.26	18.10
1938	1.46	.95	4.31	2.16	11.55	4.59	.63	.48	.31	.21	.21	.54	27.40
1939	1.04	5.45	6.40	2.34	2.36	2.56	.98	5.90	2.96	.78	.25	.45	31.47
1940	.63	3.97	8.41	2.95	2.08	3.89	1.77	.46	.15	.10	.09	.09	24.59
1941	.40	.52	.36	3.62	4.08	7.64	2.84	.56	.29	.20	.31	.37	21.19
1942	.68	6.01	8.86	6.36	1.95	.97	16.73	6.55	.78	1.51	9.37	3.34	63.11
1943	14.46	7.31	1.53	.74	5.53	2.42	.46	.18	.22	.21	.12	1.93	35.11
1944	1.17	.69	.32	.44	.81	7.62	2.84	.30	.16	.10	.07	.05	14.57
1945	.06	.04	.25	3.92	3.58	1.55	.57	.22	.11	.08	.07	.06	10.51
1946	.34	1.11	.96	1.03	6.42	4.17	1.35	.43	.62	.60	.27	.29	17.59
1947	.63	6.24	5.38	3.17	2.34	5.73	2.49	.61	.24	.11	.07	.08	27.09
1948	.30	.51	.71	1.41	4.16	4.56	1.71	.49	.21	.12	.09	.21	14.48
1949	.28	.62	5.39	2.22	.68	2.45	1.47	.62	.27	.18	.47	.36	15.01
1950	.23	.29	3.18	5.84	2.32	.93	.71	.34	.14	.09	1.82	1.31	17.20
1951	.93	.43	3.18	13.93	7.77	1.98	.63	.28	.15	.19	.23	.17	29.87
1952	.48	.97	4.46	1.99	7.85	2.97	.40	.22	.11	.08	.38	.36	20.27
1953	.53	.62	.83	.99	4.43	1.87	.54	.65	.47	.23	.11	.44	11.71
1954	5.09	2.62	.87	7.78	4.10	1.13	.73	.46	.23	.13	.08	.17	23.39
1955	.35	.43	3.95	1.43	4.76	6.95	2.15	.27	.14	.10	.10	.25	20.88
1956	.42	3.56	12.64	12.42	3.61	4.77	2.09	.41	.16	.19	.41	8.03	48.71
1957	10.59	3.36	.71	3.41	4.67	1.51	2.07	.99	.21	.10	.07	.19	27.88
1958	.26	2.47	5.76	4.99	10.11	3.58	.76	9.20	3.40	.29	.20	.17	41.19
1959	.54	.80	.99	.76	4.45	2.15	4.25	1.65	.19	.10	.14	.28	16.30
1960	.53	1.29	6.32	2.74	3.28	4.15	2.55	.82	.24	.16	.15	.37	22.60
1961	.45	2.20	1.51	10.20	4.96	2.86	1.58	.59	.20	.09	.19	.18	25.01
1962	.23	5.76	3.98	3.57	1.31	8.49	3.26	.32	.17	.71	.59	.20	28.59
1963	.68	1.37	.72	6.80	2.69	.85	.83	.42	.32	.28	.16	.51	15.63
1964	3.21	1.88	.97	.92	.74	.32	.15	.19	2.15	1.34	.88	.77	13.52
1965	.66	.68	.71	5.57	2.44	.37	.19	.34	.29	.16	.25	.23	11.89
1966	.35	1.30	3.23	9.13	10.06	6.96	3.21	.91	.23	.17	.14	.08	35.77
1967	.35	4.44	2.05	3.73	1.68	.75	.55	.26	.11	.08	.27	.32	14.59
1968	.33	.57	3.27	1.67	1.35	9.40	3.68	.81	.48	.29	.21	.25	22.31
1969	3.41	1.77	3.63	1.92	1.02	.56	.23	.18	.19	.15	.69	2.68	16.43
1970	1.98	.85	2.14	2.03	.93	.61	.56	.68	.47	.46	.71	.47	11.89
1971	.70	.91	1.13	3.32	2.51	9.96	3.48	.35	.24	.16	.12	.07	22.95
1972	.29	.78	.48	2.38	9.98	3.83	3.58	1.46	.22	.12	.45	.95	24.52
1973	.73	.90	.89	9.56	6.55	4.70	1.92	.59	.32	.26	.18	.09	26.69
1974	.09	.64	.97	5.01	7.67	2.48	.51	.26	.10	.07	.06	5.13	22.99
1975	2.08	3.09	9.03	11.51	9.77	14.69	4.59	.44	.24	.14	.11	.26	55.95
1976	3.12	1.42	.68	2.80	1.20	3.25	1.71	.46	.16	.09	.12	.50	15.51
1977	1.43	1.02	6.94	9.93	3.09	2.76	4.18	1.42	.22	.13	.14	.60	31.86
1978	3.82	2.80	10.66	7.36	2.50	1.00	.52	.62	.43	.31	.49	.40	30.91
1979	.35	.26	.39	1.23	1.04	.65	.34	.16	.09	.07	.07	1.18	5.83
1980	.81	3.06	3.00	4.80	4.93	1.58	.35	.21	.19	.17	.43	.58	20.11
1981	.32	2.52	1.19	.92	.79	5.18	2.08	.28	.13	.10	.08	.43	14.02
1982	3.44	1.59	.81	.59	.25	.66	.61	.33	.17	.27	.38	.28	9.38
1983	.44	7.62	4.09	3.76	1.65	3.11	1.62	.45	.22	.19	.25	.21	23.61
1984	.71	.66	.52	8.34	17.46	5.61	.40	.10	.06	.07	.07	.10	34.10
1985	3.95	4.96	6.14	5.59	1.90	.70	.41	.16	.15	.15	.18	.16	24.45
1986	.72	.90	2.46	5.34	5.69	7.09	2.31	.29	.27	.29	1.90	27.99	55.25
1987	10.07	1.33	.84	1.10	12.10	10.54	2.60	.35	.44	.44	.28	.17	40.26
1988	.41	.79	5.62	2.45	6.47	2.43	.22	.10	.10	.10	.08	.06	18.83
1989	.31	5.83	3.86	1.12	2.87	4.38	1.71	.40	.17	.10	.37	.37	21.49
1990	.59	.60	4.38	7.98	6.18	2.04	.49	.23	.16	.12	.11	.21	23.09
1991	3.85	1.77	.60	.36	4.13	1.85	.37	.14	.07	.06	.08	.12	13.40
1992	.35	.53	.81	.58	3.22	3.87	1.31	.32	.17	.10	.15	.22	11.63
1993	4.01	1.76	5.10	5.14	1.57	3.29	1.48	.32	.15	.13	.28	.19	23.42
1994	.39	.22	.53	2.10	.78	.45	.59	.38	.56	.47	.23	.12	6.82

Runoff – TM24.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	9.70	6.03	2.73	2.02	10.07	34.64	19.01	2.73	.92	.49	.39	2.53	91.26
1921	3.53	96.71	90.92	28.76	10.51	46.24	26.27	3.00	1.40	1.10	1.65	3.06	313.15
1922	12.84	36.05	30.52	28.73	15.50	3.71	1.00	.29	.27	.51	.55	.34	130.31
1923	.48	.58	.52	21.50	21.85	9.83	4.13	1.67	.65	.39	.40	1.42	63.42
1924	2.12	9.13	17.16	10.69	17.19	102.18	58.10	6.44	1.57	.68	.44	.72	226.42
1925	1.81	3.72	3.19	2.65	2.92	3.10	2.01	.87	.99	1.12	.69	2.93	26.00
1926	4.07	3.96	3.91	4.47	24.63	25.71	9.21	1.47	.40	.61	.87	.61	79.92
1927	1.73	1.96	11.84	10.07	5.29	5.10	3.49	1.42	.56	.35	.43	1.13	43.37
1928	1.77	1.41	1.91	3.55	3.00	35.70	21.56	2.22	.99	1.93	1.81	7.35	83.20
1929	6.93	24.31	16.68	30.62	18.37	3.02	1.63	1.18	.62	.58	.75	.93	105.62
1930	1.02	.71	13.64	49.05	28.36	5.64	2.11	.82	.38	.38	.40	.27	102.78
1931	.38	1.03	1.33	2.68	20.59	17.76	5.82	2.80	2.24	1.22	.57	.43	56.85
1932	.56	1.37	5.38	4.00	1.64	2.73	3.10	1.73	.67	.63	.66	.39	22.86
1933	.30	29.86	30.96	103.01	57.32	7.21	3.57	2.24	1.37	1.28	2.05	1.61	240.78
1934	1.27	7.55	27.74	17.20	21.03	18.19	7.04	2.35	.98	.56	.42	.49	104.82
1935	.70	.60	.76	22.91	26.18	37.43	18.76	16.38	10.54	2.18	.67	.37	137.48
1936	.95	30.40	18.55	49.05	48.16	15.30	2.84	1.17	.52	.33	.27	.42	167.96
1937	.55	.51	24.08	17.18	5.44	3.02	2.11	1.53	1.86	2.46	2.08	1.25	62.07
1938	12.95	9.15	20.45	15.66	35.64	22.54	4.23	1.80	1.34	1.30	1.27	1.04	127.37
1939	1.12	23.11	35.58	17.47	12.09	6.68	1.54	6.40	7.53	4.30	1.67	1.43	118.92
1940	1.61	3.68	20.76	14.60	16.32	12.20	17.62	10.29	1.76	.55	.36	.37	100.12
1941	.71	1.04	2.23	31.36	44.61	19.64	4.33	2.16	1.53	1.07	.85	1.94	111.47
1942	3.42	52.49	44.48	48.60	24.84	9.51	49.24	28.76	3.74	4.89	42.18	24.96	337.11
1943	24.10	27.03	26.87	15.71	46.77	27.26	3.01	.56	1.12	1.52	.90	3.36	178.21
1944	11.86	7.49	1.74	1.00	1.72	17.11	11.76	2.61	.86	.45	.33	.24	57.17
1945	.18	.12	.08	6.79	7.51	22.86	13.36	1.73	.44	.29	.25	.21	53.82
1946	1.48	5.78	4.97	2.51	42.67	27.58	4.94	1.75	1.11	1.12	.77	.50	95.18
1947	.73	12.65	26.99	38.13	19.01	5.91	3.29	1.35	.63	.41	.31	.64	110.05
1948	2.76	3.67	2.64	37.03	42.66	17.24	6.84	4.09	1.46	.54	.34	.47	119.74
1949	2.26	4.64	41.46	26.20	6.07	3.73	4.16	4.09	2.34	1.02	.77	.68	97.42
1950	1.22	1.76	3.67	4.00	4.96	4.73	3.30	1.93	.97	.87	2.31	2.29	32.01
1951	2.38	1.70	3.22	21.87	13.10	2.16	1.34	1.03	.61	1.58	1.84	.92	51.75
1952	.55	8.65	7.40	43.53	59.00	23.79	4.24	1.84	.80	.48	1.91	2.28	154.47
1953	1.49	3.16	3.49	2.58	47.94	35.27	7.56	2.48	1.86	1.14	.57	.95	108.49
1954	3.61	28.97	17.29	20.91	38.99	19.62	3.99	1.44	.59	.38	.32	.26	136.37
1955	1.55	2.53	2.67	2.56	13.20	21.52	9.99	2.38	1.57	.89	.46	.62	59.94
1956	1.71	19.93	53.27	29.99	12.66	21.59	21.01	8.68	2.07	6.78	6.87	10.23	194.79
1957	25.23	13.53	2.25	16.19	23.07	20.54	21.54	10.22	1.81	.56	.34	.77	136.05
1958	2.40	4.11	11.98	8.45	19.51	12.59	3.01	2.15	1.65	1.01	.65	.54	68.05
1959	2.30	18.10	12.85	4.15	6.69	5.24	4.02	3.05	1.35	.57	.61	.80	59.73
1960	1.84	3.73	34.87	20.48	2.55	6.95	7.17	3.94	1.82	.81	.43	.69	85.28
1961	1.10	3.00	3.64	14.35	24.24	11.99	2.53	.94	.42	.29	.49	.79	63.78
1962	.76	1.53	2.21	21.63	13.06	2.64	1.81	1.03	1.22	3.48	3.33	1.33	54.03
1963	1.40	5.17	4.11	10.33	7.78	3.13	2.54	1.72	1.27	1.17	.91	1.12	40.65
1964	30.98	21.74	7.52	18.42	17.60	6.39	1.40	.67	.92	1.28	1.26	1.11	109.29
1965	2.29	3.34	2.63	37.07	23.68	3.33	1.09	1.01	.78	.50	.62	1.07	77.41
1966	1.67	3.23	18.67	91.49	55.05	9.41	3.88	2.20	.92	.45	.32	.27	187.56
1967	.54	2.88	4.93	3.81	1.61	1.68	1.82	1.12	.58	.39	.90	1.00	21.26
1968	.54	1.56	3.70	11.22	8.81	23.27	16.66	5.32	2.15	1.04	.68	.50	75.45
1969	5.92	5.07	3.16	3.92	13.07	8.02	1.81	1.11	.86	.71	1.58	2.16	47.39
1970	4.24	4.46	2.47	31.47	20.43	4.17	3.35	4.58	3.53	1.79	1.37	1.27	83.13
1971	1.87	2.22	26.46	18.46	23.75	51.63	25.07	2.88	.94	.57	.41	.27	154.53
1972	.92	2.85	2.59	2.20	4.67	4.18	4.29	3.29	1.31	.51	2.12	3.96	32.89
1973	3.02	10.31	7.94	15.37	33.52	17.60	4.50	2.54	1.36	1.11	.94	.61	98.82
1974	.51	15.12	34.47	30.73	118.08	65.22	6.11	1.92	.83	.43	.32	7.57	281.31
1975	6.30	4.60	37.40	83.72	51.28	44.75	23.55	5.53	3.05	1.31	.56	.42	262.47
1976	3.36	4.08	4.35	27.82	16.78	4.26	2.85	1.25	.50	.33	.28	.52	66.38
1977	1.63	1.55	12.08	49.10	33.78	10.28	5.01	2.42	.86	.40	.79	1.82	119.72
1978	3.84	4.17	4.68	5.06	8.61	5.25	1.38	.62	.45	.86	2.42	3.71	41.05
1979	2.70	1.83	3.00	34.86	43.90	17.03	2.50	.72	.34	.27	.25	1.30	108.70
1980	2.06	2.26	3.57	5.26	14.11	8.20	1.45	.51	.49	.55	.83	1.91	41.20
1981	2.40	1.85	1.17	3.40	3.17	2.34	1.57	.71	.38	.37	.35	.38	18.09
1982	6.03	4.66	1.55	2.06	1.86	1.60	1.41	1.29	1.09	.81	.81	.66	23.83
1983	2.27	31.41	59.82	54.58	20.55	18.39	11.36	2.20	.78	.74	1.94	2.09	206.13
1984	16.81	11.50	3.11	28.76	73.30	35.29	2.85	.37	.20	.24	.25	.35	173.03
1985	5.89	13.28	11.63	33.08	39.61	16.84	4.33	1.91	.86	.59	.44	.35	128.81
1986	1.21	2.40	4.17	12.63	28.35	15.16	2.98	1.19	.59	.43	1.18	60.86	131.15
1987	50.85	25.91	15.85	8.17	7.23	11.00	6.34	1.58	.77	.73	.55	.43	129.41
1988	2.60	3.20	28.94	21.35	65.35	37.94	3.77	.70	.42	.46	.37	.24	165.34
1989	.96	50.07	51.14	16.38	4.12	14.01	9.56	2.41	.81	.43	.44	.37	150.70
1990	.34	.24	2.00	19.84	43.94	22.43	3.38	.79	.80	.97	.64	.58	95.95
1991	16.63	12.36	53.27	32.00	40.51	23.69	2.89	.78	.36	.27	.77	.86	184.39
1992	.74	1.40	1.98	1.54	37.59	23.41	2.95	.78	.35	.26	.35	.47	71.82
1993	34.17	22.55	5.89	40.66	33.39	10.81	3.84	1.56	.63	.48	.68	.66	155.32
1994	1.43	1.48	4.09	22.06	13.95	7.16	5.13	2.10	.85	.45	.32	.21	59.23

Runoff – TM25.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	20.88	9.89	2.50	2.06	9.65	43.44	24.37	3.23	1.07	.53	.43	3.93	121.98
1921	3.51	144.62	134.49	40.92	13.93	86.29	48.93	4.44	1.67	1.21	1.66	3.60	485.27
1922	19.35	64.00	53.60	33.13	17.99	5.47	1.12	.31	.28	.55	.56	.34	196.70
1923	.49	.92	.92	26.97	26.14	16.07	7.13	1.68	.60	.37	.36	1.81	83.46
1924	2.27	12.30	18.31	11.43	13.84	127.27	73.73	7.27	1.71	.72	.44	.85	270.14
1925	2.05	13.30	8.53	4.87	4.50	4.25	2.69	1.10	1.25	1.24	.70	5.03	49.51
1926	4.59	4.62	5.76	7.06	43.25	33.75	8.55	1.49	.43	.80	1.00	.59	111.89
1927	3.43	3.17	12.54	11.14	5.44	7.40	5.01	1.75	.77	.44	.47	1.26	52.82
1928	1.92	1.66	3.33	6.23	4.24	39.93	24.05	2.56	1.38	2.12	1.70	14.64	103.76
1929	20.19	32.30	26.63	46.58	24.79	3.10	1.54	1.10	.60	.59	.71	.82	158.95
1930	.86	.59	16.24	64.81	39.84	8.01	2.57	1.14	.49	.44	.44	.29	135.72
1931	.43	1.24	1.48	4.10	27.21	25.87	8.73	3.25	2.22	1.07	.52	.41	76.53
1932	.67	1.67	7.57	4.84	6.44	7.63	4.24	1.60	.62	.69	.69	.41	37.07
1933	.40	32.78	52.78	138.01	71.63	9.44	4.01	1.97	1.27	1.41	2.17	1.58	317.45
1934	1.48	13.43	39.40	23.34	17.86	17.24	7.37	2.01	.81	.49	.37	.44	124.24
1935	.70	.61	.92	22.42	22.86	29.06	14.74	23.47	14.69	2.37	.69	.40	132.93
1936	1.21	37.21	22.55	74.32	88.02	30.47	3.15	.80	.35	.24	.21	.41	258.94
1937	.63	.60	55.25	36.06	6.71	2.66	2.39	2.01	2.07	2.22	1.69	1.04	113.33
1938	16.65	11.56	31.39	37.05	77.14	42.56	5.54	1.87	1.32	1.80	2.15	1.57	230.60
1939	1.30	41.58	44.69	22.39	14.04	6.18	1.67	12.16	10.69	4.23	1.55	1.31	161.79
1940	1.34	6.37	32.00	21.76	14.13	13.92	20.20	10.65	1.74	.55	.36	.36	123.38
1941	.70	1.01	3.79	45.35	45.05	16.66	4.76	2.32	1.51	.98	.79	2.25	125.17
1942	4.18	50.49	67.21	57.27	23.23	20.14	64.21	34.33	4.15	8.77	42.21	23.76	399.95
1943	24.18	24.05	31.13	20.43	60.54	35.07	3.75	.68	1.95	2.27	1.12	6.89	212.06
1944	13.32	7.21	1.72	1.06	2.40	23.06	14.61	2.38	.73	.40	.31	.22	67.42
1945	.16	.14	.14	15.71	16.37	34.51	18.77	2.03	.49	.31	.25	.20	89.08
1946	2.95	8.59	5.76	2.39	44.27	29.17	5.58	1.96	1.21	1.30	1.00	.58	104.76
1947	.70	12.04	27.70	39.54	20.19	7.12	3.64	1.32	.65	.41	.30	.86	114.47
1948	4.11	3.99	2.19	55.24	49.05	16.09	8.64	4.78	1.38	.52	.33	.49	146.81
1949	3.73	6.81	35.59	23.28	6.87	8.51	8.64	5.48	2.68	1.18	.84	.69	104.30
1950	1.37	1.81	6.97	5.62	13.99	9.28	2.66	1.45	.85	.82	2.66	2.24	49.72
1951	3.17	2.23	5.97	28.37	15.98	2.19	1.32	1.01	.57	2.56	2.47	.98	66.82
1952	.54	18.75	13.55	32.11	96.22	49.40	6.09	2.04	.83	.47	2.56	2.07	224.63
1953	.97	5.29	4.67	2.67	44.06	38.56	10.68	2.78	1.81	1.02	.51	1.17	114.19
1954	5.80	30.99	17.84	25.88	64.77	33.23	4.63	1.31	.55	.38	.30	.26	185.94
1955	2.60	3.33	3.16	2.49	12.69	40.67	21.22	3.18	1.67	.86	.45	.63	92.95
1956	2.45	35.52	92.59	49.99	14.48	24.90	20.36	6.70	1.51	9.13	8.32	18.87	284.82
1957	33.45	15.64	2.64	42.11	34.67	16.73	19.88	10.08	1.81	.57	.33	.84	178.75
1958	2.96	5.35	25.37	15.67	14.45	8.91	2.36	2.28	1.85	1.05	.60	.53	81.38
1959	4.31	33.99	21.76	4.39	8.24	6.36	5.61	3.79	1.31	.56	.61	.84	91.77
1960	2.63	5.91	54.07	31.06	3.46	8.94	12.53	6.93	2.65	1.30	.63	1.14	131.25
1961	1.72	8.39	6.97	13.22	19.76	9.66	2.16	.79	.35	.26	.50	.85	64.63
1962	.91	2.82	3.36	40.92	24.15	3.88	2.05	.98	1.62	24.15	15.27	2.05	122.16
1963	2.14	8.67	5.73	21.94	14.95	4.07	2.86	1.71	1.16	.94	.73	1.06	65.96
1964	64.86	42.57	11.45	29.16	22.66	6.21	1.33	.68	.96	1.18	1.12	.97	183.15
1965	2.91	6.13	4.10	26.05	16.85	2.60	.94	.81	.59	.41	.60	1.39	63.38
1966	2.34	4.49	26.82	97.25	59.15	10.73	3.44	1.93	.82	.47	.41	.34	208.19
1967	.95	5.72	7.66	4.76	1.82	3.88	3.29	1.27	.54	.36	.92	.94	32.11
1968	.53	2.96	5.80	15.58	11.33	30.58	22.19	6.16	2.07	1.05	.67	.56	99.48
1969	8.58	6.84	8.27	8.52	12.23	6.58	1.42	.86	.65	.64	1.63	2.02	58.24
1970	6.37	5.68	2.53	22.21	14.53	3.50	6.62	7.36	3.85	1.53	1.13	1.12	76.43
1971	2.11	2.78	21.87	22.93	25.98	53.04	26.23	2.95	.97	.54	.38	.26	160.04
1972	.98	4.38	3.53	3.15	22.34	14.69	7.30	4.48	1.33	.52	3.93	5.11	71.74
1973	3.89	10.66	8.25	14.29	30.57	16.44	5.07	2.91	1.43	1.08	.89	.69	96.17
1974	.71	16.78	34.16	41.23	107.18	55.31	5.29	1.65	.70	.38	.30	8.35	272.04
1975	6.52	18.89	34.24	57.04	39.37	38.37	19.85	5.24	2.89	1.16	.52	.40	224.49
1976	6.13	5.33	6.19	24.65	15.08	6.57	3.94	1.22	.46	.32	.27	21.96	92.12
1977	15.68	3.81	11.85	46.61	32.04	10.27	4.45	1.81	.70	.37	.99	2.08	130.66
1978	6.10	5.46	6.18	5.67	8.12	4.48	1.07	.59	.42	.86	3.02	4.19	46.16
1979	2.91	2.09	4.44	45.76	47.56	15.63	1.95	.49	.26	.22	.21	1.70	123.22
1980	2.14	13.93	13.06	14.04	31.33	16.04	2.04	.70	.58	.56	.88	2.19	97.49
1981	2.59	2.73	2.34	17.49	10.75	2.36	1.15	.45	.32	.34	.34	.37	41.23
1982	10.02	6.94	1.67	2.54	1.81	1.24	1.06	1.18	1.11	.81	.87	.72	29.97
1983	6.26	27.05	56.82	94.31	43.94	21.53	12.21	2.12	.97	1.70	3.86	3.08	273.85
1984	13.00	8.58	2.73	20.74	89.95	47.32	3.51	.43	.23	.28	.26	.33	187.36
1985	8.08	14.50	12.62	31.95	42.23	19.59	4.91	1.83	.81	.60	.46	.38	137.96
1986	1.43	2.64	8.84	13.54	21.00	10.83	2.15	.83	.46	.43	1.46	66.71	130.32
1987	56.42	51.23	30.95	20.10	14.38	12.94	6.85	1.47	.82	1.08	.91	.67	197.82
1988	14.39	10.24	23.07	34.21	92.60	48.60	4.35	.96	.85	.88	.58	.30	231.03
1989	1.15	43.34	56.31	22.20	6.49	12.68	8.44	2.57	.91	.45	.47	.40	155.41
1990	.55	.48	8.05	56.18	63.82	29.50	6.93	1.22	1.05	1.02	.59	.56	169.95
1991	16.79	12.68	44.07	26.20	31.46	18.38	2.18	.53	.26	.20	.72	.70	154.17
1992	.66	1.68	2.33	1.91	34.92	22.38	3.90	1.58	.72	.40	.37	.45	71.30
1993	46.55	30.24	8.61	37.76	29.35	21.02	10.47	2.00	.64	.43	.56	.56	188.19
1994	1.90	1.82	7.31	18.11	10.76	9.00	6.38	2.43	1.05	.55	.36	.23	59.90

Runoff – TM26.INC – first and second phase revisions Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	52.15	22.45	5.29	3.02	2.32	30.83	18.35	1.83	.48	.29	.22	.23	137.46
1921	1.83	71.73	71.70	20.91	3.26	2.76	1.63	.74	.72	.66	1.56	1.69	179.19
1922	48.89	59.39	59.59	27.04	4.11	1.01	.24	.16	.20	.38	.44	.28	201.73
1923	.33	.89	2.39	30.75	23.05	12.18	6.44	2.04	.89	.43	.31	1.85	81.55
1924	2.62	22.28	18.21	6.79	4.44	66.34	40.69	6.14	2.48	1.10	.55	.96	172.60
1925	1.88	9.11	5.69	1.67	9.39	7.61	2.43	.92	1.18	1.19	.64	1.93	43.64
1926	2.31	2.59	2.02	1.93	26.06	16.81	3.19	1.17	.43	.71	.81	.45	58.48
1927	20.17	14.75	32.12	18.96	15.17	14.20	5.67	1.88	.86	.44	.32	1.02	125.56
1928	2.77	3.62	22.97	15.38	4.67	26.41	15.72	1.81	.93	1.11	.87	2.65	98.91
1929	13.29	44.58	48.68	37.81	15.05	2.90	1.39	.70	.36	.42	.57	.43	166.18
1930	.19	.35	7.05	47.66	60.79	23.73	4.63	2.43	.87	.80	.83	.42	149.75
1931	.31	.90	1.17	1.36	26.88	33.76	12.67	2.04	1.23	.90	.50	.29	82.01
1932	.69	1.77	7.51	4.63	34.76	21.57	3.50	1.47	.59	.44	.39	.29	77.61
1933	.66	50.54	97.35	85.61	29.75	5.09	3.17	1.94	1.13	1.17	1.93	1.43	279.77
1934	1.04	15.04	26.43	16.39	16.34	25.48	12.02	1.61	.52	.39	.29	.28	115.83
1935	.80	.94	1.01	30.86	19.77	14.67	8.39	22.10	13.76	1.97	.53	.38	115.18
1936	1.79	55.54	33.78	59.45	81.58	31.07	2.50	.37	.17	.14	.14	.52	267.05
1937	15.72	9.91	61.29	37.05	3.81	1.40	2.63	2.18	1.22	1.09	1.01	.74	138.05
1938	16.31	10.57	26.98	24.93	72.63	46.08	7.26	1.56	1.00	2.67	3.77	2.41	216.17
1939	1.43	43.80	44.87	15.61	4.75	3.70	2.32	5.71	5.84	3.04	1.12	.59	132.78
1940	1.01	13.73	9.91	17.55	35.65	17.70	9.35	5.46	1.12	.37	.26	.28	112.39
1941	.53	.94	1.28	40.73	25.73	10.20	7.20	4.73	4.56	2.93	1.37	2.38	102.58
1942	4.38	30.74	73.26	44.05	24.81	18.50	73.04	42.41	4.96	3.32	4.35	3.22	327.04
1943	18.72	11.73	5.75	4.38	71.85	43.16	4.11	.72	2.48	2.99	1.39	2.67	169.95
1944	23.51	14.67	2.36	1.02	4.36	48.32	27.79	2.41	.52	.30	.25	.19	125.70
1945	.14	.35	.31	36.62	29.13	35.44	18.38	1.70	.37	.25	.23	.19	123.11
1946	2.16	12.53	8.69	3.58	18.60	13.12	4.03	1.66	.75	.73	.57	.52	66.94
1947	.63	27.81	42.73	43.15	17.56	7.30	4.60	1.20	.37	.22	.18	.67	146.42
1948	1.65	2.23	2.01	24.90	16.42	8.08	16.54	8.82	1.33	.39	.24	.68	83.29
1949	2.50	11.99	8.58	4.29	4.01	2.76	2.16	2.42	1.91	.99	1.15	1.42	44.18
1950	1.70	1.76	1.36	2.35	2.20	1.10	.56	.56	.50	.35	1.64	1.89	15.97
1951	18.99	11.43	4.30	27.32	16.33	3.06	2.00	1.24	.58	2.10	2.36	1.00	90.71
1952	.58	20.99	13.50	2.67	62.62	38.36	5.26	2.00	.77	.37	.32	.36	147.80
1953	.57	9.32	8.08	3.97	8.95	11.17	5.55	2.68	2.07	1.17	.56	1.67	55.76
1954	7.67	5.95	2.38	30.08	66.60	38.12	7.72	1.42	.48	.33	.30	.26	161.31
1955	1.38	9.49	10.09	4.76	24.11	47.36	21.57	3.10	1.61	.85	.46	1.32	126.10
1956	7.39	20.96	69.55	37.29	12.15	9.65	4.19	1.42	.83	5.35	5.56	38.66	213.00
1957	47.41	17.78	10.01	60.66	34.15	3.32	2.81	2.53	1.04	.38	.24	1.13	181.46
1958	2.68	8.82	30.07	16.67	3.66	2.52	1.86	2.20	1.75	.85	.51	.87	72.46
1959	4.18	39.44	24.04	4.68	6.51	5.09	5.61	3.65	1.04	.38	.44	.89	95.95
1960	2.17	22.63	54.10	26.33	3.66	6.60	17.39	10.24	2.75	1.36	.61	1.81	149.65
1961	2.86	14.30	21.66	10.41	3.04	1.82	1.11	.60	.29	.21	.27	.58	57.15
1962	.95	23.37	25.28	54.45	28.69	3.74	1.99	1.03	1.88	43.75	26.32	2.47	213.92
1963	1.11	24.26	14.51	28.50	17.03	2.26	1.99	1.61	.74	.40	.37	.47	93.25
1964	41.65	26.08	5.06	4.71	3.96	2.16	1.35	.94	.75	.73	.66	.74	88.79
1965	1.34	11.11	7.44	3.14	7.77	4.55	.77	.26	.23	.24	.35	1.27	38.47
1966	2.32	2.35	16.92	57.44	52.96	17.24	2.47	.92	.43	.60	.78	.59	155.02
1967	1.22	12.43	9.62	3.57	1.64	8.52	5.69	1.07	.34	.25	1.00	1.10	46.45
1968	.71	13.38	11.52	15.33	9.12	23.44	15.54	3.74	1.55	.70	.40	.62	96.05
1969	10.02	7.31	14.30	9.66	4.10	2.56	1.06	.51	.44	.53	.93	1.13	52.55
1970	10.24	8.72	3.33	5.41	4.68	2.69	16.46	11.51	2.86	1.01	.47	.64	68.02
1971	2.07	14.81	20.46	25.11	20.49	14.53	6.30	1.69	.89	.50	.30	.19	107.34
1972	.39	6.84	5.29	11.87	31.52	18.16	7.69	4.23	1.16	.42	2.52	4.94	95.03
1973	5.11	10.32	7.57	7.98	12.12	7.57	4.33	3.11	1.73	1.27	.96	.52	62.59
1974	.53	9.60	41.98	50.27	34.73	12.36	2.80	1.51	.72	.37	.25	1.28	156.40
1975	2.52	18.37	32.25	16.28	8.86	13.86	8.48	3.84	2.16	.87	.38	.30	108.17
1976	5.40	4.94	28.17	51.52	28.31	7.52	2.69	.95	.34	.22	.24	.80	131.10
1977	2.75	3.80	8.57	56.92	46.25	12.02	2.28	1.04	.47	.27	.63	1.85	136.85
1978	16.69	12.19	4.48	2.36	1.23	.80	.69	.54	.36	.70	2.21	3.65	45.90
1979	3.24	3.14	2.74	28.23	45.59	19.04	1.82	.39	.22	.19	.19	.74	105.53
1980	1.16	16.47	11.98	20.05	36.94	21.39	5.33	1.54	.84	.63	.78	1.83	118.94
1981	2.55	2.30	2.14	18.28	10.91	1.42	.58	.34	.24	.27	.27	.23	39.53
1982	1.89	1.87	1.16	1.52	1.14	1.20	1.40	1.62	1.39	.91	.96	.76	15.82
1983	9.10	19.04	33.60	89.52	46.31	11.02	5.68	1.36	.65	1.51	3.21	2.72	223.72
1984	2.28	1.96	1.93	12.22	63.41	34.11	2.48	.35	.28	.30	.25	.22	119.79
1985	7.02	8.70	5.12	9.67	15.61	9.20	3.60	1.63	.70	.48	.34	.31	62.38
1986	.84	2.00	29.55	18.79	4.96	3.30	1.55	.57	.37	.45	1.38	26.91	90.67
1987	28.24	36.71	18.62	19.85	12.03	2.88	1.56	.66	.38	.60	.75	.72	123.00
1988	19.05	12.39	11.30	25.46	65.91	33.40	3.24	1.10	1.36	1.31	.74	.32	175.58
1989	.99	32.94	27.60	9.02	4.66	18.10	12.06	2.85	.89	.36	.37	.32	110.16
1990	.71	.72	5.47	46.89	49.00	31.12	10.97	1.36	.75	.67	.43	.33	148.42
1991	12.29	8.51	19.45	11.68	13.44	8.07	1.14	.29	.16	.14	.20	.21	75.58
1992	.57	1.16	13.12	8.85	13.06	9.90	4.21	2.16	.84	.37	.26	.33	54.83
1993	39.93	26.10	4.29	9.55	10.84	24.33	13.46	1.76	.43	.23	.23	.26	131.41
1994	1.53	1.60	2.33	6.14	4.70	3.28	3.20	2.07	.92	.43	.29	.20	26.69

Runoff – TM26.INC – third phase revisions Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	46.22	19.46	3.88	2.16	1.60	27.96	16.69	1.62	.40	.23	.17	.16	120.55
1921	1.00	68.23	69.02	20.15	2.53	1.83	1.17	.57	.49	.46	.95	1.09	167.49
1922	45.23	56.67	58.07	25.59	3.43	.88	.22	.12	.14	.24	.28	.20	191.07
1923	.21	.53	1.40	27.55	20.11	10.05	5.29	1.62	.73	.36	.23	1.04	69.12
1924	1.62	19.43	15.33	5.05	3.08	64.36	38.88	4.98	1.95	.91	.45	.62	156.66
1925	1.17	5.87	3.86	1.20	5.93	5.03	1.83	.73	.79	.81	.47	1.13	28.82
1926	1.45	1.65	1.36	1.26	22.84	14.55	2.52	.94	.36	.46	.54	.32	48.25
1927	15.23	10.98	30.17	17.77	12.38	11.49	4.56	1.51	.69	.36	.24	.61	105.99
1928	1.65	2.31	20.56	13.37	3.40	24.25	14.48	1.60	.67	.75	.61	1.57	85.22
1929	10.23	42.32	47.08	35.95	13.83	2.31	1.05	.54	.28	.28	.38	.29	154.54
1930	.15	.21	2.73	44.02	59.05	22.67	3.58	1.78	.71	.54	.55	.31	136.30
1931	.21	.54	.73	.86	23.48	31.00	11.85	1.71	.92	.66	.39	.22	72.57
1932	.42	1.05	4.17	2.79	31.27	19.21	2.77	1.13	.47	.33	.28	.21	64.10
1933	.40	46.38	94.21	84.04	28.73	3.94	2.24	1.44	.86	.81	1.25	1.00	265.30
1934	.72	11.23	23.35	14.19	13.98	23.63	11.21	1.43	.43	.29	.22	.19	100.87
1935	.47	.59	.64	26.89	16.99	12.20	7.04	18.85	11.69	1.68	.47	.29	97.80
1936	1.03	52.21	31.47	57.07	79.61	30.35	2.35	.34	.14	.12	.11	.32	255.12
1937	11.22	7.23	57.96	34.64	3.26	1.02	1.63	1.46	.87	.77	.72	.54	121.32
1938	12.01	7.88	24.23	21.97	70.73	44.40	6.51	1.24	.73	1.59	2.39	1.71	195.39
1939	1.05	40.45	41.97	14.04	3.47	2.59	1.69	2.58	3.37	2.32	.96	.47	114.96
1940	.66	9.97	7.21	14.79	33.24	16.54	6.91	4.06	.95	.32	.21	.20	95.06
1941	.34	.58	.80	36.89	22.93	7.93	5.40	3.37	3.24	2.22	1.11	1.54	86.35
1942	2.79	28.61	71.43	42.02	22.48	16.37	71.43	41.07	4.29	2.29	2.93	2.33	308.04
1943	15.86	9.91	2.89	2.40	69.38	41.34	3.63	.63	1.28	1.71	.93	1.57	151.53
1944	20.63	12.89	1.93	.75	1.83	46.44	27.26	2.24	.45	.23	.18	.14	114.97
1945	.11	.21	.20	31.66	25.00	33.63	17.67	1.58	.33	.19	.17	.14	110.89
1946	1.16	9.06	6.42	2.52	15.72	10.77	3.02	1.32	.60	.53	.41	.36	51.89
1947	.42	23.87	39.44	41.22	16.60	4.46	2.84	.97	.33	.19	.15	.40	130.89
1948	.99	1.41	1.33	21.73	14.04	5.81	14.19	7.85	1.18	.35	.20	.41	69.49
1949	1.45	8.85	6.39	3.06	2.89	2.06	1.54	1.65	1.36	.76	.78	.95	31.74
1950	1.12	1.17	.93	1.43	1.43	.80	.42	.39	.35	.25	.93	1.17	10.39
1951	15.03	9.16	2.27	25.18	15.31	2.42	1.43	.92	.45	1.21	1.47	.72	75.57
1952	.40	16.57	10.65	1.98	59.47	35.97	4.27	1.55	.63	.31	.24	.25	132.29
1953	.37	5.23	4.92	2.75	6.33	8.60	4.46	1.98	1.51	.91	.45	.99	38.50
1954	4.36	3.75	1.75	26.86	63.92	36.36	6.83	1.22	.41	.25	.22	.19	146.12
1955	.77	5.92	6.75	3.43	21.76	45.32	20.82	2.55	1.19	.66	.37	.79	110.33
1956	3.89	18.37	68.05	36.02	9.75	7.22	3.13	1.16	.64	2.09	3.18	37.42	190.92
1957	46.27	17.03	7.29	58.07	33.04	2.95	1.79	1.67	.78	.32	.19	.64	170.04
1958	1.60	5.82	27.45	15.54	2.76	1.77	1.33	1.47	1.23	.65	.39	.56	60.57
1959	1.95	37.57	22.91	3.60	3.94	3.31	3.23	2.31	.87	.34	.32	.57	80.92
1960	1.32	19.83	51.67	25.26	2.97	3.75	14.59	8.99	2.20	1.09	.51	1.07	133.25
1961	1.79	11.22	18.61	8.96	2.26	1.33	.82	.45	.23	.16	.19	.37	46.39
1962	.59	19.74	21.83	52.35	27.73	3.04	1.42	.78	1.17	40.39	24.31	2.21	195.56
1963	.77	20.97	12.62	25.07	14.92	1.84	1.33	1.09	.56	.31	.26	.32	80.06
1964	37.19	23.01	3.84	3.19	2.85	1.69	1.01	.68	.54	.51	.46	.49	75.46
1965	.84	7.58	5.23	2.14	4.99	3.11	.64	.21	.17	.17	.23	.74	26.05
1966	1.42	1.54	13.52	54.48	51.24	16.34	2.08	.73	.35	.40	.52	.41	143.03
1967	.74	8.78	6.93	2.69	1.29	5.02	3.58	.86	.29	.19	.59	.69	31.65
1968	.48	9.20	7.71	12.76	7.74	21.27	13.68	2.92	1.24	.58	.33	.41	78.32
1969	5.95	4.63	11.42	7.61	2.85	1.83	.83	.40	.32	.36	.59	.74	37.53
1970	6.44	5.72	2.42	2.40	2.53	1.93	13.37	9.23	2.27	.85	.39	.44	47.99
1971	1.24	11.52	17.31	22.52	18.11	12.42	5.32	1.37	.69	.39	.23	.15	91.27
1972	.24	2.66	2.59	8.80	28.84	16.44	6.39	3.61	1.01	.37	1.43	3.12	75.50
1973	3.57	8.37	5.96	5.55	9.56	6.00	3.08	2.26	1.34	.96	.72	.40	47.77
1974	.36	5.53	38.61	48.38	33.15	11.45	2.21	1.14	.57	.29	.19	.73	142.61
1975	1.52	15.04	29.42	14.66	7.33	11.99	7.04	2.85	1.65	.72	.32	.23	92.77
1976	1.66	2.42	25.88	49.23	26.26	6.03	2.06	.78	.28	.18	.18	.48	115.44
1977	1.60	2.39	5.81	54.44	44.20	10.95	1.84	.80	.38	.21	.40	1.11	124.13
1978	13.15	9.45	3.22	1.73	.91	.58	.47	.38	.26	.42	1.27	2.26	34.10
1979	2.19	2.12	1.86	25.20	42.99	18.23	1.66	.34	.18	.15	.14	.43	95.49
1980	.72	12.48	8.97	17.98	34.99	19.51	4.36	1.25	.65	.47	.53	1.13	103.04
1981	1.63	1.55	1.43	14.76	8.93	1.16	.44	.25	.17	.19	.19	.16	30.86
1982	1.03	1.14	.77	.95	.76	.77	.91	1.06	.96	.66	.66	.54	10.21
1983	4.87	15.42	31.64	87.78	44.99	8.82	4.40	1.13	.52	.95	1.99	1.84	204.35
1984	1.56	1.35	1.28	8.80	60.62	33.32	2.36	.31	.19	.20	.17	.15	110.31
1985	2.33	4.79	3.66	7.09	12.92	7.54	2.69	1.27	.57	.37	.26	.22	43.71
1986	.51	1.20	26.29	16.48	3.58	2.34	1.19	.46	.27	.31	.81	23.35	76.79
1987	25.33	35.18	17.64	16.93	10.13	2.17	1.16	.53	.29	.39	.49	.48	110.72
1988	11.82	1.75	11.47	31.20	38.66	10.49	2.07	1.15	3.50	1.12	1.35	.98	115.56
1989	.03	4.25	15.87	4.11	2.08	3.88	2.07	1.52	.13	.28	.95	1.08	36.25
1990	.02	.21	.78	10.12	29.94	29.04	5.27	1.29	.91	.97	.77	1.28	80.60
1991	3.69	2.66	2.64	.95	1.33	1.15	.35	.01	.10	.68	.90	1.46	15.92
1992	.78	1.11	1.71	2.04	6.96	10.57	.98	.05	.13	.67	.90	.95	26.85
1993	27.94	5.95	4.21	12.52	15.32	13.17	5.43	1.11	.67	.67	1.17	.38	88.54
1994	.97	1.45	1.52	1.23	1.82	.56	2.71	.50	.64	.61	.71	.67	13.39

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	12.88	8.69	5.43	4.34	2.97	10.53	8.78	3.22	1.24	.86	.76	1.09	60.79
1921	2.43	262.32	241.50	62.80	6.03	1.86	.97	.92	1.27	1.24	2.31	2.70	586.35
1922	107.30	142.09	109.66	42.67	14.54	7.60	1.77	.52	.41	.69	.80	.55	428.60
1923	.84	1.51	5.71	22.33	17.58	21.68	13.32	3.49	1.45	.82	.55	1.20	90.48
1924	3.15	38.92	25.55	8.61	18.22	307.01	178.54	15.24	3.24	1.52	1.01	1.66	602.67
1925	2.49	3.24	3.53	6.10	5.43	14.48	10.01	3.01	2.72	2.61	1.45	26.45	81.52
1926	18.48	4.99	3.95	2.79	8.02	21.43	12.39	2.31	.68	2.00	2.55	1.54	81.13
1927	2.66	2.42	3.18	4.12	4.12	3.78	2.61	1.35	.69	.49	.76	1.56	27.74
1928	2.47	2.02	5.06	4.57	2.22	37.95	24.33	3.43	2.05	2.90	2.20	4.34	93.54
1929	23.89	20.86	9.19	43.55	27.56	5.04	1.78	.77	.47	.87	1.54	1.77	137.29
1930	1.44	.98	5.37	57.64	35.21	4.56	1.83	1.50	.86	.73	.73	.46	111.31
1931	.41	.92	1.07	.94	39.91	45.44	16.99	6.66	6.32	3.88	1.65	.73	124.92
1932	.44	.26	23.28	16.52	3.87	1.64	1.08	.75	.49	.89	1.09	.73	51.04
1933	.75	21.78	112.82	124.56	44.41	7.11	3.82	2.26	1.35	1.61	2.85	2.45	325.77
1934	2.27	6.75	20.76	13.80	5.91	4.32	3.53	2.53	1.36	.77	.59	.52	63.11
1935	.75	.63	2.45	272.11	164.44	43.83	21.14	55.40	34.26	4.75	1.27	1.38	602.41
1936	2.79	72.62	43.27	23.66	54.27	27.89	3.65	.82	.39	.34	.32	.63	230.65
1937	.93	.98	2.76	4.64	5.09	5.11	6.62	4.79	2.65	2.54	2.07	1.34	39.52
1938	3.49	4.25	111.25	85.61	173.72	108.08	16.65	3.37	1.69	2.38	2.80	1.87	515.16
1939	1.95	17.62	12.38	3.00	3.17	2.77	1.45	18.07	16.39	6.88	2.64	1.40	87.72
1940	1.60	3.44	5.91	4.84	8.14	6.30	6.95	5.48	2.10	.86	.57	.69	46.88
1941	.96	1.08	1.98	75.00	54.05	64.57	34.94	4.00	2.30	2.15	1.45	1.87	244.35
1942	2.96	47.56	34.20	9.86	10.68	34.45	60.49	29.93	5.24	14.94	59.73	33.73	343.77
1943	17.02	34.80	31.02	42.74	64.91	30.60	4.28	.93	5.35	6.39	3.03	3.09	244.16
1944	8.58	6.33	1.82	1.38	8.15	77.99	45.59	4.84	1.22	.68	.50	.41	157.49
1945	.32	.41	.34	2.06	4.22	6.35	4.49	1.73	.71	.49	.43	.60	22.15
1946	2.63	4.98	3.86	2.17	8.19	8.26	4.16	1.73	1.42	1.90	1.52	.80	41.62
1947	.91	48.86	40.51	11.59	42.08	28.90	6.34	1.87	.81	.59	.46	1.01	183.93
1948	3.33	4.24	2.74	25.96	36.99	17.06	10.11	7.06	2.41	.89	.55	.73	112.07
1949	3.95	5.09	8.44	6.69	3.60	2.92	2.85	2.57	1.86	1.17	1.03	.80	40.97
1950	1.10	2.53	3.73	2.89	1.62	2.03	3.12	2.73	1.55	.87	3.69	4.78	30.64
1951	4.62	2.77	7.81	47.47	27.77	4.65	3.31	2.46	1.26	2.18	2.51	1.25	108.06
1952	.46	5.52	6.44	3.33	89.72	54.35	6.43	2.38	1.14	.71	.93	1.03	172.44
1953	.96	6.67	5.80	2.34	47.46	29.91	4.03	1.62	1.40	1.08	.69	1.23	103.19
1954	5.55	43.20	25.97	106.87	148.90	58.03	6.32	1.53	.68	.54	.48	.38	398.45
1955	3.02	5.16	4.59	2.38	38.41	32.66	9.72	3.88	2.84	1.56	.77	.96	105.95
1956	4.50	13.08	83.47	50.02	8.54	7.57	15.89	10.73	3.80	23.03	17.10	71.81	309.54
1957	119.87	50.56	4.37	2.37	3.48	3.03	11.76	9.14	2.72	.99	.64	.76	209.69
1958	2.55	7.37	11.31	8.76	7.22	4.64	2.01	2.05	2.02	1.26	.77	.89	50.85
1959	3.98	10.36	8.86	3.71	3.53	4.09	4.30	3.86	2.33	1.15	.97	1.80	48.94
1960	4.16	29.74	165.19	89.18	15.22	9.44	7.64	6.21	3.67	2.07	1.07	1.70	335.29
1961	2.69	5.31	4.77	22.10	19.66	7.50	2.48	.98	.58	.46	.82	1.44	68.79
1962	2.43	27.19	53.72	37.59	11.37	3.18	2.50	1.60	2.16	108.57	65.97	6.20	322.48
1963	3.41	11.16	7.37	12.74	10.25	3.92	1.70	.82	.75	.87	.86	.76	54.61
1964	66.14	42.30	8.57	40.65	26.16	4.69	1.33	.64	1.02	1.53	1.79	1.83	196.65
1965	3.31	6.31	4.51	11.77	12.67	5.61	1.72	1.05	.92	.80	1.06	2.35	52.08
1966	3.28	2.66	3.26	69.91	53.37	15.03	5.30	1.90	.77	.62	.59	.45	157.14
1967	1.35	16.18	13.88	6.56	3.08	2.39	1.94	.90	.45	.38	1.01	1.16	49.28
1968	.75	2.40	7.18	9.54	6.39	11.80	10.07	4.50	1.89	1.07	.83	.83	57.25
1969	11.00	9.47	5.15	4.99	5.99	4.23	1.97	1.18	.96	.97	1.56	2.34	49.81
1970	5.63	6.14	3.92	9.83	7.32	2.36	3.16	4.92	3.67	1.88	1.28	1.15	51.26
1971	2.93	3.71	7.20	11.94	31.46	20.57	5.61	2.43	1.71	1.24	.77	.46	90.03
1972	.68	2.27	2.56	2.53	32.27	21.58	6.60	4.11	1.78	.80	3.06	5.37	83.61
1973	4.14	3.76	3.96	9.05	8.93	6.63	5.66	3.83	2.27	2.05	1.71	.93	52.92
1974	.82	12.71	81.95	81.69	69.28	30.70	8.12	5.21	2.23	.97	.63	3.39	297.70
1975	4.19	7.65	18.49	26.36	17.55	20.17	13.89	6.72	3.93	1.78	.83	.66	122.22
1976	6.46	7.60	40.26	69.50	32.03	7.10	3.94	1.56	.61	.45	.42	1.15	171.08
1977	3.22	6.09	7.95	77.50	58.46	13.57	3.89	2.41	1.26	.70	1.20	2.63	178.88
1978	13.32	17.60	9.53	5.50	5.78	3.78	1.85	1.22	.97	1.20	3.68	6.89	71.32
1979	5.79	4.06	3.47	43.97	33.32	8.50	2.12	.65	.42	.38	.37	1.10	104.15
1980	1.56	6.65	16.47	86.30	55.19	12.68	5.48	2.56	1.56	1.24	1.45	3.41	194.55
1981	3.74	2.28	1.51	7.85	6.80	4.10	2.65	1.15	.56	.52	.51	.57	32.24
1982	3.16	3.16	1.88	2.78	2.27	1.96	2.19	2.93	2.71	1.71	1.59	1.28	27.62
1983	2.11	56.98	60.86	264.17	147.77	16.03	6.60	2.83	1.45	2.00	3.76	3.97	568.53
1984	3.96	3.22	1.90	3.03	89.06	53.06	4.51	.68	.37	.37	.36	.44	160.96
1985	36.25	27.47	11.23	52.97	49.56	19.91	7.15	2.79	1.34	1.08	.80	.62	211.17
1986	1.01	2.26	41.79	52.26	21.51	6.71	4.45	2.17	1.00	.73	2.03	107.07	242.99
1987	77.64	34.72	18.97	30.40	18.03	3.58	1.78	1.13	1.26	2.10	2.09	1.41	193.11
1988	3.58	5.68	70.17	44.10	48.85	28.96	4.45	1.47	1.26	1.28	.90	.52	211.22
1989	1.85	65.63	43.29	8.03	4.54	5.35	7.61	5.36	2.02	.86	.79	.65	145.98
1990	.72	.66	1.76	36.36	88.72	44.87	5.93	1.53	1.18	1.17	.83	.66	184.39
1991	6.53	6.18	36.15	24.07	9.12	5.21	1.73	.69	.42	.37	.45	.49	91.41
1992	.61	1.51	3.91	4.04	12.27	9.71	3.40	1.21	.56	.42	.51	.64	38.79
1993	47.98	31.85	6.47	9.26	17.84	13.24	5.79	2.27	.85	.59	.73	.66	137.53
1994	1.83	1.94	2.87	7.50	5.44	3.22	2.78	1.82	1.04	.66	.49	.35	29.94

Runoff – TM28.INC Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	15.02	12.18	25.97	17.35	27.98	27.96	12.45	4.07	1.68	1.15	.93	5.73	152.47
1921	7.43	211.88	253.06	90.05	14.47	7.52	3.62	1.93	2.53	2.74	5.17	6.08	606.48
1922	69.35	106.15	88.28	39.69	19.72	10.13	2.48	.72	.60	.99	1.16	.84	340.10
1923	1.19	2.40	5.30	25.31	23.27	22.54	13.16	4.23	2.01	1.20	1.03	2.08	103.74
1924	4.40	16.95	24.20	30.55	49.49	320.84	181.46	16.63	3.49	1.67	1.21	2.29	653.18
1925	4.95	5.39	4.56	4.82	4.13	3.84	3.00	2.15	3.17	3.37	2.01	7.09	48.49
1926	11.30	14.36	10.72	6.53	33.60	48.25	21.73	3.70	1.05	1.65	2.21	1.61	156.70
1927	3.52	3.84	7.45	28.62	18.62	6.11	3.54	1.79	.97	.75	.97	2.59	78.76
1928	4.97	3.96	6.28	6.68	4.82	54.81	35.52	5.75	2.99	3.84	3.17	6.78	139.57
1929	17.27	31.06	19.47	26.78	18.67	7.97	5.67	3.33	1.56	1.33	1.72	2.35	137.19
1930	2.97	2.30	20.61	100.06	57.47	8.24	2.72	1.41	.85	.86	.91	.63	199.03
1931	1.22	1.89	1.94	2.08	109.48	93.49	25.19	7.78	6.05	3.64	1.74	1.06	255.55
1932	.95	1.34	13.69	10.86	5.00	4.16	3.03	1.68	.90	1.54	1.85	1.17	46.17
1933	1.08	39.13	89.44	163.84	79.93	13.59	7.02	4.05	2.56	2.81	4.91	4.14	412.51
1934	2.91	7.81	101.95	62.40	11.56	7.96	7.79	5.73	2.85	1.49	1.02	.92	214.38
1935	1.05	1.09	3.64	161.43	140.58	70.07	26.58	28.09	19.27	4.97	1.76	1.27	459.79
1936	2.88	101.39	61.37	62.38	74.83	31.70	6.88	2.15	.93	.74	.68	.89	346.81
1937	1.19	1.59	40.42	31.72	23.31	15.44	8.08	4.95	4.60	7.06	6.00	3.08	147.44
1938	14.19	12.43	107.06	84.23	161.59	96.20	13.95	4.02	2.64	3.05	3.26	2.90	505.52
1939	3.36	75.45	55.69	14.08	6.68	4.65	3.39	32.83	28.78	11.81	4.56	3.36	244.64
1940	4.43	6.40	69.51	45.24	17.47	12.42	26.49	17.53	4.14	1.52	1.00	1.05	207.22
1941	1.64	2.87	4.62	133.65	107.58	55.63	23.54	4.06	2.30	2.06	1.78	3.24	342.97
1942	5.39	61.16	79.86	62.51	27.88	13.79	42.71	29.91	9.27	15.37	94.78	55.88	498.50
1943	55.94	73.13	46.13	34.43	70.52	38.37	5.75	1.48	3.77	5.10	2.95	5.68	343.24
1944	10.02	6.91	3.80	4.61	7.17	71.77	44.71	6.60	2.01	1.09	.81	.62	160.13
1945	.51	.44	.29	2.91	4.28	5.97	5.01	2.35	1.04	.75	.66	.68	24.89
1946	4.49	10.61	9.23	5.32	27.34	21.20	7.23	2.90	2.29	2.60	1.88	1.36	96.45
1947	2.44	72.11	66.13	30.37	31.33	21.59	9.41	4.10	1.75	1.07	.82	1.16	242.27
1948	5.40	8.36	6.74	56.86	62.97	28.55	13.12	7.19	2.82	1.35	.95	1.21	195.52
1949	5.42	7.56	44.46	28.56	6.80	6.08	6.64	5.72	3.71	2.04	1.65	1.35	119.99
1950	1.78	5.22	32.77	21.73	5.41	7.05	7.24	4.32	2.26	1.43	5.36	7.42	101.97
1951	7.39	4.34	10.44	59.10	34.96	6.55	4.19	2.89	1.74	2.61	2.89	1.60	138.69
1952	1.28	5.05	8.83	11.39	146.93	87.56	10.74	3.99	1.85	1.15	1.99	2.24	282.99
1953	1.71	6.98	6.77	3.62	42.20	30.41	8.09	5.11	4.12	2.50	1.39	2.40	115.30
1954	18.22	77.87	43.61	99.88	151.18	64.35	9.06	2.80	1.29	.90	.76	.62	470.54
1955	3.43	7.17	7.87	4.74	85.83	64.58	14.39	4.27	2.86	1.76	1.06	1.52	199.49
1956	4.99	56.22	164.21	91.87	18.67	15.62	15.64	8.88	3.73	10.61	11.83	110.99	513.27
1957	143.49	54.10	5.90	6.97	9.29	7.27	10.06	8.58	3.61	1.41	.91	1.13	252.73
1958	3.79	12.39	16.73	11.00	11.28	8.54	3.84	3.33	3.04	2.21	1.68	1.54	79.37
1959	4.24	8.24	14.22	9.92	7.19	7.00	7.25	5.56	2.73	1.33	1.14	1.92	70.74
1960	4.47	20.86	159.60	90.03	13.13	9.36	9.97	8.85	5.49	2.89	1.49	2.15	328.28
1961	3.25	5.94	5.67	7.63	9.83	8.01	5.22	3.01	1.58	.99	1.18	1.50	53.79
1962	2.15	14.56	57.83	39.14	9.33	5.51	6.38	4.25	3.48	76.12	48.63	6.44	273.82
1963	4.22	16.83	11.67	24.05	17.01	5.11	3.07	2.11	1.76	1.77	1.55	2.11	91.25
1964	90.12	59.49	14.64	29.54	19.95	5.57	1.90	1.01	2.05	3.24	3.29	3.04	233.84
1965	4.50	6.85	5.31	52.51	39.57	9.64	2.77	2.02	1.81	1.33	1.53	1.98	129.81
1966	2.29	2.85	10.36	49.86	70.34	42.98	15.48	5.27	2.06	1.19	.98	.77	204.43
1967	2.72	14.34	14.30	8.74	4.48	4.10	3.53	1.78	.92	.76	1.69	1.98	59.33
1968	1.36	2.75	8.32	9.68	8.39	61.80	40.76	8.77	3.46	1.94	1.35	1.26	149.84
1969	11.00	9.72	6.67	20.44	23.23	11.62	4.05	2.08	1.53	1.41	3.87	6.64	102.25
1970	10.54	11.06	7.44	20.38	14.24	4.47	5.02	9.10	7.75	4.26	3.07	2.28	99.61
1971	6.78	8.87	40.75	39.76	43.19	44.23	18.57	4.43	2.91	2.15	1.47	.96	214.05
1972	2.04	6.24	6.90	6.32	78.47	49.66	11.41	6.65	2.84	1.28	3.55	6.49	181.85
1973	5.08	7.42	7.03	54.32	37.02	9.75	6.60	4.59	2.95	2.71	2.42	1.48	141.39
1974	1.31	14.13	96.71	88.27	76.28	37.07	12.36	8.03	3.37	1.47	.98	8.18	348.17
1975	8.38	7.88	22.08	40.04	28.61	25.18	16.80	8.76	5.29	2.53	1.28	1.14	167.96
1976	9.67	9.96	29.72	47.51	24.60	11.54	7.70	2.99	1.16	.80	.74	2.40	148.79
1977	6.61	7.75	6.33	94.16	70.25	17.18	6.17	3.46	1.80	1.10	1.48	3.17	219.48
1978	31.63	24.31	8.95	7.72	10.32	7.57	3.45	1.81	1.20	1.74	5.35	9.38	113.45
1979	7.71	4.43	4.23	28.59	21.38	6.81	2.78	1.26	.81	.69	.65	2.52	81.87
1980	3.89	5.06	19.23	70.17	42.17	8.24	2.80	1.64	2.22	2.54	2.73	4.61	165.30
1981	4.75	4.88	3.46	4.57	5.00	9.13	7.61	3.11	1.24	1.03	.98	1.35	47.12
1982	15.46	12.65	5.30	4.64	3.34	2.98	2.83	2.67	2.29	2.03	2.51	2.01	58.71
1983	2.70	130.63	130.15	411.28	226.29	41.87	22.30	6.98	2.78	2.63	4.55	4.55	986.72
1984	6.90	10.19	7.31	6.73	187.40	110.70	8.76	1.19	.57	.57	.62	.81	341.76
1985	33.37	28.83	12.38	37.82	30.54	13.18	7.15	3.35	1.83	1.55	1.23	1.03	172.26
1986	1.71	2.63	31.56	39.65	20.01	17.55	12.10	4.21	1.85	1.43	2.72	216.89	352.32
1987	138.99	26.66	27.23	47.92	41.07	18.52	6.90	2.76	1.83	2.90	2.92	2.25	319.93
1988	5.89	9.05	68.51	42.75	80.70	49.67	7.35	1.97	1.32	1.36	1.06	.71	270.33
1989	2.00	141.50	96.67	16.95	5.91	4.98	6.37	5.22	2.48	1.25	1.36	1.21	285.89
1990	1.70	1.85	4.74	112.56	155.16	62.55	8.71	2.89	2.65	2.53	1.71	1.34	358.38
1991	5.84	7.72	17.70	15.91	18.48	11.82	3.85	1.52	.79	.62	.69	.68	85.63
1992	.88	2.72	6.88	6.58	10.67	19.50	11.64	3.13	1.14	.77	1.01	1.28	66.20
1993	95.59	62.55	17.58	16.65	12.68	18.70	12.46	3.83	1.39	.99	1.24	1.28	244.93
1994	2.39	2.62	3.45	5.54	4.28	8.61	7.25	3.27	1.81	1.28	.98	.66	42.13

Runoff – TM29.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	9.68	12.62	27.72	18.76	21.02	22.36	10.53	4.28	2.14	1.48	1.14	3.53	135.26
1921	6.08	54.79	95.27	43.93	9.14	5.84	3.54	2.67	4.12	4.24	5.79	6.10	241.54
1922	10.05	29.77	38.84	29.70	16.21	8.07	3.45	1.49	.99	1.26	1.29	.96	142.09
1923	.95	2.33	5.39	13.67	15.23	9.04	4.06	2.43	1.76	1.27	1.24	2.68	60.06
1924	5.78	66.30	103.23	69.05	37.24	372.57	155.03	11.25	3.32	2.30	1.92	3.60	831.59
1925	7.84	7.45	5.42	8.42	5.47	4.49	3.45	2.50	3.56	3.54	2.15	6.13	60.41
1926	28.83	28.71	15.27	7.72	12.52	19.76	11.34	3.58	1.64	1.84	3.09	2.59	136.89
1927	3.56	3.56	7.69	58.79	29.33	7.37	4.47	2.40	1.46	1.09	1.14	2.38	123.23
1928	4.43	3.34	2.04	3.12	4.31	20.13	15.04	4.89	3.68	5.45	4.41	6.39	77.23
1929	7.88	12.24	10.00	13.53	10.73	22.14	12.61	4.56	2.02	1.36	1.66	2.61	101.34
1930	4.00	3.92	4.89	22.69	14.66	5.59	3.69	2.24	1.23	1.36	1.36	.87	66.50
1931	1.95	2.22	2.71	3.97	144.79	76.74	13.47	6.39	5.39	3.38	1.77	1.94	264.75
1932	2.08	5.62	10.75	6.46	5.57	5.47	3.42	1.69	1.03	2.01	2.25	1.28	47.62
1933	1.34	30.29	60.09	178.14	72.20	11.45	8.93	6.92	4.33	3.53	5.19	4.20	386.60
1934	5.21	10.23	57.03	30.46	7.54	9.21	10.24	7.15	5.02	3.62	2.02	1.14	148.87
1935	.96	1.33	2.32	31.09	91.43	41.84	8.59	8.79	8.17	4.19	1.86	1.33	201.88
1936	2.82	37.44	22.25	16.43	23.62	15.77	6.34	2.18	1.12	1.05	.94	.93	130.90
1937	1.29	2.39	32.25	26.72	38.35	21.01	9.30	6.01	4.81	8.88	7.78	3.65	162.44
1938	6.20	7.36	32.79	24.01	79.56	39.38	6.20	3.63	2.97	2.75	2.73	3.68	211.26
1939	4.97	46.81	38.86	15.43	7.42	5.68	3.93	66.51	37.37	11.66	4.47	5.13	248.24
1940	5.76	8.88	126.72	56.07	10.47	15.09	25.36	13.12	3.77	1.79	1.29	1.17	269.49
1941	1.85	2.43	3.85	51.12	77.21	69.81	23.28	4.80	2.53	1.97	2.32	3.28	244.44
1942	5.46	19.04	99.07	79.98	29.00	10.59	106.22	54.34	13.38	24.45	166.85	66.34	674.71
1943	104.45	105.40	37.38	9.58	16.92	12.19	4.52	1.73	2.62	3.23	2.05	6.39	306.47
1944	8.79	6.57	4.92	5.14	5.28	51.76	27.08	5.28	2.40	1.52	1.05	.78	120.55
1945	.68	.54	1.18	5.43	6.02	5.42	3.68	1.87	1.11	.93	.83	.89	28.58
1946	7.84	17.49	10.68	6.60	14.50	14.74	9.70	4.72	4.75	4.92	2.86	2.29	101.09
1947	3.76	71.93	38.84	12.88	10.37	16.79	13.04	6.45	2.85	1.53	1.08	1.00	180.51
1948	3.95	7.58	9.63	48.07	47.80	22.98	12.96	7.45	3.21	1.92	1.42	1.43	168.41
1949	3.88	9.74	35.36	17.01	5.04	6.13	6.68	4.71	2.64	1.72	2.17	1.89	96.97
1950	2.14	3.48	17.22	15.80	7.46	5.96	5.20	3.22	1.92	1.42	8.72	11.13	83.68
1951	9.09	4.36	6.67	87.13	41.70	9.46	6.30	3.95	2.43	2.80	2.87	1.73	178.48
1952	2.22	5.98	11.03	11.09	94.29	50.89	7.97	3.40	2.06	1.59	3.60	3.87	197.99
1953	2.96	8.05	8.07	6.42	11.23	10.75	7.68	8.21	6.77	3.74	1.93	3.42	79.24
1954	39.08	70.41	30.09	101.91	69.84	24.77	10.22	5.07	2.42	1.46	1.03	.99	357.28
1955	3.06	7.26	10.71	5.44	50.88	39.52	10.44	3.40	2.00	1.46	1.21	1.96	137.35
1956	4.06	28.10	177.29	138.36	33.42	9.82	8.82	5.57	2.62	4.12	5.93	144.14	562.26
1957	152.22	44.77	5.36	6.74	9.88	7.38	15.65	10.64	3.77	1.65	1.08	1.28	260.41
1958	2.30	6.34	13.76	19.20	103.02	39.57	5.33	18.98	11.02	3.98	2.41	1.73	227.64
1959	4.99	6.85	7.62	7.81	9.91	10.45	11.65	7.85	3.19	1.56	1.31	1.75	74.96
1960	3.87	8.21	68.86	37.89	10.75	10.87	11.92	8.63	4.53	2.48	1.54	2.30	171.86
1961	3.13	6.15	6.17	22.67	13.95	9.91	8.81	5.16	2.36	1.36	1.97	1.96	83.60
1962	2.40	7.64	34.61	23.11	6.87	46.85	23.37	5.76	3.07	17.68	14.00	3.93	189.28
1963	4.10	9.97	6.97	70.73	30.53	5.12	4.40	3.31	2.67	2.53	1.91	2.87	145.10
1964	11.34	11.32	8.06	5.87	4.73	2.64	1.39	1.45	5.02	6.96	6.31	5.90	71.01
1965	6.76	13.24	9.39	43.46	23.24	5.00	2.35	2.52	2.21	1.56	1.82	1.81	113.37
1966	2.05	4.66	7.05	70.83	71.24	73.42	31.51	8.48	3.31	2.17	1.78	1.17	277.67
1967	2.70	8.21	8.19	7.59	5.79	6.22	5.16	2.73	1.37	1.02	1.90	2.35	53.24
1968	2.05	3.26	7.53	7.30	6.48	85.49	43.74	9.03	4.48	2.85	2.14	1.77	176.12
1969	7.15	6.88	9.40	9.06	18.47	10.41	3.49	2.26	2.08	1.72	4.67	9.39	84.99
1970	12.65	10.55	6.80	5.17	4.68	4.29	4.60	38.61	19.85	6.34	6.34	4.59	124.47
1971	18.45	15.66	28.41	37.18	20.48	24.52	10.98	4.48	3.76	2.79	1.94	1.17	169.82
1972	2.48	6.29	5.91	7.30	112.43	51.28	10.92	6.43	2.79	1.49	4.43	7.89	219.63
1973	5.99	6.26	5.35	73.05	38.23	12.48	8.41	4.52	3.10	2.90	2.22	1.28	163.78
1974	.88	5.01	40.78	36.43	24.94	10.46	5.68	4.42	2.46	1.40	1.09	15.98	149.51
1975	11.85	8.69	20.83	66.47	54.85	104.43	40.26	7.47	4.18	2.21	1.42	1.57	324.25
1976	10.28	11.22	9.72	20.32	17.04	13.22	8.91	4.06	1.92	1.31	1.20	3.10	102.31
1977	13.75	15.70	14.19	119.65	53.11	10.57	9.92	6.28	2.71	1.50	1.63	3.54	252.54
1978	54.07	29.76	22.56	13.18	11.36	8.23	4.28	3.07	2.21	2.65	4.64	5.93	161.94
1979	4.83	3.50	3.85	6.05	5.11	3.26	2.35	1.72	1.20	.97	.88	3.30	37.01
1980	4.63	5.95	7.78	30.77	16.59	4.71	1.99	1.59	2.15	2.32	2.67	3.47	84.64
1981	2.91	11.05	7.82	8.75	6.79	11.60	8.95	3.66	1.63	1.52	1.38	2.00	68.05
1982	20.94	16.34	7.48	5.03	2.69	2.91	3.83	3.12	1.94	2.03	2.68	2.13	71.11
1983	2.60	39.17	73.30	209.60	94.38	18.07	13.87	7.71	3.56	3.11	3.97	3.48	472.83
1984	17.85	12.69	6.79	18.51	202.20	83.38	5.39	1.25	.77	.80	.78	.77	351.18
1985	7.64	11.69	15.04	308.78	108.76	94.38	74.02	18.86	3.74	2.55	1.83	1.43	648.72
1986	3.35	4.95	46.69	59.89	54.97	37.72	15.52	4.31	2.40	2.30	5.38	378.52	616.02
1987	156.15	17.25	11.32	23.42	48.74	38.43	13.50	3.88	2.72	4.48	4.23	3.11	327.23
1988	6.11	9.31	26.77	15.41	37.80	21.86	3.99	1.75	1.57	1.43	1.18	.87	128.05
1989	1.95	67.41	115.61	37.64	7.08	8.71	11.05	7.09	2.91	1.49	2.63	2.65	266.21
1990	3.42	3.73	10.81	32.26	34.77	18.25	5.40	2.34	1.85	1.63	1.30	2.44	118.18
1991	10.33	8.39	8.74	10.04	44.95	21.29	5.28	2.15	1.09	.87	.93	1.08	115.14
1992	2.18	3.03	7.67	6.04	6.47	31.22	16.69	3.68	1.57	1.06	1.31	2.40	83.33
1993	86.89	42.38	17.43	13.67	8.39	10.43	7.54	3.42	1.69	1.47	2.92	2.70	198.93
1994	2.63	2.05	3.72	15.43	7.98	4.57	4.66	5.19	7.45	6.24	3.26	1.57	64.73

Runoff – TM30.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	61.45	28.95	7.69	3.68	13.32	11.10	4.70	2.97	2.12	1.52	1.33	3.03	141.86
1921	4.55	21.83	39.07	18.51	3.76	5.72	5.35	3.91	3.92	3.56	5.01	5.30	120.49
1922	3.24	11.39	8.84	41.15	26.26	5.29	2.73	1.58	.89	1.06	1.35	1.04	104.82
1923	.75	1.58	2.94	4.00	5.15	4.17	2.51	1.58	1.17	1.00	.99	3.27	29.11
1924	7.36	48.05	36.47	12.45	7.95	314.02	186.95	16.77	3.85	2.02	1.57	2.18	639.64
1925	13.62	10.83	3.62	1.86	2.99	84.05	50.60	7.01	5.87	4.80	2.52	3.54	191.31
1926	19.38	17.07	14.99	9.58	6.22	82.16	49.47	5.44	1.44	1.48	3.28	3.75	214.26
1927	5.56	5.42	5.49	22.09	17.69	8.76	5.97	3.50	1.77	1.05	1.61	4.35	83.26
1928	6.72	4.91	2.21	2.57	4.16	62.23	38.11	4.69	4.81	8.25	7.06	9.12	154.84
1929	25.05	19.80	7.00	11.64	7.59	2.18	1.63	1.29	.85	.79	2.05	5.31	85.18
1930	7.58	8.34	7.93	6.22	5.69	4.76	3.24	2.00	1.19	1.15	1.28	1.48	50.86
1931	2.43	4.26	8.03	7.58	227.32	192.49	47.59	20.22	14.07	5.63	2.67	2.14	534.43
1932	3.27	5.20	8.35	7.20	5.10	4.42	3.30	1.85	1.02	1.56	2.01	1.61	44.89
1933	2.00	21.67	51.12	68.25	31.88	23.40	16.89	8.66	6.09	4.39	5.73	5.50	245.58
1934	3.96	6.19	125.32	76.20	11.97	7.75	6.05	6.22	15.29	12.27	5.26	2.55	279.03
1935	2.53	3.02	2.78	9.83	101.22	86.93	24.62	16.62	12.35	5.10	2.56	2.90	270.46
1936	5.72	79.58	47.01	5.25	18.53	13.83	4.12	1.63	1.07	1.29	1.55	1.90	181.48
1937	3.16	3.97	53.64	55.98	41.87	18.03	7.64	6.37	3.87	6.48	7.80	5.19	214.00
1938	9.14	9.74	17.89	13.86	50.57	40.55	12.80	5.96	4.28	4.21	4.70	7.32	181.02
1939	9.04	36.70	30.92	11.13	4.17	2.87	2.77	176.86	120.24	20.82	5.18	3.83	424.53
1940	4.42	34.57	111.26	57.18	6.38	3.03	5.20	5.01	2.64	1.51	1.48	2.46	235.14
1941	3.56	4.47	3.52	3.80	5.15	16.65	12.35	4.88	3.07	2.35	3.27	6.96	70.03
1942	11.92	30.25	100.15	53.97	8.79	6.47	55.30	35.23	6.67	14.84	46.72	27.42	397.73
1943	52.67	61.62	28.05	7.02	16.14	35.34	19.00	3.78	4.06	5.30	3.91	26.24	263.13
1944	22.22	10.44	5.79	3.47	4.40	76.06	45.97	5.58	2.22	1.43	1.08	1.00	179.66
1945	3.03	3.09	2.20	12.14	10.55	5.26	3.22	2.02	1.36	1.00	.83	1.01	45.71
1946	3.82	11.76	10.48	12.29	21.20	36.89	22.11	7.09	5.63	5.59	3.83	2.86	143.55
1947	4.79	84.22	68.94	23.45	10.70	19.18	14.18	5.77	2.79	1.47	1.12	1.21	237.82
1948	2.58	4.70	5.47	9.07	10.09	9.13	23.94	16.04	4.79	2.65	1.92	2.18	92.56
1949	9.75	50.72	54.32	22.57	7.71	18.14	12.82	4.34	2.24	1.45	2.00	2.64	188.70
1950	3.73	3.43	28.28	19.77	4.91	3.04	2.53	1.72	1.31	1.19	27.50	21.74	119.15
1951	18.94	11.29	6.07	11.98	9.38	6.62	5.36	4.11	3.18	3.07	2.99	2.10	85.09
1952	2.13	22.09	39.67	21.92	16.27	10.88	4.28	2.21	1.47	1.25	1.90	3.52	127.59
1953	4.91	12.69	17.35	17.97	13.05	8.70	7.87	10.45	8.69	4.84	2.82	7.30	116.64
1954	98.60	66.41	12.09	52.11	34.70	25.91	18.44	7.48	3.96	2.32	1.50	1.97	325.49
1955	13.08	34.34	28.71	9.66	64.67	43.99	8.99	3.45	2.31	2.12	2.45	3.83	217.60
1956	5.50	14.19	114.52	69.42	17.17	13.67	13.15	8.70	4.00	2.81	2.84	77.18	343.15
1957	97.19	38.60	9.96	23.08	23.35	10.36	15.35	11.41	4.01	1.99	1.43	2.80	239.53
1958	4.02	10.30	9.54	8.99	10.22	5.90	2.08	10.00	9.47	4.08	2.96	4.11	81.67
1959	17.81	14.96	7.65	4.43	5.05	6.60	12.68	9.73	4.21	2.28	2.09	3.36	90.85
1960	5.91	32.60	88.69	55.32	13.96	5.83	31.14	20.87	6.57	5.08	3.45	4.09	273.51
1961	6.99	11.49	8.96	5.38	4.17	6.31	6.27	3.92	2.07	1.23	2.91	3.88	63.58
1962	5.69	21.11	18.07	11.63	7.47	19.27	14.58	5.04	4.48	22.54	16.72	5.09	151.69
1963	3.89	7.52	5.85	37.09	23.71	3.83	2.74	2.92	2.15	1.88	1.98	2.93	96.49
1964	20.08	15.16	6.05	3.47	2.63	1.86	1.44	2.05	5.46	8.13	9.10	9.47	84.90
1965	12.17	10.17	7.03	18.13	12.82	3.54	2.08	3.31	3.55	2.64	2.48	3.39	81.31
1966	4.75	5.95	6.29	38.57	34.40	53.36	33.85	9.10	3.62	2.79	2.63	2.02	197.33
1967	4.62	13.15	9.15	6.11	6.05	8.80	6.85	3.06	1.57	1.20	3.59	7.05	71.20
1968	7.92	6.87	36.66	22.87	4.54	53.66	36.94	11.49	7.53	4.61	2.91	4.01	200.01
1969	34.72	24.97	9.66	5.59	3.63	2.64	1.89	3.29	4.45	3.58	2.87	6.94	104.23
1970	53.52	36.17	8.96	6.31	6.90	8.12	7.83	78.15	48.08	8.74	7.93	9.09	279.80
1971	14.83	13.02	18.42	12.92	62.86	48.57	13.42	10.65	10.53	8.15	5.65	3.40	222.42
1972	3.69	5.80	6.44	8.11	36.15	25.40	9.71	5.62	2.64	1.63	6.24	67.32	178.75
1973	47.37	16.74	10.32	56.22	74.85	31.27	6.61	4.36	3.76	3.22	2.54	1.70	258.96
1974	1.24	4.02	7.14	36.70	63.36	30.02	6.36	4.05	2.87	2.10	1.86	45.62	205.34
1975	31.76	9.72	17.64	53.26	44.37	112.32	69.52	15.10	6.43	3.12	2.57	3.42	369.23
1976	11.92	12.61	7.25	18.62	69.29	46.06	11.77	3.89	1.86	1.26	2.01	5.01	191.55
1977	25.54	19.06	7.18	9.62	8.91	17.78	17.80	8.87	3.57	2.18	3.09	5.83	129.43
1978	45.65	31.03	9.88	7.32	5.45	3.82	2.80	2.46	2.08	2.39	4.04	5.51	122.43
1979	6.72	5.82	4.89	3.67	1.91	.98	.94	1.09	1.03	.95	1.36	29.46	58.82
1980	21.86	13.34	8.92	28.25	28.15	10.81	2.97	4.47	5.98	4.76	6.23	12.80	148.54
1981	11.07	36.14	22.01	12.13	9.02	24.23	17.79	6.24	3.02	1.73	1.28	1.68	146.34
1982	33.59	23.11	4.93	2.63	1.94	1.51	1.34	1.32	1.30	2.09	4.77	4.79	83.32
1983	5.02	33.52	26.96	100.72	133.47	58.34	16.10	9.13	5.14	10.88	13.56	8.98	421.82
1984	7.79	8.76	6.56	15.42	114.05	65.13	6.18	1.25	.88	1.05	1.09	1.25	229.41
1985	66.32	44.81	15.60	10.41	5.69	7.37	7.21	4.10	2.40	2.04	1.95	2.32	170.22
1986	9.78	10.58	54.98	94.99	46.30	30.78	17.88	5.25	6.91	7.56	12.33	403.67	701.01
1987	246.28	38.43	17.01	8.03	101.07	92.70	26.61	4.84	3.59	4.02	5.22	6.08	553.88
1988	7.59	16.83	46.68	25.59	40.58	24.77	4.18	2.44	2.46	2.10	1.65	1.83	176.70
1989	4.89	102.76	64.15	8.79	4.06	18.35	15.86	7.53	3.91	2.09	2.99	3.74	239.12
1990	8.55	9.32	42.07	64.42	102.67	81.36	25.68	4.20	2.35	2.31	2.14	3.49	348.56
1991	12.62	9.22	3.42	1.86	2.50	2.45	2.28	1.91	1.18	.86	.94	1.29	40.53
1992	2.18	4.88	5.20	3.00	3.34	4.74	3.95	2.31	1.29	.90	1.19	3.20	36.18
1993	64.12	40.80	8.39	14.49	9.37	9.20	6.87	2.40	.99	1.66	31.76	22.53	212.58
1994	6.56	4.40	3.66	3.66	2.58	4.96	7.81	12.24	15.89	11.56	5.89	3.15	82.36

Runoff – TM31.INC – first and second phase revisions Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	52.30	23.10	5.22	3.40	3.81	47.32	29.21	4.11	1.39	.74	.60	.75	171.95
1921	2.19	165.08	153.29	41.95	8.25	78.00	45.77	4.67	2.03	1.59	2.22	3.89	508.93
1922	48.74	95.43	86.04	37.17	11.86	4.67	1.22	.41	.41	.77	.84	.51	288.07
1923	.56	1.64	2.65	36.84	28.00	17.54	9.94	2.89	1.18	.65	.53	2.51	104.93
1924	3.48	20.56	17.78	8.44	6.36	131.07	79.45	9.80	3.33	1.48	.80	1.39	283.94
1925	2.83	17.68	11.26	5.21	8.52	8.40	4.44	1.81	1.96	1.95	1.10	2.64	67.80
1926	3.46	4.28	5.23	5.90	53.62	34.67	6.49	2.04	.72	1.28	1.51	.84	120.04
1927	15.26	12.32	25.85	16.33	10.94	12.08	7.14	3.18	1.48	.79	.65	1.68	107.70
1928	3.45	4.04	17.20	13.83	6.24	39.26	24.16	3.37	1.91	2.35	1.87	12.86	130.54
1929	28.02	52.13	52.17	60.47	28.30	4.23	1.97	1.32	.80	.81	1.00	.84	232.06
1930	.68	.62	11.25	75.29	68.15	21.71	5.76	2.96	1.15	1.01	1.04	.59	190.21
1931	.57	1.56	1.86	2.23	36.15	40.15	14.78	3.64	2.38	1.53	.83	.56	106.24
1932	1.13	2.37	5.18	3.57	31.28	21.53	5.40	2.29	.96	.91	.88	.61	76.11
1933	.91	52.99	112.95	157.76	69.10	9.35	4.40	2.75	1.83	1.96	3.01	2.29	419.30
1934	2.00	17.16	43.70	25.03	14.52	22.11	11.72	2.54	.98	.70	.52	.52	141.50
1935	1.11	1.14	1.36	29.80	20.61	14.17	8.67	31.66	20.45	3.51	1.02	.66	134.16
1936	2.20	62.91	38.69	98.99	134.46	50.71	4.17	.63	.30	.26	.26	.66	394.24
1937	10.26	6.80	97.21	59.21	6.43	2.28	3.94	3.57	2.48	2.25	1.86	1.29	197.58
1938	20.39	14.53	41.76	48.18	123.67	69.73	8.58	2.37	1.61	3.77	5.24	3.48	343.31
1939	2.14	66.23	58.88	22.45	9.67	5.25	3.01	10.29	10.82	5.68	2.17	1.11	197.70
1940	1.41	10.38	29.85	26.43	28.50	17.59	15.31	9.17	2.20	.77	.53	.48	142.62
1941	.86	1.27	3.05	60.69	39.20	11.43	7.87	5.38	4.46	2.89	1.66	2.81	141.57
1942	6.03	42.30	102.72	63.28	25.49	27.23	94.70	53.50	7.04	7.17	22.19	13.73	465.38
1943	22.74	15.91	20.47	13.22	91.38	55.69	6.18	1.17	3.46	4.37	2.21	4.30	241.10
1944	20.45	13.31	2.95	1.38	4.11	49.98	29.96	3.43	.93	.55	.46	.34	127.85
1945	.25	.37	.39	36.06	29.98	49.33	27.05	2.96	.76	.49	.42	.32	148.38
1946	3.26	10.17	7.48	4.00	33.18	23.60	7.03	3.01	1.45	1.70	1.51	.97	97.36
1947	.88	22.97	40.93	47.30	21.76	7.26	4.66	2.01	.88	.55	.41	1.30	150.91
1948	2.77	3.43	2.52	58.61	39.24	10.00	14.43	8.95	2.20	.77	.49	.90	144.31
1949	3.37	9.83	15.97	10.64	6.18	9.94	8.57	6.08	3.97	1.89	1.59	1.58	79.61
1950	2.18	2.42	4.67	4.97	13.03	8.08	1.89	1.25	1.06	.86	2.33	2.58	45.32
1951	14.46	9.16	4.18	36.15	22.21	3.67	2.33	1.72	.90	3.12	3.64	1.66	103.20
1952	.83	28.37	19.54	6.52	123.22	74.78	9.37	3.18	1.30	.70	.65	.72	269.18
1953	.81	6.99	7.32	4.62	21.28	24.56	10.72	4.08	2.84	1.65	.85	2.15	87.87
1954	6.62	18.68	11.10	35.58	99.05	54.06	8.46	2.07	.85	.60	.51	.42	238.00
1955	1.95	7.05	7.10	4.07	20.78	67.90	35.50	5.02	2.49	1.37	.75	1.38	155.36
1956	5.86	43.46	127.77	65.91	13.14	18.38	11.26	3.15	1.41	7.03	8.88	42.64	348.89
1957	54.98	22.22	7.33	84.42	50.63	6.91	8.94	6.61	2.17	.80	.50	1.36	246.87
1958	3.11	6.70	40.71	24.30	4.85	3.22	2.56	3.41	2.95	1.56	.87	1.04	95.28
1959	4.64	56.77	34.67	5.64	5.62	6.14	6.90	4.95	1.96	.80	.83	1.35	130.27
1960	3.51	18.77	79.82	43.24	5.54	6.09	18.92	13.33	5.00	2.56	1.17	2.54	200.49
1961	3.87	14.44	18.35	10.87	6.85	4.43	2.11	.97	.50	.38	.56	1.12	64.45
1962	1.56	18.03	18.80	73.68	41.73	5.24	2.60	1.56	2.91	60.32	37.14	4.10	267.67
1963	2.26	19.91	12.55	37.49	24.43	5.30	3.68	2.45	1.23	.80	.77	1.08	111.95
1964	90.51	56.01	9.51	24.91	16.73	4.15	1.87	1.23	1.15	1.28	1.30	1.22	209.87
1965	2.14	10.95	7.86	4.25	5.75	3.39	.91	.50	.55	.53	.74	2.29	39.86
1966	3.98	3.61	29.18	90.62	65.89	17.36	3.78	2.00	.98	.89	1.01	.81	220.11
1967	1.96	9.93	9.67	5.82	2.82	7.86	6.27	1.97	.71	.48	1.33	1.44	50.26
1968	.97	9.16	9.08	17.42	11.70	36.59	25.33	6.94	2.91	1.44	.89	.97	123.40
1969	9.17	8.36	14.85	11.93	6.79	3.71	1.45	.80	.72	.92	1.76	2.19	62.65
1970	8.59	8.81	4.37	4.78	4.97	3.89	15.93	13.09	4.88	1.91	1.04	1.27	73.53
1971	3.06	11.12	17.52	27.98	25.90	34.15	17.65	3.34	1.48	.86	.57	.39	144.02
1972	.77	5.01	4.98	8.96	42.76	27.52	9.76	5.71	2.05	.79	3.90	7.33	119.54
1973	7.81	9.19	7.98	8.53	15.91	11.46	6.68	4.59	2.50	1.79	1.41	1.07	78.92
1974	1.15	13.19	42.19	62.03	63.90	26.44	4.50	2.08	1.06	.61	.46	2.61	220.22
1975	4.23	29.78	33.53	15.12	11.74	18.48	11.74	5.88	3.60	1.60	.73	.54	136.97
1976	3.74	5.06	21.43	43.24	25.09	8.91	4.54	1.69	.64	.42	.45	31.11	146.32
1977	22.90	7.17	7.69	57.60	44.19	11.38	3.40	1.80	.88	.53	1.24	2.93	161.71
1978	14.35	11.78	5.25	2.52	1.43	1.19	1.10	.86	.61	1.08	3.62	5.91	49.70
1979	4.91	3.89	3.79	48.76	55.43	19.31	2.27	.52	.34	.32	.32	1.19	141.05
1980	2.10	27.36	20.46	23.37	52.89	28.30	5.07	1.87	1.14	.96	1.31	3.11	167.94
1981	3.94	4.60	4.28	27.23	16.42	2.22	.76	.48	.41	.49	.50	.49	61.82
1982	6.58	5.48	1.97	1.61	1.26	1.27	1.43	2.01	1.96	1.39	1.53	1.23	27.72
1983	9.75	18.77	45.75	143.88	76.09	18.31	9.68	2.57	1.50	3.45	6.39	4.95	341.09
1984	4.02	3.04	2.90	9.63	101.82	58.26	4.53	.64	.46	.52	.45	.40	186.67
1985	6.55	9.53	6.99	17.11	30.19	18.14	6.47	2.62	1.18	.91	.69	.60	100.98
1986	1.46	2.94	25.01	17.67	6.88	4.34	1.98	.83	.59	.75	2.16	55.37	119.98
1987	50.09	70.91	38.88	28.78	17.29	7.25	4.56	1.58	1.02	1.71	1.68	1.31	225.06
1988	27.30	18.75	11.51	40.39	113.69	57.59	5.69	1.79	2.07	2.06	1.23	.57	282.64
1989	1.46	36.38	47.92	21.83	8.18	15.60	11.58	4.24	1.51	.68	.71	.64	150.73
1990	1.16	1.12	7.94	89.92	81.10	40.69	14.28	2.32	1.40	1.24	.80	.66	242.63
1991	14.78	11.94	24.20	14.60	13.89	8.85	1.75	.48	.29	.26	.40	.44	91.88
1992	.85	2.12	9.10	6.87	20.55	16.14	6.82	3.57	1.55	.76	.51	.61	69.45
1993	61.20	40.59	8.74	19.53	15.45	33.57	20.12	3.23	.90	.49	.51	.59	204.92
1994	2.51	2.63	3.60	6.40	6.11	5.85	5.72	3.76	1.74	.89	.60	.41	40.22

Runoff – TM31.INC – third phase revisions Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	43.75	19.22	4.03	2.52	2.81	42.96	26.59	3.67	1.25	.63	.50	.59	148.53
1921	1.42	159.50	148.91	40.52	6.71	76.59	45.06	4.32	1.67	1.29	1.59	2.83	490.41
1922	43.74	91.57	83.36	34.43	9.78	3.90	1.11	.36	.32	.55	.62	.40	270.14
1923	.40	1.13	1.75	31.51	23.15	14.33	8.39	2.49	1.02	.56	.44	1.64	86.80
1924	2.39	15.44	13.18	6.41	4.91	127.64	76.75	8.58	2.80	1.27	.69	1.00	261.06
1925	1.99	12.71	8.40	3.61	4.78	5.60	3.55	1.52	1.49	1.49	.89	1.77	47.81
1926	2.45	3.08	3.90	4.46	49.49	31.64	5.54	1.76	.62	.93	1.11	.65	105.63
1927	10.72	8.81	22.39	14.24	8.36	8.27	5.26	2.70	1.30	.69	.54	1.17	84.45
1928	2.33	2.81	14.08	11.06	4.75	35.34	21.84	3.04	1.54	1.81	1.47	9.59	109.66
1929	23.44	48.91	49.30	57.18	26.55	3.66	1.59	1.06	.67	.63	.74	.66	214.39
1930	.54	.47	6.46	70.75	65.66	20.35	4.72	2.36	1.00	.76	.76	.45	174.29
1931	.42	1.06	1.32	1.58	30.19	35.01	13.29	3.13	1.94	1.25	.69	.46	90.34
1932	.80	1.61	3.15	2.43	26.09	17.94	4.45	1.91	.83	.73	.70	.50	61.16
1933	.64	46.61	107.86	155.19	67.48	8.01	3.46	2.18	1.49	1.49	2.19	1.75	398.35
1934	1.51	11.79	38.80	22.63	12.39	19.53	10.41	2.27	.87	.58	.42	.41	121.62
1935	.77	.82	.94	23.92	16.61	10.53	6.65	27.05	17.54	3.12	.94	.56	109.44
1936	1.45	57.40	35.18	94.93	131.04	49.62	3.98	.59	.26	.23	.22	.44	375.34
1937	6.54	4.55	91.45	55.32	5.67	1.84	2.78	2.65	1.95	1.77	1.46	1.03	177.01
1938	14.27	10.62	36.96	43.37	120.77	67.53	7.68	1.98	1.29	2.57	3.70	2.67	313.41
1939	1.68	61.13	53.91	19.48	7.82	4.11	2.38	7.18	8.10	4.73	1.93	.94	173.40
1940	1.04	6.71	25.83	22.78	25.64	15.34	12.29	7.63	1.98	.70	.46	.39	120.78
1941	.61	.89	2.13	55.31	35.32	8.57	5.84	4.15	3.37	2.28	1.36	1.97	121.80
1942	4.19	38.70	99.50	60.14	22.57	24.01	92.09	51.81	6.29	4.69	20.32	12.99	437.29
1943	18.61	13.02	17.91	11.40	87.26	52.78	5.55	1.07	2.18	2.96	1.67	2.92	217.33
1944	16.86	11.23	2.51	1.09	2.71	45.34	27.44	3.11	.84	.48	.36	.28	112.24
1945	.20	.26	.28	28.76	23.82	46.53	25.96	2.77	.68	.42	.34	.26	130.28
1946	2.06	6.56	5.19	2.98	28.28	19.87	5.71	2.56	1.23	1.34	1.20	.77	77.74
1947	.67	17.23	35.98	44.13	20.03	5.54	3.58	1.73	.77	.46	.35	.91	131.36
1948	1.92	2.45	1.84	52.68	34.62	7.86	12.36	7.87	1.98	.69	.41	.63	125.31
1949	2.23	6.47	12.26	8.43	4.69	7.61	6.73	4.85	3.24	1.61	1.22	1.17	60.53
1950	1.56	1.76	2.92	3.41	10.63	6.77	1.63	1.00	.84	.69	1.55	1.81	34.56
1951	10.71	6.94	2.90	31.45	19.49	3.04	1.76	1.33	.75	2.05	2.55	1.30	84.27
1952	.65	21.91	15.29	5.09	119.65	72.07	8.19	2.66	1.14	.60	.54	.54	248.34
1953	.58	3.10	4.25	3.39	16.73	20.26	9.17	3.32	2.26	1.38	.74	1.45	66.63
1954	4.07	15.41	9.59	30.87	95.01	51.79	7.44	1.81	.74	.50	.40	.34	217.99
1955	1.26	3.61	4.35	3.02	16.10	64.44	34.58	4.40	2.02	1.14	.62	.94	136.49
1956	3.43	39.58	124.65	64.03	10.31	15.11	9.60	2.73	1.20	3.98	6.26	39.99	320.87
1957	52.57	21.07	4.84	80.05	48.21	6.05	6.55	5.03	1.86	.72	.43	.90	228.28
1958	2.07	3.89	36.90	22.42	3.94	2.44	1.95	2.50	2.25	1.27	.73	.77	81.13
1959	3.06	52.44	31.98	4.62	3.99	4.50	5.08	3.83	1.68	.71	.66	.97	113.50
1960	2.42	15.00	75.75	41.49	4.78	4.38	15.60	11.25	4.23	2.20	1.04	1.74	179.89
1961	2.71	9.80	14.35	8.97	5.49	3.63	1.76	.81	.42	.31	.42	.82	49.49
1962	1.13	13.93	15.03	69.92	39.82	4.51	2.02	1.25	2.06	55.20	34.04	3.74	242.65
1963	1.73	15.71	10.13	31.89	20.72	4.45	2.85	1.92	1.00	.67	.60	.81	92.49
1964	84.19	51.71	7.75	22.01	14.63	3.45	1.48	.97	.89	.96	.99	.93	189.95
1965	1.51	5.90	4.81	3.13	3.82	2.45	.79	.42	.43	.42	.55	1.57	25.81
1966	2.80	2.67	23.93	86.03	63.04	16.01	3.21	1.65	.84	.67	.74	.62	202.20
1967	1.34	6.21	6.59	4.43	2.27	3.79	3.83	1.75	.65	.41	.91	1.03	33.22
1968	.73	5.43	5.91	13.30	9.22	32.38	22.04	5.79	2.51	1.25	.77	.73	100.05
1969	4.43	5.14	10.82	8.94	5.25	2.94	1.21	.65	.57	.69	1.27	1.61	43.51
1970	4.83	5.72	3.37	3.38	3.56	2.94	11.21	9.72	4.10	1.70	.92	.98	52.42
1971	2.11	7.88	12.98	23.87	22.40	31.29	16.39	2.95	1.26	.73	.47	.31	122.62
1972	.55	2.72	3.26	5.95	38.35	24.69	7.80	4.70	1.86	.72	2.59	5.08	98.28
1973	5.74	6.63	5.86	5.95	13.21	9.69	5.26	3.64	2.06	1.44	1.12	.85	61.46
1974	.88	7.35	36.98	58.71	60.80	24.91	3.85	1.70	.88	.51	.38	1.75	198.71
1975	2.95	24.77	29.68	13.25	8.30	15.40	10.12	4.74	2.95	1.39	.64	.45	114.64
1976	2.27	3.51	18.73	39.27	21.97	7.01	3.71	1.48	.55	.36	.36	27.93	127.15
1977	19.88	5.60	5.13	54.39	41.44	10.08	2.84	1.48	.75	.46	.90	2.01	144.95
1978	10.32	8.78	4.06	1.96	1.10	.91	.84	.68	.47	.76	2.44	4.18	36.51
1979	3.69	2.90	2.79	44.31	51.32	18.04	2.09	.47	.29	.25	.26	.79	127.19
1980	1.47	21.63	16.15	19.62	49.66	26.46	4.31	1.62	.94	.76	.99	2.18	145.81
1981	2.84	3.41	3.23	22.16	13.58	1.91	.62	.37	.33	.38	.38	.38	49.60
1982	3.10	3.23	1.53	1.13	.91	.88	.99	1.42	1.45	1.10	1.16	.95	17.84
1983	3.79	14.01	42.74	141.06	74.19	15.01	7.77	2.25	1.25	2.50	4.63	3.79	312.99
1984	3.05	2.31	2.11	6.06	97.63	56.62	4.32	.59	.36	.39	.35	.31	174.11
1985	3.07	6.19	5.37	13.05	26.01	15.72	5.29	2.24	1.01	.73	.55	.47	79.69
1986	1.02	2.02	20.21	14.32	5.30	3.36	1.61	.69	.48	.56	1.47	50.15	101.19
1987	45.80	68.58	37.18	24.85	14.82	5.24	3.46	1.41	.84	1.30	1.28	1.01	205.76
1988	21.08	14.71	7.40	36.21	95.83	47.54	4.74	1.47	1.54	1.56	.98	.48	233.54
1989	.98	30.76	42.98	19.49	6.43	12.78	9.46	3.50	1.33	.60	.56	.51	129.39
1990	.80	.81	4.41	85.65	77.97	37.76	13.00	2.09	1.13	.99	.66	.52	225.78
1991	8.29	7.66	19.91	12.16	9.23	6.14	1.51	.43	.26	.23	.31	.36	66.48
1992	.58	1.45	5.54	4.52	15.83	12.51	5.39	2.94	1.35	.65	.43	.47	51.66
1993	58.45	37.70	5.75	4.72	6.39	31.96	19.29	2.81	.75	.40	.38	.38	168.98
1994	1.49	1.66	2.21	4.06	4.01	3.67	3.58	2.51	1.29	.66	.46	.31	25.93

Runoff – TM32.INC Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	8.26	31.24	31.46	13.34	3.75	5.86	6.16	3.53	2.02	1.48	1.27	3.23	111.57
1921	5.61	41.18	27.79	5.52	2.36	3.50	3.20	2.73	3.41	3.65	4.43	4.54	107.93
1922	7.69	14.95	14.15	25.74	16.23	4.23	1.72	1.01	.79	.99	1.19	1.01	89.70
1923	1.01	4.48	19.22	12.29	5.78	5.18	3.58	2.56	1.78	1.23	1.21	2.30	60.64
1924	6.17	84.00	58.15	48.33	27.97	284.07	168.74	15.51	3.70	2.90	2.86	4.67	707.08
1925	9.31	8.33	7.26	5.96	2.90	5.36	5.38	3.63	4.77	4.67	2.79	6.52	66.86
1926	87.93	65.78	15.55	4.34	6.81	19.25	12.17	3.26	1.64	2.31	3.74	3.55	226.34
1927	4.29	3.81	6.25	68.35	41.51	6.15	2.39	1.13	.71	.65	.92	1.64	137.80
1928	3.02	2.89	1.48	2.21	2.89	8.56	7.85	3.71	3.42	5.01	4.35	4.90	50.29
1929	9.01	19.24	13.51	21.74	15.31	5.58	4.39	3.30	1.76	1.17	1.56	3.63	100.22
1930	5.03	6.32	6.30	13.27	9.94	3.73	2.23	1.66	1.05	.94	.97	.82	52.25
1931	2.36	4.35	4.22	2.98	123.69	98.17	22.85	8.32	7.77	4.83	2.39	2.37	284.32
1932	2.66	5.89	9.28	5.82	3.12	2.35	1.51	.94	.69	1.40	1.89	1.43	36.98
1933	1.62	37.15	48.74	69.65	34.51	7.90	9.39	9.40	5.96	3.88	5.68	5.42	239.31
1934	7.56	12.77	93.96	54.85	7.85	5.94	5.07	3.58	3.27	2.83	1.83	1.13	200.64
1935	1.29	2.27	2.18	5.81	57.62	37.68	8.19	7.53	6.96	3.72	1.75	1.82	136.82
1936	4.07	29.43	18.68	3.97	15.06	13.12	4.97	1.74	.91	.89	.93	1.07	94.83
1937	1.57	2.35	23.66	38.37	61.79	31.77	9.10	6.14	4.08	7.43	7.88	4.34	198.48
1938	4.46	4.82	9.67	11.20	108.27	69.30	11.50	4.64	3.18	2.70	3.14	5.70	238.58
1939	7.72	40.17	31.60	10.99	4.78	3.37	3.19	133.82	88.55	16.36	5.44	5.85	351.84
1940	6.44	13.77	85.68	49.68	8.26	6.08	10.65	8.63	3.50	1.63	1.26	1.58	197.15
1941	3.17	3.39	3.65	6.62	21.78	20.05	9.68	4.22	2.39	1.85	2.20	3.77	82.75
1942	8.26	17.06	86.94	53.11	13.42	8.01	56.39	38.06	9.06	11.26	109.54	65.49	476.60
1943	72.63	119.34	53.92	7.41	7.69	8.49	4.69	1.86	2.41	3.23	2.44	6.70	290.82
1944	13.01	10.27	6.40	5.57	5.06	38.59	24.81	4.82	2.25	1.45	1.07	.93	114.22
1945	1.26	.96	2.20	10.14	8.01	4.63	3.44	1.97	1.17	.95	.85	1.01	36.59
1946	11.66	14.48	9.43	8.16	10.01	9.53	6.62	3.90	4.67	5.17	3.34	2.93	89.89
1947	4.45	34.34	26.87	9.73	7.96	26.26	18.44	5.82	2.57	1.45	1.12	1.18	140.19
1948	3.56	5.35	11.45	27.41	39.35	24.41	12.63	7.42	3.23	2.01	1.78	1.68	140.29
1949	5.27	48.04	69.99	32.26	7.52	9.40	8.82	4.77	2.35	1.46	1.82	2.08	193.77
1950	2.99	3.44	16.76	13.20	4.77	3.29	2.62	1.65	1.21	1.11	13.93	14.66	79.63
1951	12.70	7.67	7.38	20.23	14.66	7.21	5.06	3.44	2.43	2.83	3.04	1.97	88.63
1952	2.40	9.57	18.29	14.54	69.57	42.52	6.86	2.63	1.95	1.87	3.05	4.26	177.51
1953	4.39	19.85	16.49	7.70	5.74	5.01	4.52	7.08	7.20	4.31	2.38	4.60	89.27
1954	73.94	64.00	17.81	29.75	23.11	16.36	13.34	7.18	3.28	1.70	1.17	1.09	252.73
1955	4.63	19.52	33.16	15.51	75.50	47.49	6.64	2.19	1.53	1.33	1.41	2.54	211.45
1956	6.40	30.00	77.20	42.32	9.46	5.72	6.40	5.27	2.79	2.95	3.95	113.01	305.47
1957	155.90	62.38	9.32	5.88	9.35	7.41	8.39	7.27	3.37	1.53	1.11	1.44	273.36
1958	2.64	6.76	11.87	56.45	79.40	33.28	4.88	4.58	4.64	2.76	2.23	2.38	211.86
1959	6.36	7.90	9.36	8.25	9.06	9.77	10.39	7.46	3.30	1.65	1.51	2.27	77.27
1960	5.10	10.12	72.57	47.72	11.81	6.66	6.66	5.70	3.53	2.17	1.43	2.56	176.02
1961	4.41	8.47	8.30	6.50	4.42	6.36	7.18	4.64	2.27	1.35	2.45	2.80	59.15
1962	4.66	10.73	14.04	11.82	5.93	30.44	22.31	6.16	3.12	47.15	32.22	6.20	194.78
1963	3.45	9.44	6.97	75.85	46.53	5.29	1.98	1.92	1.93	1.93	1.77	2.76	159.82
1964	9.12	9.21	7.16	4.36	2.62	1.56	1.26	2.07	4.84	6.21	6.10	6.33	60.83
1965	7.16	8.32	8.22	51.22	32.86	5.50	2.33	2.44	2.01	1.42	1.56	1.95	124.99
1966	3.07	7.24	9.72	66.43	86.59	64.41	27.30	7.57	3.01	2.18	2.07	1.72	281.29
1967	3.89	8.79	7.04	5.44	5.16	6.72	5.84	3.03	1.44	1.01	1.66	2.94	52.95
1968	3.77	3.96	16.91	13.26	4.98	35.65	26.62	8.98	4.63	2.84	2.12	2.33	126.04
1969	11.85	10.71	8.38	6.02	3.94	2.95	2.18	2.75	3.05	2.28	3.02	7.26	64.39
1970	29.34	23.05	8.95	4.76	3.73	3.57	4.94	44.08	29.13	7.42	7.55	6.76	173.29
1971	6.75	6.96	9.12	9.71	9.89	10.12	6.82	5.72	5.52	4.20	2.91	1.86	79.58
1972	3.13	4.82	4.13	5.50	93.79	59.81	11.72	5.36	2.30	1.31	3.89	13.22	208.98
1973	12.75	8.53	6.57	58.79	38.15	9.39	5.72	3.69	3.23	3.14	2.44	1.56	153.96
1974	1.10	4.88	8.92	15.40	15.80	8.38	4.75	4.29	2.99	1.72	1.39	34.21	103.83
1975	24.79	11.71	25.55	92.99	75.61	59.37	29.40	7.32	3.65	1.96	1.57	1.87	335.78
1976	8.74	11.41	8.11	20.14	37.15	23.34	8.09	3.35	1.74	1.22	1.46	3.42	128.16
1977	27.68	23.16	11.06	67.18	42.67	9.69	6.83	4.59	2.26	1.32	1.94	4.05	202.42
1978	46.14	31.00	11.48	9.86	8.49	5.72	3.55	2.60	1.74	1.61	3.11	5.55	130.84
1979	6.01	4.05	3.20	2.65	1.52	.80	.82	1.08	1.06	.93	1.04	3.05	26.19
1980	5.03	6.57	5.54	6.61	5.95	2.85	1.13	1.40	2.13	2.17	2.41	4.33	46.12
1981	5.86	27.76	17.64	5.58	5.11	26.22	19.36	6.16	2.66	1.56	1.25	1.33	120.48
1982	37.49	26.99	6.93	3.54	1.85	1.29	1.82	1.95	1.48	1.68	2.55	2.22	89.79
1983	3.79	40.69	29.23	108.24	73.15	17.71	10.19	6.70	3.88	4.93	7.08	5.97	311.56
1984	7.15	7.97	4.89	5.31	82.28	49.88	5.44	1.17	.74	.90	1.15	1.36	168.24
1985	19.76	16.23	8.70	6.95	5.05	5.93	5.99	3.73	2.24	1.79	1.56	1.68	79.60
1986	5.22	7.31	28.74	53.73	27.76	10.98	7.51	3.43	3.73	4.55	5.65	250.26	408.88
1987	153.49	21.48	11.89	8.28	17.91	16.33	7.92	3.29	2.00	3.27	4.44	4.86	255.15
1988	8.46	25.17	36.78	18.11	32.66	20.33	3.48	1.62	2.08	2.14	1.71	1.52	154.07
1989	2.71	70.77	45.21	6.85	3.71	5.97	6.59	4.48	2.31	1.32	2.75	3.65	156.31
1990	5.75	6.65	11.68	45.41	43.27	26.22	11.48	3.45	2.04	1.84	1.57	2.97	162.32
1991	11.30	9.48	5.30	3.72	4.36	3.87	2.40	1.45	.92	.81	.96	1.11	45.68
1992	1.79	3.25	3.73	2.65	2.85	4.02	3.26	1.85	1.12	.87	1.28	2.35	29.01
1993	91.14	56.54	8.31	5.23	3.42	4.79	4.47	2.28	1.24	1.34	3.56	4.09	186.42
1994	4.68	3.82	3.26	4.13	2.72	2.65	3.36	4.68	7.83	7.53	4.41	2.24	51.32

APPENDIX J

AFFORESTATION TIME SERIES

Note: Zero time series omitted

Afforestation and dryland sugar cane water use for 2030 – TM04.AFF   Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.22	.09	.10	.51	.50	.42	.19	.08	.05	.04	.03	.47	2.70
1921	.24	.41	.46	.46	.44	.22	.08	.05	.07	.05	.15	.07	2.70
1922	.46	.47	.24	.38	.43	.44	.18	.06	.05	.04	.04	.04	2.83
1923	.04	.15	.16	.48	.47	.43	.22	.11	.06	.03	.03	.11	2.29
1924	.46	.45	.44	.45	.45	.50	.24	.07	.02	.01	.01	.02	3.12
1925	.09	.46	.29	.37	.41	.40	.17	.07	.06	.05	.04	.55	2.96
1926	.00	.17	.45	.46	.45	.45	.23	.10	.05	.04	.04	.04	2.48
1927	.51	.23	.45	.49	.44	.44	.18	.08	.07	.04	.03	.02	2.98
1928	.03	.11	.48	.49	.46	.45	.24	.13	.15	.32	.12	.39	3.37
1929	.24	.43	.47	.45	.43	.43	.20	.09	.07	.07	.07	.09	3.04
1930	.10	.06	.50	.50	.46	.44	.25	.09	.04	.08	.05	.03	2.60
1931	.03	.04	.05	.51	.50	.44	.20	.11	.07	.05	.03	.03	2.06
1932	.03	.57	.53	.50	.27	.17	.13	.06	.02	.02	.03	.03	2.36
1933	.02	.51	.50	.44	.43	.44	.43	.40	.17	.08	.16	.08	3.66
1934	.46	.47	.44	.22	.43	.45	.18	.07	.05	.04	.03	.03	2.87
1935	.03	.08	.55	.52	.44	.44	.18	.42	.20	.06	.05	.03	3.00
1936	.12	.47	.48	.44	.45	.44	.18	.07	.05	.03	.03	.02	2.78
1937	.02	.08	.48	.49	.47	.24	.38	.18	.07	.13	.12	.06	2.72
1938	.53	.53	.46	.46	.44	.42	.19	.12	.07	.08	.06	.05	3.41
1939	.54	.51	.46	.46	.45	.44	.22	.47	.26	.08	.04	.10	4.03
1940	.07	.50	.50	.45	.46	.26	.38	.18	.06	.03	.02	.02	2.93
1941	.08	.06	.11	.47	.47	.44	.46	.18	.08	.06	.05	.08	2.54
1942	.45	.46	.44	.46	.45	.44	.44	.43	.18	.41	.43	.16	4.75
1943	.45	.48	.45	.46	.47	.46	.18	.08	.17	.10	.04	.50	3.84
1944	.28	.17	.10	.42	.46	.42	.20	.08	.04	.03	.02	.02	2.24
1945	.01	.02	.04	.52	.51	.45	.21	.08	.05	.04	.02	.01	1.96
1946	.46	.47	.21	.14	.43	.45	.20	.07	.05	.04	.03	.03	2.58
1947	.51	.49	.44	.45	.45	.44	.41	.16	.07	.04	.03	.02	3.51
1948	.07	.15	.46	.47	.42	.43	.24	.08	.05	.03	.02	.03	2.45
1949	.07	.54	.57	.00	.15	.43	.21	.12	.07	.04	.04	.05	2.29
1950	.09	.11	.46	.28	.39	.44	.21	.07	.04	.03	.07	.09	2.28
1951	.14	.07	.45	.47	.43	.42	.21	.07	.05	.10	.07	.04	2.52
1952	.17	.43	.45	.43	.44	.24	.16	.07	.04	.02	.02	.02	2.49
1953	.03	.53	.57	.47	.45	.42	.18	.16	.09	.04	.03	.07	3.04
1954	.17	.41	.43	.44	.43	.42	.21	.08	.05	.05	.03	.02	2.74
1955	.02	.15	.46	.22	.43	.46	.17	.07	.05	.03	.02	.03	2.11
1956	.03	.49	.49	.44	.45	.45	.42	.17	.07	.09	.15	.43	3.68
1957	.44	.23	.40	.44	.43	.37	.39	.17	.06	.05	.03	.03	3.04
1958	.07	.47	.49	.45	.45	.25	.17	.33	.14	.05	.03	.03	2.93
1959	.52	.49	.49	.00	.16	.44	.45	.18	.07	.04	.03	.03	2.90
1960	.08	.51	.51	.45	.25	.36	.43	.19	.07	.04	.03	.02	2.94
1961	.04	.50	.50	.45	.44	.45	.44	.18	.06	.04	.04	.02	3.16
1962	.03	.63	.56	.45	.44	.43	.21	.08	.06	.06	.06	.04	3.05
1963	.14	.45	.19	.45	.28	.38	.22	.07	.05	.04	.03	.11	2.41
1964	.46	.46	.45	.00	.00	.08	.11	.08	.43	.19	.15	.13	2.54
1965	.07	.42	.26	.36	.41	.16	.07	.05	.04	.04	.03	.03	1.94
1966	.03	.54	.52	.46	.45	.45	.44	.19	.08	.05	.04	.02	3.27
1967	.03	.09	.47	.49	.22	.40	.19	.05	.03	.03	.02	.02	2.04
1968	.03	.12	.46	.49	.44	.43	.24	.13	.06	.04	.03	.02	2.49
1969	.59	.32	.41	.46	.44	.24	.09	.05	.04	.03	.10	.44	3.21
1970	.00	.00	.05	.37	.42	.00	.00	.13	.06	.06	.05	.04	1.18
1971	.16	.41	.43	.44	.43	.44	.21	.11	.06	.04	.03	.03	2.79
1972	.08	.49	.25	.42	.45	.46	.44	.17	.07	.04	.11	.00	2.98
1973	.00	.22	.38	.42	.43	.43	.41	.17	.08	.06	.05	.04	2.69
1974	.03	.52	.51	.46	.46	.44	.24	.10	.05	.03	.02	.55	3.41
1975	.27	.41	.47	.45	.45	.44	.44	.23	.09	.05	.03	.07	3.40
1976	.46	.41	.41	.45	.43	.43	.42	.17	.07	.04	.03	.11	3.43
1977	.44	.45	.44	.44	.44	.44	.42	.17	.06	.04	.03	.08	3.45
1978	.47	.28	.40	.49	.45	.43	.21	.11	.06	.05	.47	.21	3.63
1979	.14	.00	.19	.45	.45	.43	.21	.08	.05	.03	.03	.47	2.53
1980	.22	.45	.48	.45	.43	.22	.09	.06	.05	.04	.11	.11	2.71
1981	.06	.46	.48	.45	.44	.41	.42	.17	.07	.04	.03	.03	3.06
1982	.51	.28	.13	.40	.25	.14	.09	.03	.02	.08	.05	.03	2.01
1983	.55	.51	.45	.46	.44	.45	.25	.10	.05	.04	.08	.05	3.43
1984	.11	.07	.10	.47	.48	.22	.08	.05	.04	.02	.01	.01	1.66
1985	.48	.48	.44	.46	.39	.41	.43	.17	.07	.05	.05	.04	3.47
1986	.58	.52	.45	.52	.48	.45	.19	.08	.05	.04	.17	.42	3.95
1987	.22	.36	.49	.46	.44	.44	.21	.08	.09	.09	.05	.04	2.97
1988	.15	.45	.47	.45	.45	.42	.22	.09	.06	.05	.04	.02	2.87
1989	.02	.50	.50	.50	.46	.47	.25	.09	.05	.04	.03	.03	2.94
1990	.03	.05	.51	.51	.44	.43	.18	.07	.05	.03	.03	.02	2.35
1991	.49	.53	.47	.47	.45	.43	.20	.08	.05	.03	.02	.02	3.24
1992	.02	.12	.46	.47	.44	.43	.22	.09	.05	.03	.03	.02	2.38
1993	.48	.52	.47	.46	.46	.45	.25	.09	.05	.04	.03	.02	3.32
1994	.03	.03	.09	.50	.47	.43	.23	.09	.05	.03	.03	.02	2.00

Afforestation and dryland sugar cane water use for 2030 – TM12.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.96	.78	.07	.10	.23	2.69	.89	.04	.02	.01	.01	.12	7.92
1921	.10	2.76	2.91	.73	.16	.15	.07	.04	.08	.07	.12	.09	7.28
1922	.10	.23	.21	.73	2.01	.62	.03	.02	.02	.03	.03	.01	4.04
1923	.02	.06	.09	.15	3.03	1.04	.03	.03	.02	.01	.01	.04	4.53
1924	.15	2.98	3.05	2.51	.58	1.75	1.01	.12	.00	.01	.00	.10	12.26
1925	.17	.12	.10	1.02	.41	.11	.05	.04	.04	.03	.01	.15	2.25
1926	.24	.21	.21	.21	.85	.69	.11	.00	.00	.00	.02	.03	2.57
1927	.12	.10	.19	.22	.15	.19	.11	.04	.01	.01	.01	.04	1.19
1928	.11	.09	.20	3.00	1.09	1.99	.68	.02	.06	.15	.10	2.61	10.10
1929	.91	2.09	.74	2.40	.76	1.94	.69	.03	.01	.01	.01	.04	9.63
1930	.06	.07	.85	2.29	.72	.10	.08	.04	.01	.03	.03	.01	4.29
1931	.03	.04	.11	.24	2.97	1.06	.07	.09	.06	.02	.01	.02	4.72
1932	.04	.12	.23	.12	.11	.21	.17	.08	.03	.07	.06	.02	1.26
1933	.00	3.20	2.75	1.58	.42	.14	.21	.16	.06	.04	.10	.07	8.73
1934	.06	3.10	3.02	.68	.15	.71	.24	.01	.01	.01	.00	.00	7.99
1935	.01	.03	.03	.19	1.52	.51	.04	.15	.10	.04	.01	.01	2.64
1936	.03	1.75	2.21	.63	2.29	.79	.06	.04	.01	.01	.01	.00	7.83
1937	.01	.03	.21	2.87	1.00	.08	.16	.10	.07	.11	.09	.04	4.77
1938	.05	.06	.08	.17	3.44	1.21	.05	.04	.03	.03	.04	.04	5.24
1939	.06	.36	.18	.07	.07	.07	.08	.10	.20	.13	.05	.05	1.42
1940	.06	.07	.21	.28	.21	2.06	.74	.04	.02	.00	.00	.01	3.70
1941	.06	.06	.05	.24	3.04	2.69	.63	.04	.02	.01	.02	.03	6.89
1942	.04	3.14	2.85	1.76	.40	.09	2.22	.79	.04	.07	2.32	.78	14.50
1943	2.37	2.62	2.50	.71	2.66	.96	.05	.01	.02	.02	.01	.13	12.06
1944	.13	.11	.06	.04	.12	3.46	1.16	.01	.01	.00	.00	.00	5.10
1945	.00	.02	.08	.09	3.20	1.11	.06	.04	.01	.00	.01	.00	4.62
1946	.10	.25	.16	.08	2.63	1.86	.36	.02	.04	.05	.01	.04	5.60
1947	.11	.22	2.85	2.96	.79	1.88	.69	.06	.02	.01	.01	.01	9.61
1948	.05	.09	.39	.22	.20	1.52	.47	.00	.00	.00	.00	.02	2.96
1949	.04	.12	.12	.07	.05	3.69	1.27	.06	.04	.01	.03	.04	5.54
1950	.07	2.96	2.97	.76	.16	.22	.16	.07	.02	.02	.07	.11	7.59
1951	.10	.05	.11	3.42	1.20	.19	.11	.03	.01	.04	.05	.03	5.34
1952	.09	.17	2.75	1.02	2.26	.79	.08	.04	.01	.00	.02	.02	7.25
1953	.04	.11	.24	.15	.99	.37	.07	.07	.04	.02	.00	.05	2.15
1954	.19	2.68	.95	2.56	2.82	.71	.05	.05	.03	.01	.00	.00	10.05
1955	.01	.03	1.33	.45	.54	2.05	.64	.01	.01	.01	.00	.02	5.10
1956	.02	.11	3.46	2.55	.44	1.49	.47	.00	.00	.03	.08	2.68	11.33
1957	2.51	.57	.12	.21	2.72	.91	.14	.09	.03	.00	.00	.01	7.31
1958	.04	.15	.23	.18	.21	.11	.09	.14	.10	.04	.01	.01	1.31
1959	.14	.22	.18	.09	.21	2.36	1.83	.29	.00	.00	.00	.01	5.33
1960	.04	.13	.51	.20	.17	.22	.24	.08	.02	.01	.01	.03	1.66
1961	.04	.08	.13	2.99	2.93	.74	.12	.06	.02	.01	.00	.01	7.13
1962	.01	.17	3.02	2.90	.75	.63	.21	.01	.03	.03	.02	.01	7.79
1963	.04	1.98	.64	.56	.20	.16	.18	.08	.04	.03	.02	.09	4.02
1964	2.25	1.69	.37	.09	.10	.06	.04	.03	.08	.11	.14	.15	5.11
1965	.09	.09	.13	3.42	1.23	.05	.02	.03	.04	.03	.03	.02	5.18
1966	.04	.22	2.57	2.93	2.57	.73	1.89	.65	.03	.02	.00	.00	11.65
1967	.02	.05	.04	.13	.17	.20	.13	.05	.01	.01	.02	.02	.85
1968	.01	.05	.12	.19	.15	2.82	.97	.07	.06	.03	.01	.01	4.49
1969	.14	.11	.19	.15	.46	.19	.03	.02	.02	.02	.08	.17	1.58
1970	.15	.12	.07	3.11	.97	.02	.06	.08	.05	.04	.05	.03	4.75
1971	.06	.16	.26	.24	.17	2.66	.90	.04	.04	.01	.01	.01	4.56
1972	.04	.23	.15	.09	.21	.16	.21	.12	.04	.01	.08	.13	1.47
1973	.07	.16	.20	2.29	1.85	2.23	.70	.05	.02	.01	.02	.01	7.61
1974	.02	.11	3.37	3.20	2.71	.74	.09	.05	.02	.01	.00	.41	10.73
1975	.14	2.39	2.59	2.62	2.65	2.42	.62	.06	.04	.01	.01	.02	13.57
1976	.11	.17	.16	2.99	1.02	.12	.10	.04	.02	.01	.00	.04	4.78
1977	.88	.35	.16	2.56	.92	.19	.15	.06	.02	.00	.02	.08	5.39
1978	.20	.17	3.00	1.07	2.49	.89	.07	.05	.03	.02	.10	.09	8.18
1979	.08	.10	.17	.22	.22	.14	.10	.06	.02	.00	.00	.10	1.21
1980	.10	.41	2.32	2.83	2.68	.69	.04	.03	.03	.02	.04	.06	9.25
1981	.04	.08	.12	.25	.15	.08	.05	.02	.01	.01	.01	.02	.84
1982	.18	.14	.17	.26	.14	.09	.07	.06	.05	.04	.04	.02	1.26
1983	.07	.17	3.01	1.06	.07	.21	.23	.10	.03	.01	.04	.04	5.04
1984	.11	.09	.05	3.54	1.91	.23	.00	.00	.01	.01	.01	.01	5.97
1985	.17	.19	.60	1.46	.42	.06	.05	.02	.03	.03	.02	.02	3.07
1986	2.73	.96	2.38	2.65	2.52	2.50	.64	.00	.01	.02	.11	2.56	17.08
1987	.89	.08	.22	2.58	2.73	.73	.09	.04	.04	.08	.06	.03	7.57
1988	.15	.13	1.69	.58	2.52	.89	.04	.02	.02	.02	.01	.00	6.07
1989	.03	3.11	2.95	.68	.09	.14	.14	.08	.02	.01	.04	.03	7.32
1990	.03	.03	1.58	2.37	2.43	.64	.03	.01	.02	.02	.01	.01	7.18
1991	2.77	1.00	.59	.25	.18	.13	.06	.02	.00	.00	.01	.01	5.02
1992	.01	.10	.20	.16	.25	.27	.14	.04	.01	.00	.00	.01	1.19
1993	.67	.33	2.35	2.80	.76	2.23	.76	.03	.01	.01	.02	.02	9.99
1994	.03	.04	.05	3.48	1.20	.75	.24	.01	.00	.01	.00	.02	5.83

Afforestation and dryland sugar cane water use for 2030 – TM13.AFF Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.54	.89	.28	.33	.87	1.19	.59	.28	.23	.09	.06	.13	6.48
1921	.18	.84	1.29	.73	.37	.26	.12	.05	.08	.08	.09	.10	4.19
1922	.07	.62	.77	.71	1.20	.82	.19	.12	.08	.12	.12	.06	4.88
1923	.04	.22	.23	.83	.99	.80	.66	.11	.09	.06	.05	.14	4.22
1924	.27	.77	1.32	1.40	1.47	1.55	1.38	.71	.18	.12	.09	.16	9.42
1925	.30	.27	.12	.23	.38	.18	.05	.04	.08	.09	.03	.68	2.45
1926	1.27	.80	.88	1.34	.88	.30	.13	.06	.04	.03	.04	.04	5.81
1927	.70	.73	1.01	1.67	.80	.44	.39	.09	.08	.05	.04	.04	6.04
1928	.44	.43	.74	1.51	1.26	.77	.39	.15	.16	.20	.10	.24	6.39
1929	.31	.52	.56	.87	.89	.71	.65	.12	.09	.06	.05	.04	4.87
1930	.11	.13	.11	.78	.77	.17	.27	.20	.05	.12	.13	.04	2.88
1931	.07	.09	.13	.95	1.54	.91	.27	.14	.12	.06	.04	.05	4.37
1932	.06	.89	1.58	.81	.92	1.05	.27	.11	.08	.12	.12	.05	6.06
1933	.05	.83	1.53	1.51	.95	.39	.37	.26	.13	.12	.24	.17	6.55
1934	.14	.79	1.40	.81	.77	.90	.27	.11	.08	.08	.05	.04	5.44
1935	.03	.04	.13	.84	1.43	.92	.27	.50	.46	.04	.05	.03	4.74
1936	.10	.61	.66	.27	.80	.75	.13	.08	.06	.05	.04	.02	3.57
1937	.02	.10	.92	1.51	.84	.26	.74	.71	.11	.17	.16	.07	5.61
1938	.80	.88	.89	.93	.96	1.03	.27	.12	.11	.08	.06	.11	6.24
1939	.25	.87	1.46	.97	.41	.37	.21	.73	.83	.16	.06	.10	6.42
1940	.10	.21	.85	.88	.91	1.35	.83	.23	.10	.07	.05	.04	5.62
1941	.12	.13	.16	.83	1.20	1.00	.68	.26	.12	.09	.08	.07	4.74
1942	.14	.79	1.21	1.29	.94	.39	.92	.90	.23	.32	.79	.58	8.50
1943	.86	1.45	.87	.40	.86	.76	.14	.10	.08	.06	.05	.74	6.37
1944	.79	.22	.19	.12	.26	.83	.71	.12	.09	.07	.05	.02	3.47
1945	.02	.03	.05	.79	1.41	.76	.17	.07	.06	.03	.03	.02	3.44
1946	.13	.78	.80	.20	.66	1.28	.78	.16	.22	.20	.08	.06	5.35
1947	.23	.65	.99	1.09	1.04	1.02	.72	.22	.10	.07	.05	.03	6.21
1948	.05	.10	.43	1.01	1.23	1.34	.87	.19	.11	.07	.05	.06	5.51
1949	.07	.79	1.49	.87	.27	.87	.85	.20	.12	.08	.12	.11	5.84
1950	.06	.08	.66	1.28	.85	.88	.78	.14	.10	.06	.16	.20	5.25
1951	.15	.10	.74	1.48	.99	.94	.79	.13	.09	.09	.10	.07	5.67
1952	.18	.31	.83	.80	.86	.82	.18	.14	.09	.06	.10	.10	4.47
1953	.12	.73	1.31	.80	.72	.79	.29	.21	.14	.06	.05	.11	5.33
1954	.33	.70	1.20	1.46	1.42	1.37	.88	.26	.13	.09	.06	.05	7.95
1955	.04	.05	.97	1.02	.75	1.37	.80	.17	.11	.08	.05	.05	5.46
1956	.06	.71	1.40	1.46	.88	.80	.81	.22	.09	.10	.20	.79	7.52
1957	1.25	.69	.29	.77	1.27	.84	.34	.26	.08	.05	.03	.03	5.90
1958	.05	.17	.28	.35	.72	.56	.19	.72	.65	.09	.07	.05	3.90
1959	.19	.76	1.27	.84	.97	1.55	.85	.15	.08	.06	.05	.04	6.81
1960	.12	.73	1.33	.79	.45	.94	.73	.21	.08	.05	.04	.06	5.53
1961	.07	.15	.26	.74	1.25	1.39	1.01	.31	.09	.07	.05	.05	5.44
1962	.05	.85	1.47	1.34	.78	.92	.92	.16	.12	.10	.08	.05	6.84
1963	.14	.86	.87	.92	.89	.31	.28	.09	.06	.05	.04	.35	4.86
1964	.75	.70	.45	.28	.18	.08	.08	.08	.31	.27	.12	.17	3.47
1965	.08	.10	.21	.88	.89	.19	.10	.09	.09	.06	.06	.05	2.80
1966	.09	.62	1.04	1.05	1.28	1.39	1.36	.79	.17	.11	.09	.06	8.05
1967	.09	.74	.87	.33	.22	.21	.16	.06	.04	.03	.03	.03	2.81
1968	.03	.12	.30	.33	.23	.62	.63	.21	.12	.04	.02	.05	2.70
1969	.62	.64	.79	.96	.98	.83	.13	.09	.07	.05	.62	.86	6.64
1970	.35	.16	.16	.90	.92	.17	.12	.16	.14	.09	.11	.08	3.36
1971	.16	.28	.29	.77	.82	.74	.61	.12	.09	.07	.05	.04	4.04
1972	.13	.61	.57	.52	.99	.73	.37	.19	.05	.03	.17	.27	4.63
1973	.11	.63	1.27	1.37	1.49	1.25	.74	.30	.12	.10	.08	.06	7.52
1974	.05	.33	.94	1.35	1.39	.83	.26	.16	.09	.06	.04	.82	6.32
1975	.87	.88	1.54	1.49	1.51	1.51	.89	.27	.21	.11	.08	.06	9.42
1976	.65	.71	.25	.71	.64	.37	.43	.15	.04	.03	.02	.08	4.08
1977	.74	.81	.77	1.33	.85	.52	.46	.10	.04	.04	.03	.10	5.79
1978	.67	.75	.89	1.19	.59	.24	.16	.17	.16	.04	.16	.15	5.17
1979	.05	.06	.21	.81	.77	.22	.13	.07	.05	.04	.03	.15	2.59
1980	.16	.44	.94	1.23	1.41	.80	.19	.13	.11	.09	.16	.16	5.82
1981	.06	.40	.45	.76	.74	.81	.83	.13	.09	.07	.05	.17	4.56
1982	.73	.63	.14	.30	.23	.20	.25	.10	.04	.05	.07	.05	2.79
1983	.16	.63	1.18	.87	.24	.77	.86	.19	.08	.06	.10	.09	5.23
1984	.18	.22	.19	.67	1.26	.83	.18	.11	.08	.06	.04	.03	3.85
1985	.84	1.30	.70	.89	.88	.31	.15	.08	.07	.06	.09	.09	5.46
1986	.40	.47	.28	.31	.73	1.27	.73	.10	.07	.05	.28	.66	5.35
1987	.53	.18	.15	.91	1.59	1.41	.75	.19	.24	.21	.09	.07	6.32
1988	.07	.15	.69	.80	.72	.60	.17	.09	.08	.05	.04	.02	3.48
1989	.07	.87	.98	.31	.22	.25	.23	.09	.03	.03	.09	.09	3.26
1990	.05	.07	.82	1.57	1.17	.47	.12	.09	.06	.06	.04	.04	4.56
1991	.75	.88	.95	.90	.88	.90	.20	.13	.08	.06	.04	.03	5.80
1992	.04	.12	.83	1.36	1.15	.74	.29	.11	.09	.05	.04	.04	4.86
1993	.76	.90	.90	1.38	1.35	1.43	.84	.19	.11	.08	.06	.06	8.06
1994	.07	.07	.81	1.42	.71	.48	.45	.07	.05	.05	.03	.03	4.24

Afforestation and dryland sugar cane water use for 2030 – TM18.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.49	.87	.26	.28	1.05	1.64	.82	.25	.21	.09	.08	.10	7.14
1921	.15	.90	1.60	.94	.35	.29	.13	.07	.09	.10	.10	.10	4.82
1922	.17	.86	.87	.92	1.41	.78	.19	.11	.08	.07	.07	.06	5.59
1923	.06	.15	.19	.87	.98	.78	.68	.11	.09	.06	.05	.11	4.13
1924	.21	.57	1.11	1.08	1.13	1.41	1.28	.68	.19	.12	.09	.12	7.99
1925	.23	.25	.12	.16	.28	.19	.07	.06	.07	.06	.06	.01	1.56
1926	.31	.45	.79	1.31	.79	.32	.20	.07	.06	.05	.03	.04	4.42
1927	.00	.00	.84	1.24	.47	.28	.24	.09	.07	.06	.03	.04	3.36
1928	.18	.20	.43	.76	.59	.56	.41	.12	.12	.23	.18	.17	3.95
1929	.25	.86	.86	.88	.93	.85	.75	.13	.09	.06	.06	.05	5.77
1930	.09	.10	.10	.28	.25	.10	.18	.15	.04	.07	.08	.04	1.48
1931	.04	.06	.12	.98	1.55	.83	.24	.13	.12	.07	.05	.04	4.23
1932	.05	.89	1.54	.76	.91	1.00	.23	.11	.07	.08	.08	.06	5.78
1933	.05	.93	1.59	1.42	.88	.33	.31	.24	.13	.08	.16	.13	6.25
1934	.11	.84	1.44	.77	1.04	1.16	.27	.13	.09	.08	.06	.04	6.03
1935	.04	.04	.10	1.10	1.69	.86	.24	.24	.23	.08	.05	.03	4.70
1936	.08	.94	1.01	.23	.51	.44	.06	.05	.04	.03	.02	.02	3.43
1937	.02	.07	.94	1.53	.80	.23	.35	.26	.02	.10	.10	.06	4.48
1938	.80	.89	.87	.90	.95	.99	.23	.11	.09	.09	.07	.10	6.09
1939	.20	.88	1.43	.86	.33	.30	.18	.73	.80	.14	.07	.08	6.00
1940	.09	.16	.60	.64	.89	1.34	.78	.20	.10	.06	.05	.03	4.94
1941	.10	.10	.12	1.04	1.71	1.47	.88	.23	.12	.09	.07	.07	6.00
1942	.12	1.00	1.69	1.49	.89	.33	.92	.90	.20	.21	.74	.64	9.13
1943	.84	1.40	.79	.32	1.01	.96	.17	.10	.08	.07	.06	.76	6.56
1944	.82	.20	.15	.08	.20	.90	.85	.14	.10	.07	.05	.03	3.59
1945	.02	.03	.04	.51	.76	.41	.19	.08	.05	.03	.02	.02	2.16
1946	.08	.81	.85	.19	.98	1.56	.75	.17	.15	.12	.07	.06	5.79
1947	.17	.92	1.52	1.53	1.06	.61	.48	.17	.08	.06	.04	.03	6.67
1948	.03	.07	.24	.96	1.37	1.27	.78	.18	.11	.07	.06	.05	5.19
1949	.05	.83	1.49	.81	.25	.91	.91	.20	.12	.08	.10	.10	5.85
1950	.06	.07	1.03	1.64	.82	.86	.81	.15	.09	.06	.11	.16	5.86
1951	.14	.10	.22	.98	.95	.83	.73	.11	.09	.07	.09	.07	4.38
1952	.14	.25	.87	.85	.88	.86	.19	.12	.08	.05	.06	.08	4.43
1953	.10	.33	.64	.47	.94	1.00	.24	.18	.12	.06	.04	.08	4.20
1954	.21	.92	1.45	1.38	1.10	1.06	.81	.25	.14	.08	.07	.05	7.52
1955	.04	.04	.98	1.02	1.02	1.60	.76	.17	.11	.08	.06	.05	5.93
1956	.05	.22	.93	1.41	.86	.86	.83	.19	.09	.08	.14	.85	6.51
1957	1.31	.67	.26	1.01	1.51	.79	.29	.21	.08	.05	.04	.03	6.25
1958	.03	.19	.30	.27	.80	.74	.18	.75	.70	.10	.07	.06	4.19
1959	.14	.49	.72	.46	.89	1.43	.83	.23	.10	.06	.04	.04	5.43
1960	.10	.28	.56	.41	.22	.91	.86	.16	.07	.06	.04	.04	3.71
1961	.06	.12	.26	.92	1.14	1.07	.87	.25	.10	.06	.06	.04	4.95
1962	.05	.92	1.53	1.30	.78	.96	.96	.18	.10	.09	.07	.06	7.00
1963	.09	.88	.93	.91	.89	.28	.27	.12	.06	.05	.04	.15	4.67
1964	.84	.77	.15	.16	.14	.07	.07	.06	.19	.24	.19	.16	3.04
1965	.09	.08	.15	.92	.96	.17	.11	.09	.09	.06	.05	.05	2.82
1966	.06	.93	1.27	.67	.98	1.30	1.26	.72	.16	.11	.07	.06	7.59
1967	.06	.27	.30	.17	.15	.16	.12	.06	.05	.03	.03	.03	1.43
1968	.03	.09	.24	.29	.26	.81	.76	.20	.12	.05	.03	.03	2.91
1969	.18	.21	.44	.46	.69	.69	.11	.07	.06	.04	.16	.30	3.41
1970	.16	.06	.10	.87	.93	.16	.10	.14	.13	.08	.10	.09	2.92
1971	.13	.23	.25	.59	.51	.58	.63	.13	.08	.06	.05	.03	3.27
1972	.09	.91	.90	.26	.91	.86	.29	.16	.06	.03	.11	.23	4.81
1973	.17	.18	.81	1.33	1.35	1.39	.89	.23	.12	.09	.07	.06	6.69
1974	.04	.19	.94	1.47	1.34	.79	.23	.15	.08	.07	.05	.80	6.15
1975	.83	.84	1.46	1.40	1.41	1.39	.83	.25	.18	.10	.07	.06	8.82
1976	.20	.26	.19	.92	.89	.25	.33	.19	.05	.02	.02	.05	3.37
1977	.77	.85	.32	.55	.46	.26	.30	.16	.04	.02	.03	.07	3.83
1978	.23	.22	.69	.96	.37	.16	.13	.14	.13	.05	.13	.14	3.35
1979	.06	.06	.15	.41	.33	.10	.09	.05	.04	.03	.02	.09	1.43
1980	.11	.20	.90	1.42	1.35	.78	.19	.12	.09	.07	.11	.12	5.46
1981	.06	.20	.26	.81	.77	.81	.84	.13	.08	.06	.05	.12	4.19
1982	.76	.72	.14	.27	.23	.19	.22	.11	.05	.04	.05	.05	2.83
1983	.10	.91	1.48	.85	.27	.81	.85	.17	.08	.06	.08	.08	5.74
1984	.13	.17	.16	.99	1.58	.79	.18	.11	.06	.05	.04	.03	4.29
1985	.83	1.53	.88	.84	.84	.27	.14	.07	.06	.05	.06	.06	5.63
1986	.18	.27	.25	.28	.82	1.31	.68	.10	.08	.06	.14	.89	5.06
1987	.85	.18	.15	.93	1.54	1.08	.51	.20	.20	.19	.10	.06	5.99
1988	.07	.13	.98	1.07	.92	.86	.17	.09	.07	.07	.04	.02	4.49
1989	.03	.88	1.00	.26	.21	.21	.21	.10	.04	.03	.06	.06	3.09
1990	.05	.06	.63	1.33	.92	.24	.10	.08	.05	.04	.04	.03	3.57
1991	.99	1.11	.92	.91	.89	.90	.20	.11	.07	.05	.03	.03	6.21
1992	.03	.09	1.03	1.59	1.39	.95	.25	.13	.08	.06	.03	.03	5.66
1993	.84	.97	.87	1.35	1.30	1.33	.78	.19	.12	.07	.06	.05	7.93
1994	.05	.05	.20	.57	.42	.23	.22	.07	.06	.03	.04	.01	1.95

Afforestation and dryland sugar cane water use for 2030 – TM20.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.21	0.22	0.11	0.05	0.16	0.19	0.07	0.04	0.03	0.02	0.00	0.01	1.11
1921	0.03	0.15	0.18	0.08	0.04	0.15	0.08	0.03	0.02	0.01	0.02	0.01	0.80
1922	0.15	0.19	0.19	0.22	0.21	0.20	0.08	0.03	0.02	0.02	0.00	0.01	1.32
1923	0.01	0.15	0.09	0.15	0.07	0.04	0.02	0.02	0.01	0.01	0.00	0.02	0.59
1924	0.04	0.14	0.19	0.19	0.11	0.15	0.16	0.07	0.03	0.03	0.02	0.17	1.30
1925	0.19	0.06	0.03	0.18	0.10	0.14	0.05	0.03	0.01	0.02	0.00	0.15	0.96
1926	0.09	0.04	0.16	0.09	0.16	0.20	0.08	0.03	0.02	0.02	0.01	0.02	0.92
1927	0.15	0.06	0.18	0.22	0.11	0.15	0.06	0.02	0.02	0.02	0.01	0.01	1.01
1928	0.00	0.00	0.12	0.21	0.10	0.16	0.08	0.03	0.04	0.04	0.01	0.16	0.95
1929	0.09	0.14	0.07	0.17	0.21	0.20	0.07	0.03	0.03	0.02	0.01	0.01	1.05
1930	0.02	0.03	0.18	0.21	0.09	0.14	0.07	0.03	0.00	0.02	0.01	0.01	0.81
1931	0.01	0.00	0.02	0.18	0.19	0.10	0.04	0.01	0.01	0.02	0.01	0.01	0.60
1932	0.00	0.18	0.21	0.08	0.21	0.12	0.04	0.02	0.01	0.02	0.01	0.01	0.91
1933	0.01	0.17	0.20	0.20	0.10	0.16	0.17	0.08	0.02	0.03	0.05	0.02	1.21
1934	0.03	0.15	0.18	0.08	0.19	0.19	0.08	0.03	0.02	0.01	0.01	0.01	0.98
1935	0.00	0.02	0.00	0.15	0.20	0.18	0.07	0.04	0.02	0.01	0.01	0.01	0.71
1936	0.03	0.15	0.09	0.17	0.20	0.10	0.03	0.02	0.02	0.01	0.00	0.01	0.83
1937	0.00	0.02	0.17	0.20	0.21	0.10	0.14	0.06	0.02	0.03	0.03	0.01	0.99
1938	0.18	0.10	0.16	0.19	0.20	0.18	0.09	0.04	0.02	0.02	0.00	0.03	1.21
1939	0.03	0.13	0.09	0.16	0.19	0.18	0.08	0.14	0.08	0.03	0.02	0.03	1.16
1940	0.03	0.16	0.20	0.22	0.21	0.19	0.08	0.03	0.02	0.02	0.01	0.01	1.18
1941	0.01	0.05	0.04	0.15	0.20	0.19	0.09	0.03	0.02	0.01	0.01	0.02	0.82
1942	0.02	0.15	0.19	0.20	0.20	0.09	0.17	0.15	0.06	0.12	0.14	0.06	1.55
1943	0.17	0.19	0.20	0.00	0.00	0.11	0.04	0.01	0.01	0.01	0.02	0.17	0.93
1944	0.09	0.03	0.02	0.04	0.15	0.20	0.07	0.03	0.02	0.01	0.00	0.00	0.66
1945	0.01	0.00	0.02	0.16	0.19	0.20	0.08	0.03	0.03	0.02	0.01	0.00	0.75
1946	0.02	0.17	0.10	0.04	0.15	0.19	0.07	0.02	0.02	0.02	0.02	0.01	0.83
1947	0.02	0.15	0.18	0.20	0.20	0.19	0.09	0.05	0.01	0.01	0.00	0.01	1.11
1948	0.00	0.02	0.15	0.21	0.23	0.20	0.07	0.03	0.02	0.01	0.01	0.01	0.96
1949	0.02	0.15	0.19	0.10	0.05	0.15	0.16	0.08	0.03	0.02	0.03	0.01	0.99
1950	0.01	0.03	0.00	0.08	0.20	0.09	0.05	0.03	0.02	0.01	0.04	0.03	0.59
1951	0.03	0.01	0.18	0.20	0.18	0.17	0.07	0.03	0.03	0.01	0.02	0.02	0.95
1952	0.03	0.14	0.18	0.09	0.17	0.09	0.03	0.03	0.02	0.02	0.01	0.01	0.82
1953	0.02	0.04	0.17	0.09	0.15	0.09	0.03	0.03	0.02	0.01	0.01	0.02	0.68
1954	0.15	0.18	0.09	0.15	0.18	0.08	0.04	0.02	0.01	0.02	0.00	0.01	0.93
1955	0.00	0.00	0.16	0.08	0.18	0.20	0.07	0.03	0.02	0.01	0.01	0.01	0.77
1956	0.02	0.16	0.20	0.20	0.19	0.19	0.10	0.03	0.02	0.01	0.03	0.14	1.29
1957	0.16	0.08	0.14	0.18	0.20	0.09	0.16	0.07	0.02	0.01	0.01	0.01	1.13
1958	0.01	0.14	0.18	0.18	0.18	0.00	0.00	0.09	0.04	0.02	0.01	0.01	0.86
1959	0.02	0.13	0.19	0.09	0.14	0.08	0.14	0.07	0.01	0.01	0.01	0.01	0.90
1960	0.03	0.14	0.18	0.09	0.15	0.18	0.09	0.03	0.02	0.00	0.01	0.00	0.92
1961	0.01	0.16	0.20	0.19	0.20	0.19	0.16	0.07	0.02	0.02	0.02	0.00	1.24
1962	0.01	0.18	0.20	0.18	0.09	0.18	0.08	0.03	0.02	0.03	0.03	0.01	1.04
1963	0.15	0.19	0.09	0.18	0.10	0.17	0.09	0.02	0.01	0.02	0.01	0.13	1.16
1964	0.17	0.18	0.19	0.22	0.11	0.04	0.03	0.02	0.15	0.07	0.03	0.04	1.25
1965	0.01	0.03	0.03	0.16	0.17	0.08	0.02	0.02	0.01	0.01	0.01	0.02	0.57
1966	0.01	0.19	0.21	0.20	0.21	0.19	0.19	0.08	0.03	0.02	0.01	0.01	1.35
1967	0.02	0.14	0.17	0.20	0.11	0.05	0.01	0.01	0.00	0.01	0.00	0.02	0.74
1968	0.00	0.03	0.16	0.18	0.19	0.19	0.10	0.05	0.02	0.00	0.01	0.01	0.94
1969	0.16	0.08	0.16	0.19	0.18	0.07	0.03	0.01	0.02	0.01	0.15	0.15	1.21
1970	0.14	0.06	0.03	0.06	0.05	0.05	0.02	0.03	0.01	0.02	0.03	0.01	0.51
1971	0.12	0.08	0.05	0.16	0.18	0.18	0.08	0.04	0.02	0.02	0.01	0.00	0.94
1972	0.02	0.17	0.08	0.06	0.16	0.17	0.19	0.07	0.02	0.01	0.02	0.04	1.01
1973	0.03	0.15	0.18	0.19	0.19	0.18	0.10	0.04	0.02	0.02	0.01	0.01	1.12
1974	0.01	0.16	0.20	0.20	0.20	0.10	0.06	0.02	0.02	0.01	0.02	0.16	1.16
1975	0.06	0.16	0.20	0.19	0.21	0.21	0.09	0.04	0.03	0.03	0.02	0.03	1.27
1976	0.16	0.07	0.05	0.00	0.00	0.17	0.10	0.03	0.02	0.00	0.01	0.03	0.64
1977	0.04	0.04	0.13	0.18	0.19	0.19	0.19	0.08	0.03	0.02	0.00	0.03	1.12
1978	0.13	0.18	0.20	0.21	0.11	0.05	0.02	0.03	0.03	0.02	0.03	0.01	1.02
1979	0.01	0.01	0.03	0.17	0.19	0.19	0.08	0.03	0.03	0.01	0.00	0.04	0.79
1980	0.01	0.15	0.18	0.18	0.20	0.09	0.03	0.02	0.01	0.02	0.03	0.02	0.94
1981	0.01	0.15	0.09	0.13	0.07	0.17	0.08	0.03	0.02	0.01	0.00	0.01	0.77
1982	0.02	0.01	0.06	0.05	0.02	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.21
1983	0.02	0.15	0.20	0.21	0.10	0.15	0.08	0.02	0.02	0.01	0.02	0.01	0.99
1984	0.02	0.01	0.02	0.16	0.20	0.09	0.03	0.03	0.02	0.01	0.01	0.01	0.61
1985	0.00	0.04	0.18	0.20	0.19	0.09	0.06	0.03	0.02	0.00	0.01	0.01	0.83
1986	0.13	0.16	0.18	0.20	0.20	0.19	0.08	0.03	0.01	0.01	0.04	0.15	1.38
1987	0.08	0.13	0.09	0.05	0.16	0.18	0.09	0.03	0.03	0.01	0.01	0.01	0.87
1988	0.04	0.15	0.18	0.21	0.21	0.19	0.08	0.03	0.02	0.01	0.00	0.00	1.12
1989	0.00	0.17	0.22	0.21	0.09	0.17	0.08	0.03	0.01	0.01	0.01	0.01	1.01
1990	0.01	0.02	0.17	0.21	0.20	0.18	0.06	0.03	0.03	0.00	0.01	0.01	0.93
1991	0.16	0.18	0.19	0.09	0.20	0.09	0.03	0.02	0.01	0.00	0.01	0.01	0.99
1992	0.00	0.00	0.04	0.05	0.15	0.20	0.07	0.02	0.02	0.00	0.01	0.02	0.58
1993	0.05	0.03	0.14	0.18	0.09	0.05	0.03	0.01	0.01	0.02	0.00	0.00	0.61
1994	0.02	0.00	0.02	0.16	0.08	0.20	0.12	0.03	0.02	0.02	0.02	0.01	0.70

Afforestation and dryland sugar cane water use for 2030 – TM22.AFF Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.06	.06	.04	.06	.10	.52	.18	.02	.02	.02	.02	.04	1.14
1921	.04	.62	.68	.18	.04	.06	.04	.02	.02	.04	.04	.02	1.80
1922	.06	.54	.22	.56	.22	.04	.02	.02	.00	.00	.00	.00	1.68
1923	.02	.02	.04	.06	.08	.06	.02	.02	.00	.02	.00	.02	.36
1924	.06	.64	.64	.58	.20	.50	.18	.02	.02	.00	.02	.04	2.90
1925	.06	.04	.04	.06	.06	.06	.04	.02	.02	.00	.00	.04	.44
1926	.08	.08	.06	.06	.08	.08	.04	.02	.02	.02	.02	.02	.58
1927	.04	.04	.08	.54	.20	.04	.02	.00	.00	.00	.00	.02	.98
1928	.04	.02	.02	.08	.06	.08	.06	.02	.02	.04	.04	.06	.54
1929	.06	.08	.04	.08	.06	.66	.24	.00	.02	.00	.00	.02	1.26
1930	.02	.04	.04	.08	.04	.04	.04	.02	.00	.02	.02	.02	.38
1931	.02	.02	.04	.08	.66	.24	.02	.02	.02	.00	.00	.02	1.14
1932	.02	.06	.54	.20	.08	.06	.04	.02	.00	.00	.00	.00	1.02
1933	.02	.68	.64	.60	.16	.06	.06	.04	.02	.02	.02	.04	2.36
1934	.04	.56	.68	.18	.04	.08	.06	.04	.04	.02	.02	.00	1.76
1935	.00	.02	.02	.08	.64	.24	.02	.04	.04	.02	.00	.02	1.14
1936	.04	.64	.24	.04	.08	.06	.02	.00	.00	.02	.00	.00	1.14
1937	.00	.04	.08	.10	.08	.04	.06	.04	.02	.02	.02	.00	.50
1938	.06	.04	.08	.06	.58	.22	.04	.02	.00	.00	.02	.02	1.14
1939	.06	.54	.60	.18	.06	.06	.04	.54	.18	.02	.02	.02	2.32
1940	.04	.08	.60	.20	.06	.08	.06	.02	.02	.02	.00	.00	1.18
1941	.02	.02	.02	.08	.10	.54	.18	.02	.00	.02	.02	.02	1.04
1942	.04	.60	.66	.54	.16	.04	.60	.22	.00	.04	.46	.16	3.52
1943	.54	.22	.06	.06	.58	.22	.02	.02	.02	.00	.02	.04	1.80
1944	.04	.04	.04	.04	.06	.66	.24	.00	.00	.00	.00	.00	1.12
1945	.00	.00	.02	.08	.10	.06	.04	.00	.00	.02	.00	.00	.32
1946	.02	.04	.06	.08	.60	.22	.04	.02	.04	.04	.02	.02	1.20
1947	.04	.60	.24	.06	.06	.50	.18	.02	.00	.00	.00	.00	1.70
1948	.02	.04	.06	.08	.10	.08	.04	.02	.00	.00	.00	.02	.46
1949	.02	.04	.00	.00	.00	.04	.04	.04	.00	.02	.02	.02	.24
1950	.02	.02	.08	.58	.22	.04	.04	.02	.02	.00	.06	.06	1.16
1951	.06	.02	.08	.64	.26	.06	.02	.00	.02	.00	.02	.00	1.18
1952	.04	.06	.10	.06	.62	.22	.02	.02	.02	.00	.02	.02	1.20
1953	.02	.06	.06	.06	.10	.06	.02	.04	.02	.00	.00	.04	.48
1954	.56	.22	.04	.62	.24	.04	.02	.02	.02	.02	.00	.02	1.82
1955	.02	.02	.08	.06	.08	.56	.18	.00	.00	.00	.00	.02	1.02
1956	.02	.08	.60	.70	.20	.46	.16	.02	.00	.00	.02	.62	2.88
1957	.56	.14	.04	.08	.10	.04	.06	.04	.00	.00	.00	.02	1.08
1958	.02	.06	.56	.24	.00	.00	.04	.58	.20	.00	.00	.00	1.70
1959	.04	.06	.06	.06	.08	.06	.08	.04	.02	.00	.02	.02	.54
1960	.04	.06	.60	.22	.06	.06	.06	.02	.02	.00	.00	.02	1.16
1961	.04	.08	.08	.68	.26	.06	.04	.04	.02	.00	.02	.02	1.34
1962	.02	.62	.24	.06	.04	.64	.22	.00	.02	.04	.04	.02	1.96
1963	.02	.06	.04	.66	.24	.04	.06	.02	.02	.02	.02	.04	1.24
1964	.06	.06	.06	.06	.04	.04	.02	.00	.06	.06	.06	.04	.56
1965	.04	.04	.06	.60	.22	.02	.02	.02	.02	.02	.02	.02	1.10
1966	.02	.06	.08	.64	.68	.54	.16	.02	.02	.02	.00	.00	2.24
1967	.02	.08	.08	.08	.06	.04	.04	.00	.02	.00	.00	.02	.44
1968	.02	.04	.08	.06	.08	.64	.22	.02	.02	.00	.02	.02	1.22
1969	.08	.06	.08	.08	.06	.04	.02	.02	.02	.02	.04	.06	.58
1970	.08	.04	.06	.08	.06	.04	.02	.04	.04	.02	.04	.04	.56
1971	.04	.06	.06	.08	.08	.62	.20	.00	.02	.00	.00	.00	1.16
1972	.02	.04	.04	.08	.70	.26	.06	.02	.00	.00	.02	.04	1.28
1973	.04	.06	.06	.68	.28	.38	.16	.02	.02	.02	.00	.02	1.74
1974	.00	.04	.06	.10	.56	.18	.02	.00	.00	.00	.00	.06	1.02
1975	.04	.06	.60	.70	.62	.58	.16	.02	.02	.02	.00	.02	2.84
1976	.08	.06	.04	.08	.04	.08	.06	.04	.00	.00	.00	.02	.50
1977	.06	.06	.62	.70	.18	.06	.08	.04	.02	.02	.00	.04	1.88
1978	.08	.08	.62	.60	.16	.04	.02	.04	.04	.02	.02	.02	1.74
1979	.04	.02	.04	.06	.06	.04	.02	.00	.00	.00	.00	.04	.32
1980	.04	.06	.08	.08	.44	.16	.02	.02	.02	.00	.02	.02	.96
1981	.02	.06	.04	.06	.04	.58	.20	.00	.00	.00	.00	.02	1.02
1982	.08	.06	.04	.04	.04	.06	.04	.02	.00	.02	.02	.02	.44
1983	.04	.66	.26	.06	.06	.08	.06	.02	.00	.00	.02	.02	1.28
1984	.04	.04	.04	.72	.68	.18	.00	.00	.00	.00	.00	.00	1.70
1985	.08	.08	.50	.56	.16	.04	.02	.00	.00	.02	.02	.00	1.48
1986	.04	.06	.06	.54	.56	.56	.14	.02	.02	.02	.06	.62	2.70
1987	.22	.04	.04	.06	.06	.44	.16	.02	.02	.02	.02	.00	1.10
1988	.04	.04	.60	.22	.54	.20	.02	.00	.00	.00	.00	.00	1.66
1989	.02	.62	.24	.04	.06	.08	.06	.02	.02	.00	.02	.02	1.20
1990	.04	.04	.08	.60	.56	.14	.02	.02	.02	.02	.00	.02	1.56
1991	.08	.06	.04	.04	.08	.06	.04	.00	.00	.00	.00	.00	.40
1992	.02	.04	.04	.06	.08	.10	.04	.02	.02	.00	.00	.02	.44
1993	.08	.06	.00	.00	.00	.04	.04	.02	.00	.02	.02	.02	.30
1994	.02	.02	.04	.08	.04	.04	.04	.02	.04	.02	.02	.00	.38

Afforestation and dryland sugar cane water use for 2030 – TM23.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.27	0.40	0.13	0.22	0.91	1.07	0.29	0.04	0.03	0.01	0.01	0.13	4.51
1921	0.16	1.11	1.30	0.40	0.14	0.14	0.06	0.04	0.09	0.06	0.10	0.07	3.67
1922	0.84	0.73	1.03	1.27	1.14	0.35	0.05	0.01	0.01	0.03	0.03	0.02	5.51
1923	0.02	0.08	0.11	0.96	0.33	0.08	0.04	0.03	0.02	0.01	0.02	0.11	1.81
1924	0.16	1.07	1.23	1.21	1.21	1.28	0.42	0.05	0.01	0.02	0.01	0.10	6.77
1925	0.22	0.08	0.08	0.16	0.15	0.15	0.03	0.02	0.05	0.04	0.01	1.01	2.00
1926	1.03	0.35	0.93	0.42	0.59	0.74	0.20	0.01	0.00	0.01	0.07	0.05	4.40
1927	0.16	0.10	1.33	1.49	0.40	0.68	0.17	0.00	0.02	0.00	0.01	0.07	4.43
1928	0.14	0.10	0.11	1.18	0.46	1.09	0.39	0.03	0.08	0.14	0.07	0.04	3.83
1929	0.48	0.72	0.25	1.21	0.48	1.10	0.40	0.03	0.01	0.01	0.02	0.05	4.76
1930	0.12	0.12	0.17	1.02	0.38	0.12	0.11	0.05	0.01	0.06	0.05	0.01	2.22
1931	0.08	0.06	0.12	1.11	1.35	1.16	0.29	0.10	0.07	0.02	0.00	0.05	4.41
1932	0.08	1.23	1.46	0.40	1.21	0.50	0.07	0.02	0.00	0.10	0.07	0.02	5.16
1933	0.05	1.25	1.44	1.35	0.41	0.98	0.41	0.09	0.03	0.05	0.10	0.07	6.23
1934	0.12	1.04	1.31	0.35	0.34	0.72	0.26	0.06	0.13	0.06	0.02	0.01	4.42
1935	0.03	0.06	0.08	1.33	1.42	1.14	0.28	0.70	0.16	0.00	0.00	0.02	5.22
1936	0.11	1.14	0.45	0.14	1.20	0.46	0.04	0.01	0.01	0.01	0.00	0.02	3.59
1937	0.05	0.13	1.08	1.37	1.20	0.33	1.00	0.33	0.03	0.11	0.08	0.03	5.74
1938	0.74	0.23	1.14	0.45	0.84	0.37	0.07	0.07	0.04	0.02	0.03	0.12	4.12
1939	0.19	0.92	1.18	0.36	0.74	1.01	0.28	0.94	0.38	0.03	0.01	0.09	6.13
1940	0.12	1.16	1.33	0.41	0.96	1.19	0.36	0.04	0.01	0.01	0.01	0.01	5.61
1941	0.10	0.13	0.09	1.29	1.33	1.17	0.35	0.06	0.03	0.02	0.06	0.07	4.70
1942	0.14	1.06	1.28	1.35	0.44	0.16	1.07	0.40	0.00	0.50	0.47	0.12	6.99
1943	1.16	1.22	0.38	0.14	1.06	0.42	0.06	0.02	0.03	0.02	0.01	1.00	5.52
1944	0.38	0.11	0.06	0.13	0.19	1.08	0.37	0.03	0.02	0.01	0.00	0.00	2.38
1945	0.01	0.01	0.09	1.34	1.28	0.38	0.06	0.02	0.01	0.00	0.01	0.01	3.22
1946	0.09	0.35	0.16	0.16	0.79	1.04	0.33	0.03	0.06	0.05	0.01	0.05	3.12
1947	0.13	1.08	1.32	1.20	1.08	1.06	0.34	0.05	0.02	0.01	0.00	0.02	6.31
1948	0.07	0.13	0.17	0.53	0.87	1.12	0.35	0.04	0.01	0.01	0.01	0.05	3.36
1949	0.06	0.16	1.10	0.43	0.14	1.00	0.39	0.06	0.02	0.02	0.09	0.06	3.53
1950	0.04	0.08	1.24	1.31	0.40	0.14	0.10	0.04	0.01	0.00	0.48	0.22	4.06
1951	0.11	0.06	1.25	1.44	1.27	0.42	0.06	0.03	0.02	0.03	0.03	0.02	4.74
1952	0.11	0.17	0.97	0.40	1.09	0.39	0.06	0.03	0.01	0.00	0.08	0.06	3.37
1953	0.11	0.14	0.19	0.13	0.90	0.35	0.08	0.11	0.06	0.02	0.00	0.10	2.19
1954	0.99	0.48	0.10	1.08	1.03	0.22	0.06	0.05	0.02	0.01	0.01	0.04	4.09
1955	0.08	0.11	1.27	0.42	1.38	1.30	0.31	0.02	0.01	0.01	0.01	0.06	4.98
1956	0.10	1.18	1.38	1.31	0.43	0.89	0.34	0.03	0.01	0.02	0.07	1.09	6.85
1957	1.18	0.36	0.12	1.16	1.33	0.35	0.97	0.33	0.01	0.01	0.00	0.04	5.86
1958	0.06	1.14	1.26	1.29	1.29	0.38	0.11	1.01	0.33	0.01	0.02	0.02	6.92
1959	0.13	0.16	0.16	0.10	1.14	0.46	0.98	0.32	0.01	0.00	0.02	0.06	3.54
1960	0.12	0.45	0.84	0.36	1.00	1.19	0.84	0.12	0.00	0.01	0.02	0.08	5.03
1961	0.09	1.05	0.47	1.08	1.13	1.07	0.36	0.05	0.01	0.00	0.03	0.03	5.37
1962	0.05	1.19	1.25	1.24	0.37	1.15	0.42	0.02	0.02	0.11	0.05	0.01	5.88
1963	0.16	0.39	0.13	1.15	0.45	0.16	0.13	0.05	0.05	0.03	0.02	0.12	2.84
1964	1.03	0.41	0.10	0.14	0.13	0.05	0.03	0.04	0.99	0.35	0.08	0.09	3.44
1965	0.11	0.13	0.16	1.11	0.45	0.05	0.04	0.08	0.05	0.02	0.05	0.04	2.29
1966	0.08	0.53	0.90	1.22	1.25	1.09	0.93	0.24	0.01	0.02	0.02	0.01	6.30
1967	0.10	1.25	0.50	1.13	0.44	0.13	0.09	0.03	0.01	0.01	0.05	0.06	3.80
1968	0.07	0.14	1.16	0.48	0.40	0.77	0.28	0.09	0.04	0.03	0.03	0.05	3.54
1969	1.15	0.46	1.09	0.48	0.17	0.09	0.03	0.03	0.03	0.01	0.14	0.87	4.55
1970	0.54	0.10	0.98	0.89	0.20	0.08	0.09	0.11	0.06	0.07	0.12	0.07	3.31
1971	0.14	0.17	0.23	0.89	0.91	0.71	0.18	0.04	0.03	0.01	0.01	0.01	3.33
1972	0.08	0.18	0.10	1.17	1.34	0.42	0.91	0.30	0.01	0.01	0.08	0.16	4.76
1973	0.10	0.14	0.12	1.09	1.29	1.22	0.37	0.05	0.03	0.03	0.02	0.01	4.47
1974	0.02	0.17	0.20	1.03	1.23	0.36	0.08	0.04	0.00	0.01	0.00	1.24	4.38
1975	0.44	1.11	1.33	1.31	1.25	1.24	0.35	0.05	0.03	0.01	0.01	0.05	7.18
1976	1.11	0.41	0.14	1.09	0.39	1.13	0.44	0.04	0.01	0.01	0.02	0.11	4.90
1977	0.51	0.18	1.02	1.31	0.40	1.00	1.12	0.28	0.01	0.01	0.02	0.13	5.99
1978	1.06	1.01	0.78	1.22	0.70	0.14	0.04	0.10	0.05	0.04	0.08	0.07	5.29
1979	0.07	0.06	0.11	0.49	0.20	0.08	0.05	0.03	0.01	0.00	0.00	0.52	1.62
1980	0.15	1.02	1.20	1.33	1.30	0.36	0.05	0.03	0.03	0.02	0.08	0.10	5.67
1981	0.05	1.14	0.43	0.22	0.11	0.94	0.34	0.03	0.01	0.01	0.01	0.10	3.39
1982	1.07	0.41	0.16	0.13	0.06	0.10	0.05	0.02	0.01	0.03	0.06	0.04	2.14
1983	0.10	1.17	1.12	0.88	0.29	1.01	0.39	0.03	0.03	0.02	0.04	0.04	5.12
1984	0.16	0.12	0.12	1.23	1.40	0.41	0.04	0.00	0.00	0.00	0.01	0.02	3.51
1985	1.24	1.34	1.20	1.33	0.43	0.12	0.07	0.02	0.03	0.02	0.03	0.03	5.86
1986	0.16	0.16	1.02	1.40	1.35	1.18	0.32	0.02	0.04	0.04	0.92	1.17	7.78
1987	0.37	0.26	0.12	0.29	0.85	1.12	0.32	0.04	0.07	0.06	0.04	0.02	3.56
1988	0.10	0.17	1.06	0.44	1.03	0.36	0.03	0.01	0.02	0.01	0.00	0.01	3.24
1989	0.08	1.14	1.22	0.36	1.07	1.24	0.35	0.03	0.02	0.01	0.07	0.06	5.65
1990	0.13	0.13	1.26	1.37	1.30	0.42	0.05	0.03	0.02	0.01	0.01	0.04	4.77
1991	1.20	0.46	0.12	0.09	1.31	0.49	0.04	0.01	0.01	0.01	0.01	0.02	3.77
1992	0.09	0.13	0.18	0.13	1.16	1.23	0.31	0.03	0.02	0.01	0.03	0.04	3.36
1993	1.21	0.45	1.28	1.42	0.38	1.09	0.39	0.02	0.02	0.01	0.05	0.03	6.35
1994	0.09	0.04	0.16	1.06	0.34	0.11	0.12	0.06	0.10	0.06	0.02	0.01	2.17

Afforestation and dryland sugar cane water use for 2030 – TM24.AFF Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.61	0.25	0.04	0.04	0.51	0.65	0.23	0.03	0.01	0.00	0.00	0.05	2.42
1921	0.06	0.53	0.67	0.57	0.54	0.57	0.23	0.02	0.02	0.01	0.03	0.05	3.30
1922	0.46	0.61	0.61	0.66	0.29	0.04	0.01	0.00	0.01	0.01	0.00	0.00	2.70
1923	0.01	0.02	0.01	0.66	0.73	0.26	0.04	0.01	0.01	0.00	0.00	0.03	1.78
1924	0.04	0.50	0.67	0.28	0.46	0.63	0.26	0.03	0.01	0.00	0.00	0.02	2.90
1925	0.04	0.07	0.06	0.05	0.06	0.06	0.03	0.01	0.02	0.01	0.01	0.05	0.47
1926	0.06	0.07	0.07	0.07	0.51	0.64	0.22	0.02	0.00	0.01	0.02	0.01	1.70
1927	0.04	0.04	0.55	0.35	0.07	0.07	0.04	0.01	0.00	0.01	0.00	0.02	1.20
1928	0.03	0.03	0.05	0.08	0.05	0.53	0.30	0.02	0.02	0.03	0.02	0.46	1.62
1929	0.28	0.50	0.32	0.44	0.25	0.04	0.03	0.02	0.01	0.01	0.01	0.02	1.93
1930	0.02	0.02	0.59	0.74	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47
1931	0.01	0.03	0.03	0.07	0.55	0.62	0.21	0.04	0.03	0.01	0.00	0.01	1.61
1932	0.01	0.04	0.50	0.28	0.03	0.07	0.05	0.02	0.00	0.01	0.01	0.01	1.03
1933	0.01	0.65	0.77	0.65	0.26	0.07	0.05	0.03	0.02	0.02	0.03	0.03	2.59
1934	0.02	0.50	0.72	0.31	0.48	0.58	0.21	0.03	0.01	0.01	0.00	0.01	2.88
1935	0.02	0.02	0.03	0.66	0.74	0.59	0.22	0.47	0.27	0.02	0.00	0.01	3.05
1936	0.02	0.63	0.37	0.56	0.71	0.27	0.04	0.01	0.01	0.00	0.01	0.01	2.64
1937	0.01	0.01	0.66	0.41	0.08	0.04	0.03	0.02	0.04	0.04	0.03	0.01	1.38
1938	0.52	0.31	0.56	0.64	0.58	0.25	0.04	0.02	0.02	0.02	0.01	0.01	2.98
1939	0.02	0.60	0.77	0.31	0.41	0.22	0.03	0.47	0.29	0.03	0.01	0.02	3.18
1940	0.03	0.08	0.52	0.32	0.44	0.06	0.00	0.00	0.00	0.00	0.00	0.00	1.45
1941	0.02	0.03	0.06	0.53	0.66	0.25	0.04	0.02	0.02	0.01	0.01	0.04	1.69
1942	0.06	0.51	0.68	0.63	0.26	0.45	0.60	0.23	0.02	0.40	0.52	0.18	4.54
1943	0.50	0.66	0.65	0.59	0.59	0.25	0.03	0.01	0.03	0.03	0.02	0.00	3.36
1944	0.00	0.00	0.00	0.03	0.05	0.57	0.32	0.03	0.01	0.00	0.00	0.01	1.02
1945	0.01	0.00	0.00	0.58	0.37	0.47	0.25	0.01	0.00	0.00	0.00	0.00	1.69
1946	0.03	0.47	0.28	0.05	0.55	0.34	0.05	0.02	0.02	0.02	0.01	0.00	1.84
1947	0.02	0.56	0.74	0.64	0.26	0.07	0.04	0.02	0.00	0.01	0.00	0.02	2.38
1948	0.06	0.07	0.05	0.54	0.71	0.28	0.07	0.03	0.00	0.01	0.00	0.01	1.83
1949	0.05	0.08	0.48	0.30	0.07	0.05	0.07	0.05	0.02	0.01	0.01	0.01	1.20
1950	0.03	0.04	0.08	0.07	0.08	0.06	0.05	0.03	0.01	0.01	0.04	0.04	0.54
1951	0.05	0.03	0.08	0.54	0.30	0.04	0.02	0.02	0.01	0.03	0.04	0.01	1.17
1952	0.01	0.53	0.34	0.50	0.64	0.25	0.05	0.02	0.00	0.01	0.04	0.03	2.42
1953	0.02	0.07	0.07	0.05	0.55	0.63	0.21	0.03	0.02	0.01	0.01	0.02	1.69
1954	0.07	0.47	0.26	0.57	0.69	0.26	0.04	0.01	0.01	0.00	0.00	0.00	2.38
1955	0.03	0.06	0.06	0.06	0.52	0.66	0.23	0.04	0.02	0.01	0.00	0.01	1.70
1956	0.04	0.56	0.70	0.58	0.55	0.59	0.55	0.20	0.02	0.42	0.25	0.37	4.83
1957	0.57	0.22	0.04	0.59	0.72	0.59	0.56	0.21	0.01	0.01	0.00	0.01	3.53
1958	0.05	0.07	0.47	0.28	0.51	0.29	0.04	0.03	0.03	0.01	0.01	0.00	1.79
1959	0.05	0.52	0.32	0.06	0.46	0.27	0.07	0.04	0.01	0.00	0.00	0.01	1.81
1960	0.04	0.08	0.50	0.28	0.04	0.50	0.31	0.04	0.01	0.00	0.01	0.02	1.83
1961	0.02	0.07	0.08	0.52	0.68	0.26	0.03	0.01	0.00	0.00	0.00	0.02	1.69
1962	0.01	0.04	0.05	0.59	0.33	0.05	0.03	0.01	0.02	0.06	0.04	0.01	1.24
1963	0.03	0.46	0.27	0.52	0.31	0.05	0.04	0.03	0.02	0.01	0.01	0.02	1.77
1964	0.00	0.00	0.36	0.61	0.59	0.22	0.02	0.02	0.02	0.02	0.02	0.02	1.90
1965	0.05	0.07	0.05	0.54	0.33	0.03	0.02	0.02	0.01	0.01	0.01	0.02	1.16
1966	0.04	0.07	0.52	0.69	0.58	0.22	0.05	0.02	0.01	0.00	0.00	0.00	2.20
1967	0.01	0.07	0.09	0.06	0.02	0.05	0.04	0.02	0.01	0.00	0.02	0.02	0.41
1968	0.00	0.04	0.09	0.47	0.29	0.48	0.30	0.04	0.01	0.01	0.01	0.00	1.74
1969	0.48	0.29	0.06	0.07	0.47	0.26	0.03	0.02	0.01	0.01	0.03	0.04	1.77
1970	0.07	0.06	0.04	0.65	0.39	0.06	0.06	0.07	0.04	0.02	0.02	0.02	1.50
1971	0.04	0.05	0.61	0.39	0.48	0.63	0.23	0.02	0.01	0.00	0.00	0.00	2.46
1972	0.02	0.07	0.05	0.05	0.47	0.27	0.07	0.04	0.01	0.00	0.04	0.06	1.15
1973	0.04	0.50	0.31	0.50	0.64	0.24	0.06	0.03	0.01	0.02	0.01	0.00	2.36
1974	0.01	0.58	0.71	0.64	0.64	0.25	0.05	0.02	0.01	0.00	0.00	0.47	3.38
1975	0.28	0.07	0.47	0.65	0.61	0.59	0.24	0.06	0.02	0.00	0.00	0.00	2.99
1976	0.07	0.07	0.08	0.55	0.31	0.07	0.04	0.01	0.00	0.00	0.00	0.01	1.21
1977	0.03	0.04	0.57	0.72	0.60	0.25	0.05	0.02	0.01	0.00	0.01	0.03	2.33
1978	0.07	0.07	0.08	0.08	0.42	0.23	0.02	0.01	0.01	0.02	0.06	0.06	1.13
1979	0.04	0.03	0.07	0.52	0.64	0.24	0.03	0.01	0.01	0.00	0.00	0.03	1.62
1980	0.04	0.05	0.07	0.09	0.44	0.24	0.02	0.01	0.01	0.01	0.01	0.04	1.03
1981	0.05	0.04	0.03	0.08	0.06	0.04	0.03	0.01	0.00	0.00	0.01	0.01	0.36
1982	0.49	0.29	0.04	0.06	0.04	0.04	0.04	0.03	0.02	0.02	0.01	0.01	1.09
1983	0.05	0.50	0.67	0.62	0.25	0.49	0.28	0.02	0.01	0.00	0.03	0.04	2.96
1984	0.53	0.32	0.05	0.62	0.73	0.25	0.02	0.00	0.00	0.00	0.01	0.00	2.53
1985	0.49	0.64	0.56	0.59	0.65	0.28	0.05	0.02	0.01	0.01	0.00	0.00	3.30
1986	0.03	0.05	0.09	0.47	0.67	0.27	0.04	0.01	0.01	0.00	0.02	0.54	2.20
1987	0.64	0.59	0.58	0.25	0.37	0.52	0.21	0.02	0.01	0.00	0.00	0.00	3.19
1988	0.05	0.06	0.60	0.68	0.61	0.25	0.03	0.01	0.01	0.01	0.00	0.00	2.31
1989	0.03	0.56	0.74	0.28	0.07	0.48	0.28	0.02	0.00	0.00	0.01	0.01	2.48
1990	0.01	0.00	0.06	0.57	0.69	0.25	0.03	0.00	0.01	0.01	0.00	0.01	1.64
1991	0.56	0.34	0.49	0.29	0.49	0.28	0.02	0.01	0.00	0.00	0.01	0.01	2.50
1992	0.01	0.04	0.06	0.04	0.57	0.33	0.03	0.01	0.00	0.00	0.00	0.00	1.09
1993	0.63	0.39	0.09	0.47	0.61	0.25	0.04	0.01	0.00	0.01	0.01	0.01	2.52
1994	0.03	0.04	0.50	0.71	0.28	0.42	0.24	0.03	0.01	0.01	0.00	0.00	2.27

Afforestation and dryland sugar cane water use for 2030 – TM25.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.01	.48	.16	.18	.75	1.10	.46	.05	.01	.00	.00	.61	4.81
1921	.40	.84	1.18	1.09	1.03	1.12	.46	.07	.06	.03	.12	.39	6.79
1922	.63	.97	1.12	1.15	1.09	.41	.03	.01	.01	.02	.01	.01	5.46
1923	.06	.06	.06	.88	1.14	1.05	.42	.04	.00	.00	.01	.30	4.02
1924	.19	.72	1.10	1.14	1.12	1.16	.73	.16	.00	.01	.01	.06	6.40
1925	.16	.57	.36	.67	.51	.25	.07	.01	.03	.02	.01	.64	3.30
1926	.44	.72	.98	.98	1.09	1.07	.40	.03	.01	.06	.05	.01	5.84
1927	.68	.43	.83	1.06	.92	1.02	.43	.04	.01	.00	.01	.09	5.52
1928	.12	.08	.69	1.14	.50	.86	.47	.03	.09	.14	.06	.69	4.87
1929	.48	.78	1.02	1.12	.55	.11	.10	.05	.01	.03	.03	.05	4.33
1930	.07	.04	.85	1.25	1.04	.42	.07	.02	.01	.02	.01	.01	3.81
1931	.04	.13	.14	.85	1.17	1.04	.38	.39	.19	.00	.00	.02	4.35
1932	.04	.21	.71	.38	.12	.77	.47	.06	.01	.04	.03	.01	2.85
1933	.02	.87	1.18	1.22	.57	.77	.44	.09	.04	.09	.13	.05	5.47
1934	.09	.75	1.15	1.16	1.13	1.04	.43	.06	.01	.01	.01	.02	5.86
1935	.05	.05	.11	.86	1.13	1.11	.43	.77	.43	.03	.00	.01	4.98
1936	.11	.81	.47	.93	1.20	.48	.11	.04	.01	.00	.00	.03	4.19
1937	.03	.04	.88	1.20	.98	.38	.14	.07	.00	.00	.01	.03	3.76
1938	.76	.49	.85	1.09	1.13	1.07	.38	.15	.09	.09	.06	.04	6.20
1939	.08	.81	1.18	1.06	1.03	.40	.06	.70	.54	.09	.00	.10	6.05
1940	.10	.72	1.13	1.04	1.05	.97	.95	.37	.02	.00	.00	.02	6.37
1941	.06	.10	.76	1.18	1.18	.86	.28	.05	.05	.02	.02	.53	5.09
1942	.69	.78	1.02	1.19	.55	.74	1.09	.45	.04	.73	1.00	.37	8.65
1943	.80	1.11	1.12	1.07	1.15	.52	.06	.00	.28	.14	.00	.67	6.92
1944	.96	.39	.08	.12	.27	.69	.38	.05	.01	.00	.00	.00	2.95
1945	.01	.00	.01	.85	1.17	1.11	.42	.03	.00	.00	.00	.00	3.60
1946	.66	1.02	.49	.17	.85	.99	.38	.05	.08	.06	.02	.01	4.78
1947	.07	.79	1.16	1.18	1.05	1.00	.39	.03	.02	.00	.00	.06	5.75
1948	.59	.43	.17	.85	1.16	1.05	.86	.30	.02	.01	.01	.03	5.48
1949	.73	.98	1.12	1.16	1.02	.45	.57	.34	.04	.01	.02	.02	6.46
1950	.12	.15	.73	.44	.62	.42	.15	.06	.01	.05	.55	.30	3.60
1951	.58	.34	.79	1.17	.47	.10	.10	.04	.01	.68	.39	.03	4.70
1952	.04	.78	.73	.81	1.10	.53	.16	.05	.01	.00	.09	.06	4.36
1953	.05	.69	.49	.19	.84	1.05	.39	.12	.07	.02	.00	.09	4.00
1954	.64	1.05	.48	.86	1.19	.72	.20	.01	.00	.01	.00	.00	5.16
1955	.66	.48	.41	.29	.74	1.05	.40	.06	.02	.00	.00	.04	4.15
1956	.20	.70	1.11	1.10	1.04	1.06	.99	.36	.04	.60	.38	.63	8.21
1957	.95	.40	.12	.83	1.13	1.06	1.00	.37	.03	.00	.00	.07	5.96
1958	.61	1.01	1.10	.69	.74	.42	.10	.11	.05	.03	.02	.02	4.90
1959	.76	1.11	1.06	.51	.75	.44	.70	.38	.03	.00	.02	.04	5.80
1960	.45	.68	1.02	.48	.13	.75	.88	.32	.03	.01	.01	.06	4.82
1961	.08	.68	.49	.71	1.06	.48	.08	.03	.00	.00	.04	.05	3.70
1962	.04	.50	.37	.79	.43	.64	.37	.04	.04	.37	.21	.01	3.81
1963	.43	.75	.36	.82	.55	.16	.15	.07	.09	.06	.02	.07	3.53
1964	.79	.99	.98	1.10	1.08	.40	.04	.01	.10	.07	.04	.05	5.65
1965	.63	.70	.28	.84	.62	.10	.10	.08	.02	.00	.03	.07	3.47
1966	.11	.63	1.06	1.23	1.09	.48	.18	.06	.00	.01	.00	.00	4.85
1967	.05	.70	.99	.46	.08	.63	.39	.04	.01	.01	.03	.02	3.41
1968	.01	.73	1.04	1.07	1.04	1.06	.90	.31	.03	.01	.00	.02	6.22
1969	.73	.47	.77	1.13	1.11	.43	.08	.05	.02	.02	.12	.11	5.04
1970	.64	.45	.14	.87	.53	.13	.53	.78	.30	.03	.04	.05	4.49
1971	.17	.15	.81	1.04	1.08	1.15	.46	.06	.02	.00	.00	.00	4.94
1972	.12	.77	.46	.50	.75	.36	.60	.32	.02	.00	.13	.15	4.18
1973	.06	.75	.63	.75	1.08	.53	.42	.18	.02	.03	.02	.01	4.48
1974	.03	.82	1.20	1.15	1.20	.51	.15	.06	.01	.00	.00	.71	5.84
1975	.43	.73	1.16	1.24	1.13	1.12	.53	.37	.15	.00	.00	.02	6.88
1976	.71	.48	.73	1.14	.50	.80	.45	.03	.01	.00	.01	.04	4.90
1977	.24	.14	.82	1.24	1.11	1.06	.48	.07	.01	.00	.09	.16	5.42
1978	.55	.34	.61	1.02	1.06	.40	.05	.02	.01	.08	.52	.36	5.02
1979	.06	.12	.68	1.13	1.17	.49	.07	.02	.01	.00	.00	.54	4.29
1980	.36	.17	.69	.99	1.05	.41	.05	.01	.03	.02	.05	.11	3.94
1981	.09	.09	.10	.78	.45	.31	.15	.00	.01	.00	.01	.01	2.00
1982	.74	.43	.12	.71	.41	.15	.09	.07	.04	.01	.02	.02	2.81
1983	.80	1.17	1.20	1.21	.56	.77	.44	.04	.01	.03	.38	.19	6.80
1984	.73	.50	.19	.84	1.20	.48	.03	.00	.00	.01	.01	.02	4.01
1985	.73	1.06	1.05	1.16	1.16	.76	.25	.03	.02	.01	.00	.01	6.24
1986	.21	.37	.66	1.00	1.13	.50	.10	.03	.01	.00	.11	.75	4.87
1987	.98	1.02	1.06	1.04	.98	.99	.39	.03	.02	.01	.01	.02	6.55
1988	.64	.43	.86	1.11	1.17	.54	.07	.01	.02	.02	.01	.00	4.88
1989	.11	.70	1.10	.52	.74	1.04	.45	.06	.01	.01	.01	.01	4.76
1990	.02	.02	.81	1.19	1.18	.55	.09	.01	.10	.07	.01	.03	4.08
1991	.77	.69	.80	.49	.83	.48	.06	.02	.01	.00	.11	.07	4.33
1992	.05	.08	.13	.11	.87	.54	.08	.02	.00	.01	.01	.03	1.93
1993	.83	.67	.67	1.08	1.11	.97	.37	.04	.00	.01	.03	.02	5.80
1994	.26	.16	.77	1.17	.54	.71	.41	.05	.01	.01	.00	.00	4.09

Afforestation and dryland sugar cane water use for 2030 – TM27.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.46	.99	.17	.15	.10	2.06	1.20	.09	.01	.02	.02	.04	7.31
1921	.09	2.34	2.84	.98	.14	.07	.04	.03	.04	.04	.08	.09	6.78
1922	2.20	2.72	2.44	1.02	1.63	.90	.06	.01	.01	.02	.02	.01	11.04
1923	.03	.07	.21	2.10	1.24	1.69	.94	.09	.02	.00	.00	.05	6.44
1924	.13	2.30	1.37	.24	1.82	2.51	.98	.11	.03	.02	.01	.06	9.58
1925	.09	.13	.15	.22	.18	1.98	1.12	.09	.09	.07	.02	2.10	6.24
1926	1.22	.16	.16	.12	1.90	1.16	.11	.01	.00	.08	.09	.05	5.06
1927	.12	.09	.15	.19	.17	.15	.09	.03	.01	.00	.03	.06	1.09
1928	.10	.09	.19	.17	.09	2.49	1.44	.09	.06	.08	.06	.14	5.00
1929	1.87	1.96	.52	1.73	1.08	.13	.04	.02	.00	.03	.05	.07	7.50
1930	.05	.04	.20	2.11	1.21	.11	.06	.05	.02	.03	.01	.01	3.90
1931	.01	.06	.06	.06	2.71	3.00	.92	.16	.14	.07	.01	.01	7.21
1932	.01	.00	2.55	1.51	.16	.07	.04	.03	.01	.03	.03	.03	4.47
1933	.04	2.37	2.94	2.54	.99	.18	.11	.06	.04	.04	.09	.06	9.46
1934	.08	.21	1.97	1.15	.20	.14	.11	.08	.02	.01	.00	.01	3.98
1935	.03	.02	.15	2.41	1.44	1.74	.94	2.13	1.21	.07	.02	.03	10.19
1936	.10	2.20	1.25	2.28	2.66	.90	.07	.02	.00	.00	.00	.02	9.50
1937	.03	.05	.16	.22	.20	.17	.19	.11	.06	.07	.04	.03	1.33
1938	.14	.16	2.25	2.85	2.54	2.34	.85	.07	.04	.07	.07	.05	11.43
1939	.07	2.22	1.29	.12	.15	.11	.06	2.23	1.32	.11	.01	.03	7.72
1940	.06	.16	.22	.17	.43	.16	.09	.09	.02	.00	.00	.02	1.42
1941	.04	.06	.13	2.39	2.71	2.28	.87	.08	.07	.06	.03	.06	8.78
1942	.11	2.42	1.47	.23	1.58	2.40	2.22	.83	.06	1.75	2.10	.69	15.86
1943	1.78	2.50	2.44	2.59	2.40	.89	.09	.01	.20	.21	.08	.11	13.30
1944	.21	.15	.05	.09	2.12	2.66	.93	.08	.02	.01	.00	.00	6.32
1945	.00	.02	.02	.14	.20	.22	.13	.03	.02	.00	.00	.02	.80
1946	.12	.20	.14	.09	2.10	1.25	.12	.04	.04	.06	.04	.01	4.21
1947	.03	2.59	2.96	.98	2.24	1.34	.14	.02	.01	.00	.00	.04	10.35
1948	.13	.16	.10	2.43	2.90	.98	1.28	.58	.00	.00	.00	.01	8.57
1949	.16	.18	.10	.03	.04	.11	.11	.09	.05	.02	.02	.02	.93
1950	.04	.13	.18	.14	.08	.12	.13	.10	.04	.01	.13	.13	1.23
1951	.13	.08	2.14	2.96	1.11	.15	.12	.09	.03	.10	.09	.05	7.05
1952	.01	.18	.22	.12	2.33	1.35	.14	.06	.02	.01	.02	.03	4.49
1953	.03	.71	.37	.03	2.53	1.47	.11	.06	.04	.02	.01	.05	5.43
1954	.19	1.87	1.07	2.19	2.76	1.00	.10	.03	.01	.01	.00	.00	9.23
1955	.13	.19	.17	.09	2.56	2.76	.83	.11	.07	.03	.01	.02	6.97
1956	.17	1.85	2.57	1.04	.18	.19	1.65	.91	.07	1.86	1.07	1.73	13.29
1957	2.32	.85	.08	.13	.18	.12	2.05	1.17	.07	.00	.00	.03	7.00
1958	.12	.24	1.70	1.01	.20	.10	.06	.09	.06	.03	.01	.02	3.64
1959	.16	1.77	1.05	.13	.15	.16	.15	.12	.06	.01	.02	.06	3.84
1960	.17	2.14	2.78	1.00	2.02	1.18	.21	.12	.06	.03	.02	.06	9.79
1961	.11	.19	.17	2.22	1.62	.21	.00	.00	.01	.00	.02	.04	4.59
1962	.10	2.29	2.99	2.56	.94	.12	.10	.06	.08	2.21	1.26	.07	12.78
1963	.11	1.85	1.04	2.17	1.27	.13	.05	.02	.04	.03	.03	.03	6.77
1964	2.57	1.54	.23	2.13	1.25	.13	.03	.02	.04	.06	.06	.06	8.12
1965	.13	.21	.14	2.14	1.32	.14	.04	.03	.03	.02	.03	.09	4.32
1966	.12	.10	.16	2.22	2.66	.95	.11	.03	.01	.01	.01	.00	6.38
1967	.06	2.23	1.36	.20	.08	.11	.07	.02	.01	.00	.03	.03	4.20
1968	.03	.12	.23	.25	.16	1.85	1.09	.11	.02	.01	.01	.02	3.90
1969	2.08	1.24	.20	.19	.20	.12	.07	.05	.03	.02	.04	.08	4.32
1970	.18	.19	.12	2.05	1.18	.09	.13	.17	.10	.03	.02	.03	4.29
1971	.12	.15	.22	1.78	2.53	1.02	.12	.04	.04	.04	.01	.00	6.07
1972	.03	.11	.13	.13	2.42	1.41	.20	.09	.03	.01	.11	.16	4.83
1973	.11	.14	.16	1.74	.87	.04	.09	.08	.04	.05	.05	.02	3.39
1974	.03	2.24	2.83	2.66	2.42	.90	.19	.10	.03	.01	.00	.13	11.54
1975	.13	.20	1.90	2.59	1.05	1.63	.95	.15	.07	.02	.00	.01	8.70
1976	.47	.24	1.81	2.52	.96	.19	.11	.02	.01	.00	.00	.04	6.37
1977	.13	.21	.23	1.93	2.52	.92	.12	.07	.02	.00	.05	.10	6.30
1978	1.97	2.45	.87	.20	.20	.11	.05	.04	.03	.04	.14	.20	6.30
1979	.15	.12	.14	2.44	2.69	.84	.07	.01	.00	.01	.00	.03	6.50
1980	.05	.01	1.01	2.16	2.26	.88	.11	.05	.03	.04	.04	.11	6.75
1981	.12	.08	.09	2.18	1.27	.18	.08	.03	.00	.00	.00	.01	4.04
1982	.13	.12	.09	.16	.10	.10	.10	.12	.08	.05	.04	.03	1.12
1983	.10	2.19	2.86	2.59	1.05	.21	.13	.05	.03	.06	.11	.12	9.50
1984	.13	.11	.08	.17	2.28	1.29	.08	.01	.00	.00	.01	.01	4.17
1985	2.38	1.46	.24	1.75	2.47	1.00	.13	.04	.02	.02	.01	.01	9.53
1986	.04	.11	2.51	3.06	1.07	.19	.11	.04	.01	.02	.07	2.17	9.40
1987	2.48	2.25	.99	1.91	1.08	.11	.07	.04	.04	.08	.05	.04	9.14
1988	.14	.20	2.03	1.22	1.75	.99	.10	.03	.05	.03	.01	.01	6.56
1989	.08	2.21	1.35	.19	.15	.18	.20	.11	.04	.01	.01	.01	4.54
1990	.03	.03	.11	2.53	2.94	1.00	.09	.03	.04	.03	.01	.01	6.85
1991	.63	.31	2.01	1.23	.23	.12	.03	.03	.01	.00	.01	.01	4.62
1992	.03	.08	.19	.18	2.07	1.20	.12	.03	.01	.00	.00	.02	3.93
1993	2.45	1.47	.19	1.85	2.47	.96	.13	.03	.01	.01	.01	.02	9.60
1994	.08	.08	.15	.26	.16	.12	.10	.06	.03	.01	.01	.00	1.06

Afforestation and dryland sugar cane water use for 2030 – TM28.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.54	1.02	.19	.16	.12	2.11	1.22	.09	.01	.01	.01	.03	7.51
1921	.11	2.34	2.84	.98	.14	.07	.05	.04	.05	.04	.08	.09	6.83
1922	2.23	2.74	2.46	1.04	1.65	.91	.06	.01	.00	.02	.02	.02	11.16
1923	.04	.09	.23	2.13	1.26	1.70	.94	.08	.03	.01	.00	.04	6.55
1924	.12	2.12	1.29	1.73	2.54	2.49	.98	.11	.03	.01	.01	.05	11.48
1925	.13	.12	.13	.18	.14	.14	.11	.07	.09	.07	.03	1.86	3.07
1926	1.12	.18	.14	.13	1.67	1.41	.33	.02	.00	.05	.07	.03	5.15
1927	.11	.11	.19	.26	.18	.13	.09	.05	.02	.00	.02	.08	1.24
1928	.14	.11	1.77	.94	.05	2.32	1.36	.09	.05	.08	.06	.16	7.13
1929	1.81	2.45	.96	2.09	1.23	.16	.07	.04	.02	.03	.05	.07	8.98
1930	.07	.07	.21	2.10	1.20	.11	.06	.05	.02	.02	.02	.01	3.94
1931	.03	.07	.12	.11	2.60	2.99	.97	.17	.12	.05	.02	.01	7.26
1932	.01	.02	2.48	1.47	.16	.08	.06	.03	.01	.03	.03	.01	4.39
1933	.03	2.51	3.01	2.55	1.01	.19	.12	.07	.04	.05	.11	.08	9.77
1934	.08	.40	1.28	.69	.20	.17	.14	.08	.03	.01	.00	.01	3.09
1935	.02	.03	.15	2.46	2.37	1.16	.34	2.00	1.15	.07	.00	.03	9.78
1936	.11	2.20	1.26	2.42	2.79	.93	.09	.02	.00	.00	.00	.02	9.84
1937	.04	.07	.20	.22	.20	.18	.18	.11	.07	.09	.07	.04	1.47
1938	.16	.17	2.23	2.92	2.59	2.25	.80	.08	.05	.08	.08	.06	11.47
1939	.08	2.23	1.33	.16	.14	.11	.06	2.23	1.32	.11	.01	.04	7.82
1940	.07	.15	.57	.28	1.68	.99	.21	.12	.03	.01	.00	.02	4.13
1941	.06	.12	.15	2.35	2.74	2.30	.87	.07	.06	.05	.03	.08	8.88
1942	.11	2.37	2.84	2.17	.99	.56	1.53	.79	.07	1.71	2.10	.71	15.95
1943	1.94	2.50	2.25	2.51	2.45	.91	.07	.01	.16	.18	.07	.12	13.17
1944	.22	.14	.08	.14	.77	1.20	.49	.05	.02	.01	.00	.01	3.13
1945	.01	.01	.02	.13	.18	.21	.14	.04	.02	.01	.00	.01	.78
1946	.13	.21	.17	.13	2.12	1.26	.13	.04	.04	.06	.03	.02	4.34
1947	.06	2.45	2.80	.94	2.10	1.25	.14	.03	.02	.00	.00	.02	9.81
1948	.15	.20	.13	2.25	2.86	1.07	.20	.09	.02	.01	.00	.02	7.00
1949	.17	.20	.65	.32	.08	.18	.15	.09	.05	.03	.02	.02	1.96
1950	.04	.05	1.31	.78	.10	.61	.31	.01	.02	.01	.13	.15	3.52
1951	.18	.12	2.13	2.74	.98	.16	.12	.07	.03	.04	.03	.01	6.61
1952	.02	.16	.24	.16	2.26	1.31	.15	.06	.02	.01	.02	.03	4.44
1953	.04	1.36	.73	.05	2.45	1.45	.13	.07	.06	.03	.01	.05	6.43
1954	.19	2.05	1.17	2.46	2.91	1.00	.11	.04	.01	.01	.00	.01	9.96
1955	.14	.20	.22	.13	2.59	2.89	.90	.10	.05	.03	.01	.04	7.30
1956	.18	1.92	2.62	1.06	.21	1.60	2.02	.71	.06	1.72	1.00	1.73	14.83
1957	2.29	.83	.08	.41	.25	.06	.17	.13	.03	.01	.00	.03	4.29
1958	.16	1.92	2.52	.97	1.04	.49	.01	.07	.07	.03	.01	.03	7.32
1959	.15	.24	1.76	1.00	.18	.15	.15	.11	.05	.02	.02	.05	3.88
1960	.17	2.11	2.75	1.01	1.96	1.15	.22	.14	.07	.04	.02	.07	9.71
1961	.11	.16	.15	.23	.23	.14	.07	.04	.02	.01	.02	.04	1.22
1962	.10	2.23	2.98	1.15	.13	.09	.12	.07	.08	2.22	1.27	.07	10.51
1963	.12	.74	.37	1.82	1.09	.13	.07	.03	.02	.01	.01	.02	4.43
1964	2.41	1.46	.81	.40	.07	.06	.03	.02	.04	.05	.06	.06	5.47
1965	.12	.20	.15	2.27	2.61	.85	.07	.05	.03	.03	.03	.06	6.47
1966	.08	.09	.59	1.51	2.17	.95	.13	.05	.02	.01	.01	.01	5.62
1967	.11	2.08	1.26	.21	.09	.15	.12	.04	.01	.01	.03	.04	4.15
1968	.03	.10	.24	.22	.15	1.94	1.13	.11	.03	.02	.01	.03	4.01
1969	2.09	1.24	.19	.17	.20	.13	.05	.03	.02	.03	.05	.09	4.29
1970	.20	.21	.19	2.10	1.21	.11	.17	.23	.12	.04	.02	.02	4.62
1971	.16	.20	1.97	2.56	2.35	.95	.10	.06	.06	.04	.02	.01	8.48
1972	.03	.14	.19	.18	2.21	1.28	.22	.12	.03	.01	.09	.16	4.66
1973	.12	.16	.18	2.24	1.31	.18	.14	.09	.05	.06	.05	.02	4.60
1974	.05	2.26	2.84	2.48	2.39	.96	1.27	.58	.00	.00	.00	.11	12.94
1975	.12	.30	1.30	2.24	1.02	1.64	.95	.14	.06	.02	.01	.02	7.82
1976	.18	.18	2.02	2.66	1.01	.70	.30	.00	.00	.00	.00	.03	7.08
1977	.11	.16	.19	2.28	1.37	.17	.09	.07	.03	.01	.02	.09	4.59
1978	2.02	1.21	.19	.21	.19	.11	.07	.05	.03	.03	.13	.20	4.44
1979	.15	.11	.11	2.09	1.27	.15	.04	.02	.01	.00	.01	.04	4.00
1980	.07	.15	1.02	1.30	.53	.08	.05	.04	.06	.06	.06	.13	3.55
1981	.14	.14	.10	.18	.18	1.36	.68	.00	.00	.00	.00	.01	2.79
1982	.16	.15	.08	.11	.08	.10	.11	.12	.09	.05	.05	.05	1.15
1983	.07	2.37	2.85	2.48	1.00	1.66	.98	.10	.04	.07	.14	.12	11.88
1984	.15	.92	.47	.08	2.18	1.26	.09	.01	.00	.01	.00	.01	5.18
1985	2.50	1.52	.22	2.10	2.49	.88	.12	.04	.02	.02	.01	.01	9.93
1986	.04	.10	2.24	2.80	1.00	1.79	1.01	.06	.02	.02	.07	2.21	11.36
1987	2.41	2.07	2.45	2.55	1.01	.14	.07	.03	.05	.10	.08	.04	11.00
1988	.15	.24	1.93	1.13	2.08	1.22	.13	.03	.02	.02	.01	.01	6.97
1989	.10	2.27	1.37	.18	.12	.12	.16	.12	.04	.01	.02	.01	4.52
1990	.03	.06	.20	2.29	2.77	.98	.10	.05	.06	.06	.03	.03	6.66
1991	.14	.21	.23	.22	1.78	1.01	.08	.01	.00	.01	.01	.01	3.71
1992	.02	.12	.25	.19	.14	.13	.08	.03	.01	.00	.01	.02	1.00
1993	2.50	1.50	1.68	2.31	.95	1.67	.93	.07	.01	.01	.02	.01	11.66
1994	.10	.13	.11	.13	.08	2.21	1.29	.09	.02	.01	.01	.00	4.18

Afforestation and dryland sugar cane water use for 2030 – TM29.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.08	.13	.11	.10	.06	.13	.08	.04	.02	.00	.00	.03	.78
1921	.08	1.52	.56	.05	.04	.05	.04	.04	.05	.05	.04	.06	2.58
1922	.08	.15	.14	.14	.12	.06	.03	.02	.00	.00	.00	.01	.75
1923	.00	.03	.06	.08	.08	.06	.02	.01	.02	.01	.02	.02	.41
1924	.09	1.79	1.85	1.57	.44	1.51	.53	.03	.00	.02	.01	.04	7.88
1925	.09	.07	.10	.07	.03	.06	.04	.04	.04	.03	.02	.07	.66
1926	1.48	.55	.07	.07	.06	.13	.07	.03	.01	.02	.05	.04	2.58
1927	.04	.03	.09	1.91	.64	.06	.04	.02	.01	.00	.02	.02	2.88
1928	.04	.03	.03	.03	.07	.12	.08	.03	.03	.05	.03	.06	.60
1929	.07	.10	.09	.13	.10	.09	.08	.04	.01	.01	.01	.03	.76
1930	.06	.06	.08	.13	.10	.07	.06	.03	.01	.01	.01	.00	.62
1931	.02	.03	.05	.06	2.20	1.70	.34	.05	.05	.02	.01	.02	4.55
1932	.03	.12	.12	.06	.05	.05	.03	.01	.01	.02	.02	.01	.53
1933	.01	.13	1.60	1.88	.48	.07	.10	.08	.04	.02	.04	.03	4.48
1934	.07	.10	.16	.09	.07	.13	.10	.05	.05	.04	.02	.01	.89
1935	.01	.03	.03	.15	1.76	.62	.05	.08	.06	.02	.00	.01	2.82
1936	.04	.15	.09	.05	.11	.13	.05	.01	.01	.00	.00	.01	.65
1937	.02	.03	.15	.16	1.40	.48	.07	.05	.03	.10	.06	.02	2.57
1938	.04	.07	.15	.15	1.59	.54	.02	.03	.03	.02	.02	.05	2.71
1939	.05	.53	.05	.00	.04	.05	.03	2.00	.69	.02	.01	.06	3.53
1940	.07	.13	1.61	.55	.08	.13	.16	.07	.01	.01	.00	.01	2.83
1941	.02	.04	.05	.12	1.63	1.56	.34	.01	.01	.01	.02	.03	3.84
1942	.07	.15	1.73	.63	.11	.08	1.75	.62	.04	.10	1.24	.41	6.93
1943	1.55	1.72	.45	.05	.10	.09	.05	.01	.03	.03	.01	.08	4.17
1944	.09	.07	.07	.07	.06	1.81	.62	.02	.01	.01	.00	.00	2.83
1945	.01	.01	.06	.10	.08	.07	.04	.01	.00	.00	.00	.02	.40
1946	.12	.13	.08	.10	.15	.14	.08	.04	.06	.05	.02	.02	.99
1947	.05	1.81	.65	.08	.07	.15	.10	.05	.02	.01	.00	.01	3.00
1948	.04	.11	.14	.17	1.26	.44	.07	.04	.02	.01	.01	.01	2.32
1949	.05	.15	1.47	.50	.04	.08	.06	.04	.01	.01	.02	.02	2.45
1950	.03	.05	.16	.14	.07	.08	.05	.02	.02	.01	.12	.10	.85
1951	.09	.04	.08	1.66	.57	.06	.06	.04	.03	.03	.02	.01	2.69
1952	.02	.08	.13	.12	1.52	.53	.03	.02	.02	.01	.07	.05	2.60
1953	.03	.13	.11	.10	.10	.10	.08	.10	.07	.03	.01	.04	.90
1954	1.59	.58	.05	1.71	.63	.11	.07	.04	.01	.00	.00	.00	4.79
1955	.04	.09	.15	.06	1.79	.64	.02	.01	.01	.00	.01	.02	2.84
1956	.07	.13	1.74	1.66	.40	.06	.09	.05	.02	.03	.05	1.44	5.74
1957	1.49	.35	.03	.09	.11	.07	.13	.08	.02	.01	.00	.01	2.39
1958	.03	.09	.16	1.40	1.61	.40	.03	.10	.08	.03	.01	.01	3.95
1959	.07	.10	.07	.11	.12	.11	.10	.06	.02	.00	.01	.01	.78
1960	.05	.10	1.62	.59	.09	.08	.08	.05	.02	.01	.01	.03	2.73
1961	.03	.08	.07	.09	.09	.11	.09	.04	.01	.01	.02	.02	.66
1962	.04	.09	.12	.13	.07	1.74	.59	.01	.01	.09	.08	.02	2.99
1963	.05	.14	.06	2.04	.69	.03	.05	.03	.02	.02	.03	.03	3.19
1964	.08	.08	.08	.05	.04	.03	.03	.02	.07	.09	.08	.06	.71
1965	.07	.11	.11	1.72	.59	.02	.03	.03	.03	.01	.01	.01	2.74
1966	.02	.08	.10	1.91	1.69	1.43	.40	.02	.01	.02	.01	.00	5.69
1967	.03	.10	.06	.09	.08	.12	.07	.04	.01	.00	.01	.02	.63
1968	.03	.04	.10	.09	.08	1.82	.62	.03	.02	.02	.01	.01	2.87
1969	.09	.06	.12	.09	.09	.07	.03	.03	.03	.01	.04	.09	.75
1970	.11	.09	.08	.05	.06	.07	.07	1.72	.57	.02	.05	.04	2.93
1971	.08	.10	.12	.12	.08	.09	.05	.05	.05	.03	.01	.01	.79
1972	.03	.07	.06	.12	1.80	.63	.05	.04	.01	.01	.06	.10	2.98
1973	.06	.06	.06	1.95	.68	.09	.05	.02	.02	.03	.02	.00	3.04
1974	.00	.08	.18	.17	.12	.04	.07	.05	.02	.01	.00	1.51	2.25
1975	.51	.07	.10	1.81	1.67	1.57	.42	.04	.02	.01	.00	.01	6.23
1976	.12	.13	.08	.14	.13	.12	.05	.02	.01	.01	.01	.04	.86
1977	.14	.16	.08	1.89	.66	.10	.08	.05	.01	.00	.02	.04	3.23
1978	1.65	.57	.08	.10	.13	.07	.05	.03	.02	.02	.04	.05	2.81
1979	.04	.04	.04	.05	.04	.02	.02	.02	.02	.00	.00	.03	.32
1980	.05	.07	.08	.17	.09	.03	.01	.02	.02	.01	.01	.03	.59
1981	.03	1.29	.30	.00	.06	.14	.08	.02	.01	.01	.00	.01	1.95
1982	.14	.11	.07	.06	.04	.04	.07	.05	.02	.01	.01	.01	.63
1983	.02	.13	1.62	1.71	.46	.06	.10	.06	.02	.03	.05	.04	4.30
1984	1.51	.52	.06	.12	1.70	.57	.01	.00	.00	.00	.00	.00	4.49
1985	.07	.09	.13	1.75	.60	1.55	1.57	.36	.01	.01	.01	.01	6.16
1986	.05	.07	1.77	1.79	1.52	.44	.03	.01	.01	.02	.08	1.72	7.51
1987	.61	.09	.11	.10	.11	.13	.06	.02	.04	.06	.05	.04	1.42
1988	.06	.10	1.57	.56	.11	.07	.04	.03	.03	.01	.01	.01	2.60
1989	.03	1.73	1.69	.40	.04	.12	.11	.05	.02	.00	.03	.02	4.24
1990	.04	.08	.14	.22	.00	.00	.01	.01	.01	.01	.01	.04	.57
1991	.13	.08	.11	.08	1.71	.59	.02	.01	.02	.00	.00	.00	2.75
1992	.06	.06	.06	.04	.06	.08	.06	.02	.02	.00	.01	.03	.50
1993	1.98	.67	.05	.07	.05	.09	.06	.02	.02	.03	.05	.03	3.12
1994	.04	.03	.08	.10	.06	.05	.07	.11	.15	.08	.02	.01	.80

Afforestation and dryland sugar cane water use for 2030 – TM30.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.22	.49	.09	.05	.85	.51	.07	.04	.03	.01	.01	.05	3.42
1921	.07	.84	1.12	.41	.06	.11	.08	.06	.06	.05	.07	.08	3.01
1922	.05	.80	.48	.98	.57	.09	.05	.02	.01	.02	.02	.01	3.10
1923	.00	.04	.08	.10	.11	.07	.04	.02	.01	.01	.01	.06	.55
1924	.12	.76	.48	.11	.10	.80	.48	.05	.02	.01	.01	.03	2.97
1925	.76	.45	.05	.04	.08	.99	.55	.08	.07	.04	.02	.05	3.18
1926	.75	.46	.12	.09	.10	.85	.48	.03	.01	.02	.06	.06	3.03
1927	.09	.08	.11	.85	.51	.11	.07	.03	.01	.00	.02	.07	1.95
1928	.11	.07	.04	.08	.10	.93	.53	.04	.07	.10	.07	.09	2.23
1929	.67	.42	.06	.11	.08	.04	.04	.03	.01	.01	.04	.10	1.61
1930	.11	.11	.10	.10	.10	.09	.05	.03	.02	.01	.01	.02	.75
1931	.05	.09	.13	.12	.87	1.06	.38	.64	.36	.03	.01	.02	3.76
1932	.06	.09	.13	.10	.08	.07	.07	.02	.01	.03	.03	.02	.71
1933	.03	.92	1.20	1.02	.42	.75	.45	.08	.04	.04	.07	.06	5.08
1934	.04	.11	.85	.52	.11	.10	.09	.08	.62	.35	.03	.01	2.91
1935	.05	.05	.07	.14	.88	1.10	.40	.66	.38	.03	.01	.03	3.80
1936	.08	.83	.47	.07	.93	.55	.06	.01	.01	.02	.02	.03	3.08
1937	.06	.08	.90	1.16	1.03	.39	.11	.08	.04	.09	.08	.05	4.07
1938	.09	.11	.73	.44	.75	.92	.34	.06	.04	.04	.06	.09	3.67
1939	.10	.81	.97	.36	.07	.05	.05	.99	.93	.25	.02	.04	4.64
1940	.06	.92	1.14	.41	.06	.06	.10	.09	.03	.01	.02	.04	2.94
1941	.07	.09	.07	.09	.12	.80	.46	.05	.03	.02	.05	.10	1.95
1942	.13	.73	1.01	.41	.10	.11	.80	.46	.04	.65	.77	.24	5.45
1943	.00	.26	.34	.06	.88	1.11	.38	.03	.05	.07	.05	.80	4.03
1944	.49	.09	.06	.05	.11	.92	.51	.04	.02	.01	.00	.01	2.31
1945	.06	.06	.05	.00	.00	.00	.00	.01	.02	.01	.00	.01	.22
1946	.07	.14	.13	.12	.71	.99	.40	.05	.06	.05	.03	.04	2.79
1947	.07	.85	1.08	.43	.10	.70	.41	.05	.02	.01	.01	.01	3.74
1948	.06	.09	.10	.12	.14	.12	.70	.39	.03	.02	.01	.03	1.81
1949	.11	.76	1.05	.44	.11	.76	.44	.04	.02	.01	.03	.03	3.80
1950	.06	.06	.97	.59	.07	.06	.05	.03	.02	.01	.86	.51	3.29
1951	.59	.33	.10	.13	.11	.10	.07	.06	.04	.04	.03	.02	1.62
1952	.03	.89	1.15	.44	.67	.39	.06	.02	.02	.01	.02	.06	3.76
1953	.08	.74	.93	.87	.39	.10	.08	.10	.06	.03	.03	.09	3.50
1954	.78	.90	.31	1.01	.63	.73	.43	.06	.02	.02	.01	.03	4.93
1955	.76	1.01	.90	.34	1.10	.68	.08	.04	.02	.02	.03	.06	5.04
1956	.08	.75	1.02	.43	.13	.10	.11	.05	.02	.03	.05	.85	3.62
1957	.97	.36	.10	.76	.95	.35	.74	.42	.03	.01	.01	.04	4.74
1958	.06	.12	.12	.11	.12	.06	.02	.12	.10	.04	.03	.05	.95
1959	.76	.46	.10	.06	.11	.11	.13	.08	.03	.01	.02	.05	1.92
1960	.09	.85	1.08	.94	.38	.08	.87	.49	.07	.04	.02	.06	4.97
1961	.10	.13	.11	.09	.08	.13	.10	.05	.02	.01	.06	.06	.94
1962	.10	.77	.48	.13	.08	.79	.47	.04	.05	.69	.39	.03	4.02
1963	.06	.10	.09	.99	.58	.06	.05	.06	.03	.04	.03	.04	2.13
1964	.81	.49	.10	.06	.07	.04	.03	.05	.10	.12	.11	.09	2.07
1965	.11	.10	.08	.78	.46	.04	.04	.07	.06	.03	.03	.05	1.85
1966	.08	.10	.11	.93	1.06	.92	.39	.06	.01	.02	.02	.02	3.72
1967	.09	.00	.00	.00	.05	.10	.07	.03	.02	.01	.07	.10	.54
1968	.09	.09	.89	.52	.07	1.07	.65	.10	.04	.04	.02	.05	3.63
1969	.83	.51	.10	.08	.07	.06	.05	.08	.08	.04	.03	.10	2.03
1970	.75	.45	.08	.09	.10	.11	.10	.76	.43	.06	.07	.10	3.10
1971	.11	.10	.66	.40	.79	.96	.34	.10	.09	.06	.04	.03	3.68
1972	.05	.11	.12	.11	.86	.53	.11	.04	.01	.02	.10	.75	2.81
1973	.44	.09	.08	.77	1.01	.39	.06	.06	.04	.04	.03	.02	3.03
1974	.02	.09	.14	.88	1.09	.39	.07	.05	.03	.02	.03	.94	3.75
1975	.56	.11	.70	1.00	.96	.97	.42	.08	.03	.01	.03	.05	4.92
1976	.12	.14	.08	.83	1.07	.43	.07	.02	.01	.00	.02	.08	2.87
1977	.77	.45	.08	.11	.12	.74	.46	.06	.02	.01	.04	.09	2.95
1978	.76	.46	.10	.09	.08	.06	.05	.04	.03	.03	.06	.08	1.84
1979	.11	.09	.08	.07	.04	.02	.02	.02	.02	.01	.02	.88	1.38
1980	.53	.12	.08	.87	1.04	.35	.04	.08	.09	.05	.08	.12	3.45
1981	.09	.80	.46	.13	.11	.83	.49	.06	.02	.01	.01	.02	3.03
1982	.91	.55	.06	.06	.06	.04	.04	.03	.03	.03	.07	.07	1.95
1983	.08	.88	.55	.76	1.02	.45	.10	.06	.03	.09	.11	.06	4.19
1984	.08	.10	.08	.80	1.08	.40	.03	.01	.01	.02	.01	.01	2.63
1985	.88	.56	.13	.11	.07	.10	.10	.04	.02	.03	.02	.03	2.09
1986	.12	.13	.77	1.04	.44	.72	.40	.05	.09	.08	.10	.27	4.21
1987	.48	.73	.36	.09	.85	1.12	.40	.04	.04	.05	.07	.07	4.30
1988	.10	.69	1.05	.43	.96	.55	.05	.04	.04	.03	.02	.02	3.98
1989	.08	.87	.53	.08	.07	.85	.50	.06	.02	.01	.04	.05	3.16
1990	.10	.11	.88	1.19	1.06	1.03	.39	.03	.02	.03	.02	.06	4.92
1991	.12	.09	.05	.05	.06	.06	.07	.05	.02	.01	.01	.02	.61
1992	.03	.10	.10	.06	.09	.11	.07	.03	.01	.01	.02	.05	.68
1993	.86	.50	.10	.00	.00	.00	.00	.01	.01	.03	.93	.53	2.97
1994	.07	.05	.07	.08	.05	.11	.13	.13	.11	.07	.02	.02	.91

Afforestation and dryland sugar cane water use for 2030 – TM31.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.78	.76	.21	.14	.13	1.38	.77	.06	.01	.01	.00	.00	5.25
1921	.12	1.45	1.82	.65	.17	.16	.09	.05	.06	.02	.10	.09	4.78
1922	1.41	1.76	1.66	.76	.14	.03	.01	.01	.01	.02	.04	.01	5.86
1923	.03	.08	.18	1.41	1.10	.54	.22	.05	.03	.01	.00	.12	3.77
1924	.13	1.48	1.11	.18	.08	1.24	.76	.15	.06	.02	.02	.07	5.30
1925	.13	1.23	.70	.12	1.33	.82	.11	.03	.05	.06	.02	.12	4.72
1926	.11	.16	.13	.14	1.13	.69	.10	.03	.01	.06	.05	.02	2.63
1927	1.51	.98	1.20	.69	1.32	1.54	.54	.08	.03	.01	.00	.07	7.97
1928	.17	.19	1.46	.92	.20	1.20	.68	.06	.01	.01	.02	.15	5.07
1929	1.14	1.60	1.63	1.79	.78	.12	.08	.03	.01	.02	.03	.02	7.25
1930	.01	.04	1.04	.74	1.13	.65	.16	.09	.02	.04	.05	.03	4.00
1931	.02	.07	.10	.12	1.72	2.03	.67	.06	.07	.03	.01	.01	4.91
1932	.05	.13	.71	.32	1.23	.77	.12	.05	.01	.01	.02	.02	3.44
1933	.04	1.53	1.94	1.73	.71	.19	.14	.09	.05	.05	.11	.06	6.64
1934	.06	1.45	1.95	.80	.56	1.33	.63	.04	.01	.02	.01	.01	6.87
1935	.05	.07	.09	1.26	.78	1.23	.67	1.38	.78	.04	.00	.01	6.36
1936	.12	1.44	.88	1.37	1.79	.66	.05	.01	.01	.00	.00	.03	6.36
1937	1.43	.83	1.51	.91	.13	.10	.17	.13	.05	.05	.04	.03	5.38
1938	1.43	.85	1.63	1.90	1.68	1.47	.50	.07	.05	.03	.02	.02	9.65
1939	.05	1.44	1.96	.82	.19	.17	.10	.02	.00	.00	.00	.02	4.77
1940	.07	1.41	.87	1.33	1.72	.67	1.05	.57	.03	.00	.00	.01	7.73
1941	.03	.08	.10	1.55	.95	1.06	.64	.16	.15	.08	.03	.12	4.95
1942	.22	1.19	1.72	1.63	1.68	1.51	1.54	.66	.06	.12	.16	.10	10.59
1943	1.33	.77	.23	.18	1.41	.84	.09	.02	.19	.19	.06	.15	5.46
1944	1.17	.70	.09	.08	.23	1.37	.73	.05	.01	.01	.00	.00	4.44
1945	.00	.04	.03	1.38	1.68	1.53	.60	.04	.01	.00	.00	.01	5.32
1946	.15	1.23	.75	.19	1.36	.85	.14	.05	.02	.02	.03	.02	4.81
1947	.04	1.73	2.00	1.68	.66	.44	.15	.00	.00	.00	.00	.03	6.73
1948	.11	.15	.15	1.68	1.01	.33	.45	.19	.01	.00	.00	.05	4.13
1949	.16	1.23	.75	.22	.21	.12	.10	.12	.10	.04	.05	.07	3.17
1950	.09	.11	.10	.18	.14	.07	.03	.04	.02	.01	.10	.10	.99
1951	1.43	.81	.21	1.31	.76	.15	.12	.06	.03	.15	.15	.04	5.22
1952	.04	1.58	.97	.16	1.51	.93	.15	.07	.02	.01	.01	.01	5.46
1953	.04	1.36	.89	.20	1.14	1.45	.53	.12	.08	.03	.03	.11	5.98
1954	.79	.35	.02	1.10	1.68	1.49	.55	.04	.01	.00	.01	.00	6.04
1955	.10	1.24	.81	.18	1.47	1.82	.63	.12	.06	.02	.01	.08	6.54
1956	.83	.78	1.30	.72	1.15	.72	.13	.03	.03	.10	.00	.88	6.67
1957	1.40	.58	1.21	1.76	.71	.10	.17	.12	.03	.01	.00	.07	6.16
1958	.16	1.14	1.64	.67	.18	.14	.09	.14	.08	.03	.01	.05	4.33
1959	.20	1.29	.78	.19	.22	.18	.20	.10	.02	.00	.01	.04	3.23
1960	.15	1.49	1.89	.71	.16	.19	.47	.27	.06	.03	.01	.10	5.53
1961	.16	1.32	1.79	.73	.15	.10	.05	.04	.00	.00	.01	.04	4.39
1962	.05	1.62	1.94	1.72	.69	.15	.11	.06	.13	1.31	.74	.04	8.56
1963	.07	1.59	.93	1.75	1.00	.12	.13	.10	.03	.02	.01	.02	5.77
1964	1.44	.90	.23	.22	.18	.10	.07	.05	.03	.03	.02	.03	3.30
1965	.10	1.32	.79	.19	.53	.19	.00	.00	.01	.01	.02	.09	3.25
1966	.15	.15	1.46	1.90	1.64	.63	.09	.03	.02	.04	.04	.04	6.19
1967	.09	1.36	.88	.18	.08	1.31	.74	.04	.00	.00	.07	.07	4.82
1968	.06	1.44	.95	1.20	.70	1.45	.86	.12	.05	.01	.00	.03	6.87
1969	1.29	.78	1.34	.81	.22	.11	.05	.03	.03	.02	.06	.07	4.81
1970	1.28	.82	.14	.21	.20	.13	1.35	.78	.08	.01	.00	.03	5.03
1971	.12	1.31	1.77	1.74	1.63	1.44	.55	.06	.03	.01	.00	.00	8.66
1972	.02	.98	.49	1.10	1.63	.71	.00	.00	.00	.00	.14	.21	5.28
1973	.18	1.04	.67	.34	.54	.32	.16	.11	.06	.05	.05	.02	3.54
1974	.03	1.36	1.83	1.69	1.70	.71	.13	.06	.02	.01	.01	.09	7.64
1975	.14	1.39	1.51	.57	1.01	1.44	.61	.13	.07	.01	.01	.02	6.91
1976	.30	.12	.81	1.53	1.49	.60	.10	.02	.00	.00	.00	.04	5.01
1977	.18	.21	.87	.65	1.16	.63	.09	.05	.01	.01	.03	.13	4.02
1978	1.34	.83	.18	.11	.08	.07	.05	.03	.01	.06	.14	.19	3.09
1979	.13	.17	.15	1.13	1.62	.63	.06	.02	.00	.01	.01	.06	3.99
1980	.08	1.49	.95	1.34	1.72	.76	.04	.00	.01	.01	.03	.11	6.54
1981	.15	.14	.15	1.51	.84	.09	.03	.02	.01	.01	.01	.00	2.96
1982	.14	.11	.08	.13	.09	.09	.11	.11	.07	.03	.06	.03	1.05
1983	1.28	1.73	1.62	1.72	.74	1.07	.58	.05	.02	.08	.15	.12	9.16
1984	.13	.12	.12	1.38	1.82	.67	.04	.01	.01	.02	.00	.00	4.32
1985	1.24	.82	.20	1.14	1.60	.67	.14	.05	.04	.02	.00	.01	5.93
1986	.07	.15	1.40	.85	.22	.14	.07	.02	.02	.02	.08	1.28	4.32
1987	1.59	1.51	.65	1.42	.83	.15	.07	.02	.01	.02	.02	.05	6.34
1988	1.48	.89	1.30	1.88	1.76	.68	.10	.05	.09	.07	.02	.01	8.33
1989	.08	1.42	1.75	.69	.21	1.22	.74	.09	.01	.00	.01	.01	6.23
1990	.07	.07	.09	.62	1.30	1.60	.62	.05	.03	.05	.01	.01	4.52
1991	1.37	.82	1.46	.85	1.37	.78	.05	.01	.01	.00	.01	.01	6.74
1992	.04	.10	1.46	.88	1.31	.80	.16	.07	.02	.00	.01	.02	4.87
1993	1.45	.94	.14	1.29	1.04	.50	.17	.02	.00	.00	.00	.00	5.55
1994	.10	.11	.17	.24	.18	.17	.15	.08	.02	.01	.00	.00	1.23

Afforestation and dryland sugar cane water use for 2030 – TM32.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.11	.91	1.22	.47	.06	.12	.11	.04	.02	.01	.01	.05	3.13
1921	.09	1.07	.65	.07	.05	.09	.06	.06	.07	.05	.07	.06	2.39
1922	.12	.04	.00	.24	.27	.05	.03	.02	.01	.01	.01	.01	.81
1923	.01	.10	.99	.56	.13	.09	.06	.04	.03	.01	.01	.03	2.06
1924	.10	1.01	1.21	1.25	.55	1.01	.60	.07	.02	.03	.03	.08	5.96
1925	.14	.11	.12	.11	.05	.12	.09	.05	.07	.07	.03	.10	1.06
1926	.93	1.14	.43	.07	.15	.92	.51	.03	.01	.04	.08	.05	4.36
1927	.08	.07	.13	1.03	.58	.08	.04	.03	.01	.00	.01	.03	2.09
1928	.06	.06	.05	.07	.08	.16	.12	.04	.05	.08	.06	.07	.90
1929	.12	.82	.49	.99	.58	.08	.09	.05	.01	.01	.01	.06	3.31
1930	.09	.11	.10	.96	.55	.06	.04	.03	.01	.01	.00	.01	1.97
1931	.05	.08	.09	.07	1.21	1.42	.46	.11	.09	.04	.01	.03	3.66
1932	.04	.11	.17	.08	.08	.06	.04	.01	.00	.03	.03	.02	.67
1933	.02	1.16	1.44	1.39	.56	.13	.14	.10	.05	.03	.08	.06	5.16
1934	.12	.15	.91	.52	.11	.11	.08	.05	.05	.03	.02	.01	2.16
1935	.02	.05	.06	.14	.00	.08	.05	.09	.09	.03	.01	.02	.64
1936	.08	1.04	.60	.07	1.08	.64	.07	.02	.01	.01	.01	.01	3.64
1937	.02	.05	1.14	1.43	1.34	.55	.12	.07	.05	.10	.10	.05	5.02
1938	.07	.08	.15	.17	.98	.60	.08	.06	.03	.03	.04	.09	2.38
1939	.11	1.03	.65	.12	.06	.07	.07	1.15	.69	.07	.01	.07	4.10
1940	.08	.90	1.27	.50	.12	.11	.16	.09	.02	.00	.00	.02	3.27
1941	.06	.07	.08	.14	.97	.60	.09	.03	.02	.02	.02	.06	2.16
1942	.14	.83	1.20	.54	.15	.09	1.11	.65	.06	.11	.81	.44	6.13
1943	.87	1.20	.49	.07	.15	.13	.06	.02	.06	.06	.04	.10	3.25
1944	.15	.10	.08	.11	.11	1.14	.64	.05	.02	.01	.00	.01	2.42
1945	.02	.02	.06	.18	.12	.08	.06	.03	.01	.01	.00	.01	.60
1946	.95	.60	.11	.12	.16	.14	.08	.04	.06	.06	.03	.04	2.39
1947	.07	1.07	.67	.13	.13	.95	.55	.05	.02	.00	.01	.01	3.66
1948	.06	.10	.17	.95	1.27	.54	.13	.05	.01	.01	.01	.02	3.32
1949	.09	1.07	1.44	.58	.10	.14	.11	.05	.02	.01	.02	.02	3.65
1950	.05	.08	1.06	.64	.09	.07	.06	.03	.02	.01	1.02	.60	3.73
1951	.13	.06	.13	.95	.55	.10	.08	.05	.04	.04	.04	.02	2.19
1952	.04	.14	.87	.52	.92	.53	.07	.03	.02	.02	.05	.07	3.28
1953	.08	1.00	.62	.12	.11	.10	.08	.12	.09	.04	.02	.07	2.45
1954	.98	1.23	.43	1.11	.69	.77	.46	.06	.02	.01	.01	.00	5.77
1955	.09	.93	1.25	.47	1.34	.79	.08	.02	.02	.02	.01	.03	5.05
1956	.11	.97	1.28	.52	.11	.10	.10	.07	.03	.04	.05	1.03	4.41
1957	1.23	.44	.08	.10	.17	.11	.13	.09	.03	.01	.00	.01	2.40
1958	.05	.13	.18	1.05	1.44	.54	.05	.07	.06	.04	.02	.03	3.66
1959	.12	.12	.14	.13	.15	.14	.14	.07	.02	.01	.01	.03	1.08
1960	.08	.14	.95	.59	.14	.09	.11	.08	.04	.02	.01	.04	2.29
1961	.08	.13	.13	.11	.09	.13	.12	.06	.02	.01	.03	.04	.95
1962	.08	.16	.17	.13	.08	1.10	.66	.06	.02	1.04	.60	.04	4.14
1963	.04	.15	.10	1.34	.78	.07	.04	.04	.03	.02	.03	.05	2.69
1964	.13	.13	.11	.09	.06	.04	.03	.05	.09	.09	.08	.09	.99
1965	.09	.13	.12	1.12	.67	.07	.04	.06	.03	.01	.02	.03	2.39
1966	.07	.15	.15	.96	1.39	1.29	.51	.07	.02	.02	.02	.02	4.67
1967	.07	.15	.11	.10	.11	.13	.09	.04	.02	.00	.02	.04	.88
1968	.06	.08	1.04	.62	.08	1.14	.69	.09	.03	.03	.02	.03	3.91
1969	.91	.54	.14	.10	.08	.06	.05	.07	.05	.03	.04	.12	2.19
1970	.89	.54	.10	.08	.09	.08	.10	1.07	.60	.06	.08	.06	3.75
1971	.08	.11	.14	.15	.15	.13	.08	.07	.07	.05	.02	.01	1.06
1972	.06	.09	.08	.12	1.09	.66	.10	.06	.01	.00	.06	.81	3.14
1973	.46	.10	.09	1.20	.72	.12	.08	.04	.04	.04	.03	.01	2.93
1974	.01	.10	.16	.88	.55	.10	.07	.07	.03	.01	.01	1.03	3.02
1975	.61	.14	.89	1.27	1.25	1.27	.52	.08	.03	.01	.01	.02	6.10
1976	.12	.16	.10	.99	1.33	.53	.08	.03	.01	.01	.01	.05	3.42
1977	.99	.62	.12	.95	.59	.12	.09	.05	.02	.00	.02	.07	3.64
1978	1.07	.64	.16	.14	.13	.08	.05	.04	.02	.00	.00	.04	2.37
1979	.08	.06	.07	.06	.04	.02	.03	.02	.02	.01	.01	.07	.49
1980	.09	.11	.09	.13	.10	.05	.03	.03	.05	.03	.04	.08	.83
1981	.08	1.01	.58	.11	.11	1.06	.61	.06	.02	.01	.01	.01	3.67
1982	1.09	.66	.09	.07	.04	.03	.05	.04	.02	.03	.04	.03	2.19
1983	.07	1.09	.68	.96	1.20	.47	.11	.06	.03	.07	.09	.08	4.91
1984	.10	.12	.07	.11	1.08	.60	.05	.01	.01	.01	.01	.01	2.18
1985	1.01	.61	.14	.10	.10	.11	.11	.05	.03	.03	.01	.02	2.32
1986	.10	.13	1.03	1.43	.57	.15	.08	.03	.06	.06	.09	1.04	4.77
1987	.64	.12	.13	.11	.94	.60	.08	.02	.02	.05	.07	.07	2.85
1988	.12	.89	1.25	.49	1.08	.62	.05	.02	.03	.02	.02	.01	4.60
1989	.05	1.07	.65	.08	.08	.12	.11	.06	.03	.01	.05	.05	2.36
1990	.09	.11	.17	1.03	1.29	1.10	.40	.05	.02	.02	.01	.04	4.33
1991	.14	.10	.08	.09	.11	.08	.04	.03	.01	.01	.01	.01	.71
1992	.04	.07	.09	.06	.08	.10	.06	.03	.01	.00	.01	.04	.59
1993	1.07	.63	.11	.10	.07	.12	.08	.03	.02	.01	.06	.06	2.36
1994	.09	.06	.07	.11	.06	.06	.07	.10	.12	.08	.04	.02	.88

Afforestation and dryland sugar cane water use for 1995 – TM04.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.09	0.04	0.04	0.21	0.21	0.17	0.08	0.03	0.02	0.02	0.01	0.19	1.12
1921	0.10	0.17	0.19	0.19	0.18	0.09	0.03	0.02	0.03	0.02	0.06	0.03	1.12
1922	0.19	0.19	0.10	0.16	0.18	0.18	0.07	0.02	0.02	0.02	0.02	0.02	1.17
1923	0.02	0.06	0.07	0.20	0.19	0.18	0.09	0.05	0.02	0.01	0.01	0.05	0.95
1924	0.19	0.19	0.18	0.19	0.19	0.21	0.10	0.03	0.01	0.00	0.00	0.01	1.29
1925	0.04	0.19	0.12	0.15	0.17	0.17	0.07	0.03	0.02	0.02	0.02	0.23	1.23
1926	0.00	0.07	0.19	0.19	0.19	0.19	0.10	0.04	0.02	0.02	0.02	0.02	1.03
1927	0.21	0.10	0.19	0.20	0.18	0.18	0.07	0.03	0.03	0.02	0.01	0.01	1.23
1928	0.01	0.05	0.20	0.20	0.19	0.19	0.10	0.05	0.06	0.13	0.05	0.16	1.40
1929	0.10	0.18	0.19	0.19	0.18	0.18	0.08	0.04	0.03	0.03	0.03	0.04	1.26
1930	0.04	0.02	0.21	0.21	0.19	0.18	0.10	0.04	0.02	0.03	0.02	0.01	1.08
1931	0.01	0.02	0.02	0.21	0.21	0.18	0.08	0.05	0.03	0.02	0.01	0.01	0.85
1932	0.01	0.24	0.22	0.21	0.11	0.07	0.05	0.02	0.01	0.01	0.01	0.01	0.98
1933	0.01	0.21	0.21	0.18	0.18	0.18	0.18	0.17	0.07	0.03	0.07	0.03	1.52
1934	0.19	0.19	0.18	0.09	0.18	0.19	0.07	0.03	0.02	0.02	0.01	0.01	1.19
1935	0.01	0.03	0.23	0.22	0.18	0.18	0.07	0.17	0.08	0.02	0.02	0.01	1.24
1936	0.05	0.19	0.20	0.18	0.19	0.18	0.07	0.03	0.02	0.01	0.01	0.01	1.15
1937	0.01	0.03	0.20	0.20	0.19	0.10	0.16	0.07	0.03	0.05	0.05	0.02	1.13
1938	0.22	0.22	0.19	0.19	0.18	0.17	0.08	0.05	0.03	0.03	0.02	0.02	1.41
1939	0.22	0.21	0.19	0.19	0.19	0.18	0.09	0.19	0.11	0.03	0.02	0.04	1.67
1940	0.03	0.21	0.21	0.19	0.19	0.11	0.16	0.07	0.02	0.01	0.01	0.01	1.21
1941	0.03	0.02	0.05	0.19	0.19	0.18	0.19	0.07	0.03	0.02	0.02	0.03	1.05
1942	0.19	0.19	0.18	0.19	0.19	0.18	0.18	0.18	0.07	0.17	0.18	0.07	1.97
1943	0.19	0.20	0.19	0.19	0.19	0.19	0.07	0.03	0.07	0.04	0.02	0.21	1.59
1944	0.12	0.07	0.04	0.17	0.19	0.17	0.08	0.03	0.02	0.01	0.01	0.01	0.93
1945	0.00	0.01	0.02	0.22	0.21	0.19	0.09	0.03	0.02	0.02	0.01	0.00	0.81
1946	0.19	0.19	0.09	0.06	0.18	0.19	0.08	0.03	0.02	0.02	0.01	0.01	1.07
1947	0.21	0.20	0.18	0.19	0.19	0.18	0.17	0.07	0.03	0.02	0.01	0.01	1.45
1948	0.03	0.06	0.19	0.19	0.17	0.18	0.10	0.03	0.02	0.01	0.01	0.01	1.01
1949	0.03	0.22	0.24	0.00	0.06	0.18	0.09	0.05	0.03	0.02	0.02	0.02	0.95
1950	0.04	0.05	0.19	0.12	0.16	0.18	0.09	0.03	0.02	0.01	0.03	0.04	0.94
1951	0.06	0.03	0.19	0.19	0.18	0.17	0.09	0.03	0.02	0.04	0.03	0.02	1.04
1952	0.07	0.18	0.19	0.18	0.18	0.10	0.07	0.03	0.02	0.01	0.01	0.01	1.03
1953	0.01	0.22	0.24	0.19	0.19	0.17	0.07	0.07	0.04	0.02	0.01	0.03	1.26
1954	0.07	0.17	0.18	0.18	0.18	0.17	0.09	0.03	0.02	0.02	0.01	0.01	1.13
1955	0.01	0.06	0.19	0.09	0.18	0.19	0.07	0.03	0.02	0.01	0.01	0.01	0.87
1956	0.01	0.20	0.20	0.18	0.19	0.19	0.17	0.07	0.03	0.04	0.06	0.18	1.52
1957	0.18	0.10	0.17	0.18	0.18	0.15	0.16	0.07	0.02	0.02	0.01	0.01	1.26
1958	0.03	0.19	0.20	0.19	0.19	0.10	0.07	0.14	0.06	0.02	0.01	0.01	1.21
1959	0.22	0.20	0.20	0.00	0.07	0.18	0.19	0.07	0.03	0.02	0.01	0.01	1.20
1960	0.03	0.21	0.21	0.19	0.10	0.15	0.18	0.08	0.03	0.02	0.01	0.01	1.22
1961	0.02	0.21	0.21	0.19	0.18	0.19	0.18	0.07	0.02	0.02	0.02	0.01	1.31
1962	0.01	0.26	0.23	0.19	0.18	0.18	0.09	0.03	0.02	0.02	0.02	0.02	1.26
1963	0.06	0.19	0.08	0.19	0.12	0.16	0.09	0.03	0.02	0.02	0.01	0.05	1.00
1964	0.19	0.19	0.19	0.00	0.00	0.03	0.05	0.03	0.18	0.08	0.06	0.05	1.05
1965	0.03	0.17	0.11	0.15	0.17	0.07	0.03	0.02	0.02	0.02	0.01	0.01	0.80
1966	0.01	0.22	0.22	0.19	0.19	0.19	0.18	0.08	0.03	0.02	0.02	0.01	1.35
1967	0.01	0.04	0.19	0.20	0.09	0.17	0.08	0.02	0.01	0.01	0.01	0.01	0.84
1968	0.01	0.05	0.19	0.20	0.18	0.18	0.10	0.05	0.02	0.02	0.01	0.01	1.03
1969	0.24	0.13	0.17	0.19	0.18	0.10	0.04	0.02	0.02	0.01	0.04	0.18	1.33
1970	0.00	0.00	0.02	0.15	0.17	0.00	0.00	0.05	0.02	0.02	0.02	0.02	0.49
1971	0.07	0.17	0.18	0.18	0.18	0.18	0.09	0.05	0.02	0.02	0.01	0.01	1.16
1972	0.03	0.20	0.10	0.17	0.19	0.19	0.18	0.07	0.03	0.02	0.05	0.00	1.23
1973	0.00	0.09	0.16	0.17	0.18	0.18	0.17	0.07	0.03	0.02	0.02	0.02	1.11
1974	0.01	0.22	0.21	0.19	0.19	0.18	0.10	0.04	0.02	0.01	0.01	0.23	1.41
1975	0.11	0.17	0.19	0.19	0.19	0.18	0.18	0.10	0.04	0.02	0.01	0.03	1.41
1976	0.19	0.17	0.17	0.19	0.18	0.18	0.17	0.07	0.03	0.02	0.01	0.05	1.42
1977	0.18	0.19	0.18	0.18	0.18	0.18	0.17	0.07	0.02	0.02	0.01	0.03	1.43
1978	0.19	0.12	0.17	0.20	0.19	0.18	0.09	0.05	0.02	0.02	0.19	0.09	1.50
1979	0.06	0.00	0.08	0.19	0.19	0.18	0.09	0.03	0.02	0.01	0.01	0.19	1.05
1980	0.09	0.19	0.20	0.19	0.18	0.09	0.04	0.02	0.02	0.02	0.05	0.05	1.12
1981	0.02	0.19	0.20	0.19	0.18	0.17	0.17	0.07	0.03	0.02	0.01	0.01	1.27
1982	0.21	0.12	0.05	0.17	0.10	0.06	0.04	0.01	0.01	0.03	0.02	0.01	0.83
1983	0.23	0.21	0.19	0.19	0.18	0.19	0.10	0.04	0.02	0.02	0.03	0.02	1.42
1984	0.05	0.03	0.04	0.19	0.20	0.09	0.03	0.02	0.02	0.01	0.00	0.00	0.69
1985	0.20	0.20	0.18	0.19	0.16	0.17	0.18	0.07	0.03	0.02	0.02	0.02	1.44
1986	0.24	0.22	0.19	0.22	0.20	0.19	0.08	0.03	0.02	0.02	0.07	0.17	1.64
1987	0.09	0.15	0.20	0.19	0.18	0.18	0.09	0.03	0.04	0.04	0.02	0.02	1.23
1988	0.06	0.19	0.19	0.19	0.19	0.17	0.09	0.04	0.02	0.02	0.02	0.01	1.19
1989	0.01	0.21	0.21	0.21	0.19	0.19	0.10	0.04	0.02	0.02	0.01	0.01	1.22
1990	0.01	0.02	0.21	0.21	0.18	0.18	0.07	0.03	0.02	0.01	0.01	0.01	0.97
1991	0.20	0.22	0.19	0.19	0.19	0.18	0.08	0.03	0.02	0.01	0.01	0.01	1.34
1992	0.01	0.05	0.19	0.19	0.18	0.18	0.09	0.04	0.02	0.01	0.01	0.01	0.99
1993	0.20	0.22	0.19	0.19	0.19	0.19	0.10	0.04	0.02	0.02	0.01	0.01	1.37
1994	0.01	0.01	0.04	0.21	0.19	0.18	0.10	0.04	0.02	0.01	0.01	0.01	0.83

Afforestation and dryland sugar cane water use for 1995 – TM12.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	1.55	0.41	0.04	0.05	0.12	1.40	0.46	0.02	0.01	0.01	0.01	0.06	4.13
1921	0.05	1.44	1.52	0.38	0.08	0.08	0.04	0.02	0.04	0.04	0.06	0.05	3.80
1922	0.05	0.12	0.11	0.38	1.05	0.32	0.02	0.01	0.01	0.02	0.02	0.01	2.11
1923	0.01	0.03	0.05	0.08	1.58	0.54	0.02	0.02	0.01	0.01	0.01	0.02	2.36
1924	0.08	1.56	1.59	1.31	0.30	0.91	0.53	0.06	0.00	0.01	0.00	0.05	6.40
1925	0.09	0.06	0.05	0.53	0.21	0.06	0.03	0.02	0.02	0.02	0.01	0.08	1.17
1926	0.13	0.11	0.11	0.11	0.44	0.36	0.06	0.00	0.00	0.00	0.01	0.02	1.34
1927	0.06	0.05	0.10	0.11	0.08	0.10	0.06	0.02	0.01	0.01	0.01	0.02	0.62
1928	0.06	0.05	0.10	1.57	0.57	1.04	0.35	0.01	0.03	0.08	0.05	1.36	5.27
1929	0.48	1.09	0.39	1.25	0.40	1.01	0.36	0.02	0.01	0.01	0.01	0.02	5.03
1930	0.03	0.04	0.44	1.20	0.38	0.05	0.04	0.02	0.01	0.02	0.02	0.01	2.24
1931	0.02	0.02	0.06	0.13	1.55	0.55	0.04	0.05	0.03	0.01	0.01	0.01	2.46
1932	0.02	0.06	0.12	0.06	0.06	0.11	0.09	0.04	0.02	0.04	0.03	0.01	0.66
1933	0.00	1.67	1.44	0.82	0.22	0.07	0.11	0.08	0.03	0.02	0.05	0.04	4.56
1934	0.03	1.62	1.58	0.35	0.08	0.37	0.13	0.01	0.01	0.01	0.00	0.00	4.17
1935	0.01	0.02	0.02	0.10	0.79	0.27	0.02	0.08	0.05	0.02	0.01	0.01	1.38
1936	0.02	0.91	1.15	0.33	1.20	0.41	0.03	0.02	0.01	0.01	0.01	0.00	4.09
1937	0.01	0.02	0.11	1.50	0.52	0.04	0.08	0.05	0.04	0.06	0.05	0.02	2.49
1938	0.03	0.03	0.04	0.09	1.80	0.63	0.03	0.02	0.02	0.02	0.02	0.02	2.74
1939	0.03	0.19	0.09	0.04	0.04	0.04	0.04	0.05	0.10	0.07	0.03	0.03	0.74
1940	0.03	0.04	0.11	0.15	0.11	1.08	0.39	0.02	0.01	0.00	0.00	0.01	1.93
1941	0.03	0.03	0.03	0.13	1.59	1.40	0.33	0.02	0.01	0.01	0.01	0.02	3.60
1942	0.02	1.64	1.49	0.92	0.21	0.05	1.16	0.41	0.02	0.04	1.21	0.41	7.57
1943	1.24	1.37	1.30	0.37	1.39	0.50	0.03	0.01	0.01	0.01	0.01	0.07	6.30
1944	0.07	0.06	0.03	0.02	0.06	1.81	0.61	0.01	0.01	0.00	0.00	0.00	2.66
1945	0.00	0.01	0.04	0.05	1.67	0.58	0.03	0.02	0.01	0.00	0.01	0.00	2.41
1946	0.05	0.13	0.08	0.04	1.37	0.97	0.19	0.01	0.02	0.03	0.01	0.02	2.92
1947	0.06	0.11	1.49	1.55	0.41	0.98	0.36	0.03	0.01	0.01	0.01	0.01	5.02
1948	0.03	0.05	0.20	0.11	0.10	0.79	0.25	0.00	0.00	0.00	0.00	0.01	1.55
1949	0.02	0.06	0.06	0.04	0.03	1.93	0.66	0.03	0.02	0.01	0.02	0.02	2.89
1950	0.04	1.55	1.55	0.40	0.08	0.11	0.08	0.04	0.01	0.01	0.04	0.06	3.96
1951	0.05	0.03	0.06	1.79	0.63	0.10	0.06	0.02	0.01	0.02	0.03	0.02	2.79
1952	0.05	0.09	1.44	0.53	1.18	0.41	0.04	0.02	0.01	0.00	0.01	0.01	3.78
1953	0.02	0.06	0.13	0.08	0.52	0.19	0.04	0.04	0.02	0.01	0.00	0.03	1.12
1954	0.10	1.40	0.50	1.34	1.47	0.37	0.03	0.03	0.02	0.01	0.00	0.00	5.25
1955	0.01	0.02	0.69	0.23	0.28	1.07	0.33	0.01	0.01	0.01	0.00	0.01	2.66
1956	0.01	0.06	1.81	1.33	0.23	0.78	0.25	0.00	0.00	0.02	0.04	1.40	5.91
1957	1.31	0.30	0.06	0.11	1.42	0.48	0.07	0.05	0.02	0.00	0.00	0.01	3.82
1958	0.02	0.08	0.12	0.09	0.11	0.06	0.05	0.07	0.05	0.02	0.01	0.01	0.68
1959	0.07	0.11	0.09	0.05	0.11	1.23	0.96	0.15	0.00	0.00	0.00	0.01	2.78
1960	0.02	0.07	0.27	0.10	0.09	0.11	0.13	0.04	0.01	0.01	0.01	0.02	0.87
1961	0.02	0.04	0.07	1.56	1.53	0.39	0.06	0.03	0.01	0.01	0.00	0.01	3.72
1962	0.01	0.09	1.58	1.51	0.39	0.33	0.11	0.01	0.02	0.02	0.01	0.01	4.07
1963	0.02	1.03	0.33	0.29	0.10	0.08	0.09	0.04	0.02	0.02	0.01	0.05	2.10
1964	1.17	0.88	0.19	0.05	0.05	0.03	0.02	0.02	0.04	0.06	0.07	0.08	2.67
1965	0.05	0.05	0.07	1.79	0.64	0.03	0.01	0.02	0.02	0.02	0.02	0.01	2.70
1966	0.02	0.11	1.34	1.53	1.34	0.38	0.99	0.34	0.02	0.01	0.00	0.00	6.08
1967	0.01	0.03	0.02	0.07	0.09	0.10	0.07	0.03	0.01	0.01	0.01	0.01	0.44
1968	0.01	0.03	0.06	0.10	0.08	1.47	0.51	0.04	0.03	0.02	0.01	0.01	2.34
1969	0.07	0.06	0.10	0.08	0.24	0.10	0.02	0.01	0.01	0.01	0.04	0.09	0.82
1970	0.08	0.06	0.04	1.62	0.51	0.01	0.03	0.04	0.03	0.02	0.03	0.02	2.48
1971	0.03	0.08	0.14	0.13	0.09	1.39	0.47	0.02	0.02	0.01	0.01	0.01	2.38
1972	0.02	0.12	0.08	0.05	0.11	0.08	0.11	0.06	0.02	0.01	0.04	0.07	0.77
1973	0.04	0.08	0.10	1.20	0.97	1.16	0.37	0.03	0.01	0.01	0.01	0.01	3.97
1974	0.01	0.06	1.76	1.67	1.41	0.39	0.05	0.03	0.01	0.01	0.00	0.21	5.60
1975	0.07	1.25	1.35	1.37	1.38	1.26	0.32	0.03	0.02	0.01	0.01	0.01	7.08
1976	0.06	0.09	0.08	1.56	0.53	0.06	0.05	0.02	0.01	0.01	0.00	0.02	2.50
1977	0.46	0.18	0.08	1.34	0.48	0.10	0.08	0.03	0.01	0.00	0.01	0.04	2.81
1978	0.10	0.09	1.57	0.56	1.30	0.46	0.04	0.03	0.02	0.01	0.05	0.05	4.27
1979	0.04	0.05	0.09	0.11	0.11	0.07	0.05	0.03	0.01	0.00	0.00	0.05	0.63
1980	0.05	0.21	1.21	1.48	1.40	0.36	0.02	0.02	0.02	0.01	0.02	0.03	4.83
1981	0.02	0.04	0.06	0.13	0.08	0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.44
1982	0.09	0.07	0.09	0.14	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.66
1983	0.04	0.09	1.57	0.55	0.04	0.11	0.12	0.05	0.02	0.01	0.02	0.02	2.63
1984	0.06	0.05	0.03	1.85	1.00	0.12	0.00	0.00	0.01	0.01	0.01	0.01	3.12
1985	0.09	0.10	0.31	0.76	0.22	0.03	0.03	0.01	0.02	0.02	0.01	0.01	1.60
1986	1.43	0.50	1.24	1.38	1.32	1.30	0.33	0.00	0.01	0.01	0.06	1.34	8.92
1987	0.46	0.04	0.11	1.35	1.43	0.38	0.05	0.02	0.02	0.04	0.03	0.02	3.95
1988	0.08	0.07	0.88	0.30	1.32	0.46	0.02	0.01	0.01	0.01	0.01	0.00	3.17
1989	0.02	1.62	1.54	0.35	0.05	0.07	0.07	0.04	0.01	0.01	0.02	0.02	3.82
1990	0.02	0.02	0.82	1.24	1.27	0.33	0.02	0.01	0.01	0.01	0.01	0.01	3.75
1991	1.45	0.52	0.31	0.13	0.09	0.07	0.03	0.01	0.00	0.00	0.01	0.01	2.62
1992	0.01	0.05	0.10	0.08	0.13	0.14	0.07	0.02	0.01	0.00	0.00	0.01	0.62
1993	0.35	0.17	1.23	1.46	0.40	1.16	0.40	0.02	0.01	0.01	0.01	0.01	5.21
1994	0.02	0.02	0.03	1.82	0.63	0.39	0.13	0.01	0.00	0.01	0.00	0.01	3.04

Afforestation and dryland sugar cane water use for 1995 – TM13.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.85	0.49	0.15	0.18	0.48	0.66	0.33	0.15	0.13	0.05	0.03	0.07	3.58
1921	0.10	0.46	0.71	0.40	0.20	0.14	0.07	0.03	0.04	0.04	0.05	0.06	2.32
1922	0.04	0.34	0.43	0.39	0.66	0.45	0.11	0.07	0.04	0.07	0.07	0.03	2.70
1923	0.02	0.12	0.13	0.46	0.55	0.44	0.36	0.06	0.05	0.03	0.03	0.08	2.33
1924	0.15	0.43	0.73	0.77	0.81	0.86	0.76	0.39	0.10	0.07	0.05	0.09	5.21
1925	0.17	0.15	0.07	0.13	0.21	0.10	0.03	0.02	0.04	0.05	0.02	0.38	1.35
1926	0.70	0.44	0.49	0.74	0.49	0.17	0.07	0.03	0.02	0.02	0.02	0.02	3.21
1927	0.39	0.40	0.56	0.92	0.44	0.24	0.22	0.05	0.04	0.03	0.02	0.02	3.34
1928	0.24	0.24	0.41	0.84	0.70	0.43	0.22	0.08	0.09	0.11	0.06	0.13	3.53
1929	0.17	0.29	0.31	0.48	0.49	0.39	0.36	0.07	0.05	0.03	0.03	0.02	2.69
1930	0.06	0.07	0.06	0.43	0.43	0.09	0.15	0.11	0.03	0.07	0.07	0.02	1.59
1931	0.04	0.05	0.07	0.53	0.85	0.50	0.15	0.08	0.07	0.03	0.02	0.03	2.42
1932	0.03	0.49	0.87	0.45	0.51	0.58	0.15	0.06	0.04	0.07	0.07	0.03	3.35
1933	0.03	0.46	0.85	0.84	0.53	0.22	0.20	0.14	0.07	0.07	0.13	0.09	3.62
1934	0.08	0.44	0.77	0.45	0.43	0.50	0.15	0.06	0.04	0.04	0.03	0.02	3.01
1935	0.02	0.02	0.07	0.46	0.79	0.51	0.15	0.28	0.25	0.02	0.03	0.02	2.62
1936	0.06	0.34	0.36	0.15	0.44	0.41	0.07	0.04	0.03	0.03	0.02	0.01	1.97
1937	0.01	0.06	0.51	0.84	0.46	0.14	0.41	0.39	0.06	0.09	0.09	0.04	3.10
1938	0.44	0.49	0.49	0.51	0.53	0.57	0.15	0.07	0.06	0.04	0.03	0.06	3.45
1939	0.14	0.48	0.81	0.54	0.23	0.20	0.12	0.40	0.46	0.09	0.03	0.06	3.55
1940	0.06	0.12	0.47	0.49	0.50	0.75	0.46	0.13	0.06	0.04	0.03	0.02	3.11
1941	0.07	0.07	0.09	0.46	0.66	0.55	0.38	0.14	0.07	0.05	0.04	0.04	2.62
1942	0.08	0.44	0.67	0.71	0.52	0.22	0.51	0.50	0.13	0.18	0.44	0.32	4.70
1943	0.48	0.80	0.48	0.22	0.48	0.42	0.08	0.06	0.04	0.03	0.03	0.41	3.52
1944	0.44	0.12	0.11	0.07	0.14	0.46	0.39	0.07	0.05	0.04	0.03	0.01	1.92
1945	0.01	0.02	0.03	0.44	0.78	0.42	0.09	0.04	0.03	0.02	0.02	0.01	1.90
1946	0.07	0.43	0.44	0.11	0.36	0.71	0.43	0.09	0.12	0.11	0.04	0.03	2.96
1947	0.13	0.36	0.55	0.60	0.58	0.56	0.40	0.12	0.06	0.04	0.03	0.02	3.43
1948	0.03	0.06	0.24	0.56	0.68	0.74	0.48	0.11	0.06	0.04	0.03	0.03	3.05
1949	0.04	0.44	0.82	0.48	0.15	0.48	0.47	0.11	0.07	0.04	0.07	0.06	3.23
1950	0.03	0.04	0.36	0.71	0.47	0.49	0.43	0.08	0.06	0.03	0.09	0.11	2.90
1951	0.08	0.06	0.41	0.82	0.55	0.52	0.44	0.07	0.05	0.05	0.06	0.04	3.14
1952	0.10	0.17	0.46	0.44	0.48	0.45	0.10	0.08	0.05	0.03	0.06	0.06	2.47
1953	0.07	0.40	0.72	0.44	0.40	0.44	0.16	0.12	0.08	0.03	0.03	0.06	2.95
1954	0.18	0.39	0.66	0.81	0.79	0.76	0.49	0.14	0.07	0.05	0.03	0.03	4.40
1955	0.02	0.03	0.54	0.56	0.41	0.76	0.44	0.09	0.06	0.04	0.03	0.03	3.02
1956	0.03	0.39	0.77	0.81	0.49	0.44	0.45	0.12	0.05	0.06	0.11	0.44	4.16
1957	0.69	0.38	0.16	0.43	0.70	0.46	0.19	0.14	0.04	0.03	0.02	0.02	3.26
1958	0.03	0.09	0.15	0.19	0.40	0.31	0.11	0.40	0.36	0.05	0.04	0.03	2.16
1959	0.11	0.42	0.70	0.46	0.54	0.86	0.47	0.08	0.04	0.03	0.03	0.02	3.77
1960	0.07	0.40	0.74	0.44	0.25	0.52	0.40	0.12	0.04	0.03	0.02	0.03	3.06
1961	0.04	0.08	0.14	0.41	0.69	0.77	0.56	0.17	0.05	0.04	0.03	0.03	3.01
1962	0.03	0.47	0.81	0.74	0.43	0.51	0.51	0.09	0.07	0.06	0.04	0.03	3.78
1963	0.08	0.48	0.48	0.51	0.49	0.17	0.15	0.05	0.03	0.03	0.02	0.19	2.69
1964	0.41	0.39	0.25	0.15	0.10	0.04	0.04	0.04	0.17	0.15	0.07	0.09	1.92
1965	0.04	0.06	0.12	0.49	0.49	0.11	0.06	0.05	0.05	0.03	0.03	0.03	1.55
1966	0.05	0.34	0.58	0.58	0.71	0.77	0.75	0.44	0.09	0.06	0.05	0.03	4.45
1967	0.05	0.41	0.48	0.18	0.12	0.12	0.09	0.03	0.02	0.02	0.02	0.02	1.55
1968	0.02	0.07	0.17	0.18	0.13	0.34	0.35	0.12	0.07	0.02	0.01	0.03	1.49
1969	0.34	0.35	0.44	0.53	0.54	0.46	0.07	0.05	0.04	0.03	0.34	0.48	3.67
1970	0.19	0.09	0.09	0.50	0.51	0.09	0.07	0.09	0.08	0.05	0.06	0.04	1.86
1971	0.09	0.15	0.16	0.43	0.45	0.41	0.34	0.07	0.05	0.04	0.03	0.02	2.23
1972	0.07	0.34	0.32	0.29	0.55	0.40	0.20	0.11	0.03	0.02	0.09	0.15	2.56
1973	0.06	0.35	0.70	0.76	0.82	0.69	0.41	0.17	0.07	0.06	0.04	0.03	4.16
1974	0.03	0.18	0.52	0.75	0.77	0.46	0.14	0.09	0.05	0.03	0.02	0.45	3.49
1975	0.48	0.49	0.85	0.82	0.84	0.84	0.49	0.15	0.12	0.06	0.04	0.03	5.21
1976	0.36	0.39	0.14	0.39	0.35	0.20	0.24	0.08	0.02	0.02	0.01	0.04	2.26
1977	0.41	0.45	0.43	0.74	0.47	0.29	0.25	0.06	0.02	0.02	0.02	0.06	3.20
1978	0.37	0.41	0.49	0.66	0.33	0.13	0.09	0.09	0.09	0.02	0.09	0.08	2.86
1979	0.03	0.03	0.12	0.45	0.43	0.12	0.07	0.04	0.03	0.02	0.02	0.08	1.43
1980	0.09	0.24	0.52	0.68	0.78	0.44	0.11	0.07	0.06	0.05	0.09	0.09	3.22
1981	0.03	0.22	0.25	0.42	0.41	0.45	0.46	0.07	0.05	0.04	0.03	0.09	2.52
1982	0.40	0.35	0.08	0.17	0.13	0.11	0.14	0.06	0.02	0.03	0.04	0.03	1.54
1983	0.09	0.35	0.65	0.48	0.13	0.43	0.48	0.11	0.04	0.03	0.06	0.05	2.89
1984	0.10	0.12	0.11	0.37	0.70	0.46	0.10	0.06	0.04	0.03	0.02	0.02	2.13
1985	0.46	0.72	0.39	0.49	0.49	0.17	0.08	0.04	0.04	0.03	0.05	0.05	3.02
1986	0.22	0.26	0.15	0.17	0.40	0.70	0.40	0.06	0.04	0.03	0.15	0.36	2.96
1987	0.29	0.10	0.08	0.50	0.88	0.78	0.41	0.11	0.13	0.12	0.05	0.04	3.49
1988	0.04	0.08	0.38	0.44	0.40	0.33	0.09	0.05	0.04	0.03	0.02	0.01	1.92
1989	0.04	0.48	0.54	0.17	0.12	0.14	0.13	0.05	0.02	0.02	0.05	0.05	1.80
1990	0.03	0.04	0.45	0.87	0.65	0.26	0.07	0.05	0.03	0.03	0.02	0.02	2.52
1991	0.41	0.49	0.53	0.50	0.49	0.50	0.11	0.07	0.04	0.03	0.02	0.02	3.21
1992	0.02	0.07	0.46	0.75	0.64	0.41	0.16	0.06	0.05	0.03	0.02	0.02	2.69
1993	0.42	0.50	0.50	0.76	0.75	0.79	0.46	0.11	0.06	0.04	0.03	0.03	4.46
1994	0.04	0.04	0.45	0.79	0.39	0.27	0.25	0.04	0.03	0.03	0.02	0.02	2.34

Afforestation and dryland sugar cane water use for 1995 – TM18.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.82	0.48	0.14	0.15	0.58	0.91	0.45	0.14	0.12	0.05	0.04	0.06	3.95
1921	0.08	0.50	0.88	0.52	0.19	0.16	0.07	0.04	0.05	0.06	0.06	0.06	2.67
1922	0.09	0.48	0.48	0.51	0.78	0.43	0.11	0.06	0.04	0.04	0.04	0.03	3.09
1923	0.03	0.08	0.11	0.48	0.54	0.43	0.38	0.06	0.05	0.03	0.03	0.06	2.28
1924	0.12	0.32	0.61	0.60	0.62	0.78	0.71	0.38	0.11	0.07	0.05	0.07	4.42
1925	0.13	0.14	0.07	0.09	0.15	0.11	0.04	0.03	0.04	0.03	0.03	0.01	0.86
1926	0.17	0.25	0.44	0.72	0.44	0.18	0.11	0.04	0.03	0.03	0.02	0.02	2.44
1927	0.00	0.00	0.46	0.69	0.26	0.15	0.13	0.05	0.04	0.03	0.02	0.02	1.86
1928	0.10	0.11	0.24	0.42	0.33	0.31	0.23	0.07	0.07	0.13	0.10	0.09	2.18
1929	0.14	0.48	0.48	0.49	0.51	0.47	0.41	0.07	0.05	0.03	0.03	0.03	3.19
1930	0.05	0.06	0.06	0.15	0.14	0.06	0.10	0.08	0.02	0.04	0.04	0.02	0.82
1931	0.02	0.03	0.07	0.54	0.86	0.46	0.13	0.07	0.07	0.04	0.03	0.02	2.34
1932	0.03	0.49	0.85	0.42	0.50	0.55	0.13	0.06	0.04	0.04	0.04	0.03	3.20
1933	0.03	0.51	0.88	0.79	0.49	0.18	0.17	0.13	0.07	0.04	0.09	0.07	3.46
1934	0.06	0.46	0.80	0.43	0.58	0.64	0.15	0.07	0.05	0.04	0.03	0.02	3.33
1935	0.02	0.02	0.06	0.61	0.93	0.48	0.13	0.13	0.13	0.04	0.03	0.02	2.60
1936	0.04	0.52	0.56	0.13	0.28	0.24	0.03	0.03	0.02	0.02	0.01	0.01	1.90
1937	0.01	0.04	0.52	0.85	0.44	0.13	0.19	0.14	0.01	0.06	0.06	0.03	2.48
1938	0.44	0.49	0.48	0.50	0.53	0.55	0.13	0.06	0.05	0.05	0.04	0.06	3.37
1939	0.11	0.49	0.79	0.48	0.18	0.17	0.10	0.40	0.44	0.08	0.04	0.04	3.32
1940	0.05	0.09	0.33	0.35	0.49	0.74	0.43	0.11	0.06	0.03	0.03	0.02	2.73
1941	0.06	0.06	0.07	0.58	0.95	0.81	0.49	0.13	0.07	0.05	0.04	0.04	3.32
1942	0.07	0.55	0.93	0.82	0.49	0.18	0.51	0.50	0.11	0.12	0.41	0.35	5.05
1943	0.46	0.77	0.44	0.18	0.56	0.53	0.09	0.06	0.04	0.04	0.03	0.42	3.63
1944	0.45	0.11	0.08	0.04	0.11	0.50	0.47	0.08	0.06	0.04	0.03	0.02	1.99
1945	0.01	0.02	0.02	0.28	0.42	0.23	0.11	0.04	0.03	0.02	0.01	0.01	1.19
1946	0.04	0.45	0.47	0.11	0.54	0.86	0.41	0.09	0.08	0.07	0.04	0.03	3.20
1947	0.09	0.51	0.84	0.85	0.59	0.34	0.27	0.09	0.04	0.03	0.02	0.02	3.69
1948	0.02	0.04	0.13	0.53	0.76	0.70	0.43	0.10	0.06	0.04	0.03	0.03	2.87
1949	0.03	0.46	0.82	0.45	0.14	0.50	0.50	0.11	0.07	0.04	0.06	0.06	3.24
1950	0.03	0.04	0.57	0.91	0.45	0.48	0.45	0.08	0.05	0.03	0.06	0.09	3.24
1951	0.08	0.06	0.12	0.54	0.53	0.46	0.40	0.06	0.05	0.04	0.05	0.04	2.42
1952	0.08	0.14	0.48	0.47	0.49	0.48	0.11	0.07	0.04	0.03	0.03	0.04	2.45
1953	0.06	0.18	0.35	0.26	0.52	0.55	0.13	0.10	0.07	0.03	0.02	0.04	2.32
1954	0.12	0.51	0.80	0.76	0.61	0.59	0.45	0.14	0.08	0.04	0.04	0.03	4.16
1955	0.02	0.02	0.54	0.56	0.56	0.88	0.42	0.09	0.06	0.04	0.03	0.03	3.28
1956	0.03	0.12	0.51	0.78	0.48	0.48	0.46	0.11	0.05	0.04	0.08	0.47	3.60
1957	0.72	0.37	0.14	0.56	0.84	0.44	0.16	0.12	0.04	0.03	0.02	0.02	3.46
1958	0.02	0.11	0.17	0.15	0.44	0.41	0.10	0.41	0.39	0.06	0.04	0.03	2.32
1959	0.08	0.27	0.40	0.25	0.49	0.79	0.46	0.13	0.06	0.03	0.02	0.02	3.00
1960	0.06	0.15	0.31	0.23	0.12	0.50	0.48	0.09	0.04	0.03	0.02	0.02	2.05
1961	0.03	0.07	0.14	0.51	0.63	0.59	0.48	0.14	0.06	0.03	0.03	0.02	2.74
1962	0.03	0.51	0.85	0.72	0.43	0.53	0.53	0.10	0.06	0.05	0.04	0.03	3.87
1963	0.05	0.49	0.51	0.50	0.49	0.15	0.15	0.07	0.03	0.03	0.02	0.08	2.58
1964	0.46	0.43	0.08	0.09	0.08	0.04	0.04	0.03	0.11	0.13	0.11	0.09	1.68
1965	0.05	0.04	0.08	0.51	0.53	0.09	0.06	0.05	0.05	0.03	0.03	0.03	1.56
1966	0.03	0.51	0.70	0.37	0.54	0.72	0.70	0.40	0.09	0.06	0.04	0.03	4.20
1967	0.03	0.15	0.17	0.09	0.08	0.09	0.07	0.03	0.03	0.02	0.02	0.02	0.79
1968	0.02	0.05	0.13	0.16	0.14	0.45	0.42	0.11	0.07	0.03	0.02	0.02	1.61
1969	0.10	0.12	0.24	0.25	0.38	0.38	0.06	0.04	0.03	0.02	0.09	0.17	1.89
1970	0.09	0.03	0.06	0.48	0.51	0.09	0.06	0.08	0.07	0.04	0.06	0.05	1.61
1971	0.07	0.13	0.14	0.33	0.28	0.32	0.35	0.07	0.04	0.03	0.03	0.02	1.81
1972	0.05	0.50	0.50	0.14	0.50	0.48	0.16	0.09	0.03	0.02	0.06	0.13	2.66
1973	0.09	0.10	0.45	0.74	0.75	0.77	0.49	0.13	0.07	0.05	0.04	0.03	3.70
1974	0.02	0.11	0.52	0.81	0.74	0.44	0.13	0.08	0.04	0.04	0.03	0.44	3.40
1975	0.46	0.46	0.81	0.77	0.78	0.77	0.46	0.14	0.10	0.06	0.04	0.03	4.88
1976	0.11	0.14	0.11	0.51	0.49	0.14	0.18	0.11	0.03	0.01	0.01	0.03	1.86
1977	0.43	0.47	0.18	0.30	0.25	0.14	0.17	0.09	0.02	0.01	0.02	0.04	2.12
1978	0.13	0.12	0.38	0.53	0.20	0.09	0.07	0.08	0.07	0.03	0.07	0.08	1.85
1979	0.03	0.03	0.08	0.23	0.18	0.06	0.05	0.03	0.02	0.02	0.01	0.05	0.79
1980	0.06	0.11	0.50	0.79	0.75	0.43	0.11	0.07	0.05	0.04	0.06	0.07	3.02
1981	0.03	0.11	0.14	0.45	0.43	0.45	0.46	0.07	0.04	0.03	0.03	0.07	2.32
1982	0.42	0.40	0.08	0.15	0.13	0.11	0.12	0.06	0.03	0.02	0.03	0.03	1.56
1983	0.06	0.50	0.82	0.47	0.15	0.45	0.47	0.09	0.04	0.03	0.04	0.04	3.17
1984	0.07	0.09	0.09	0.55	0.87	0.44	0.10	0.06	0.03	0.03	0.02	0.02	2.37
1985	0.46	0.85	0.49	0.46	0.46	0.15	0.08	0.04	0.03	0.03	0.03	0.03	3.11
1986	0.10	0.15	0.14	0.15	0.45	0.72	0.38	0.06	0.04	0.03	0.08	0.49	2.80
1987	0.47	0.10	0.08	0.51	0.85	0.60	0.28	0.11	0.11	0.11	0.06	0.03	3.31
1988	0.04	0.07	0.54	0.59	0.51	0.48	0.09	0.05	0.04	0.04	0.02	0.01	2.48
1989	0.02	0.49	0.55	0.14	0.12	0.12	0.12	0.06	0.02	0.02	0.03	0.03	1.71
1990	0.03	0.03	0.35	0.74	0.51	0.13	0.06	0.04	0.03	0.02	0.02	0.02	1.97
1991	0.55	0.61	0.51	0.50	0.49	0.50	0.11	0.06	0.04	0.03	0.02	0.02	3.43
1992	0.02	0.05	0.57	0.88	0.77	0.53	0.14	0.07	0.04	0.03	0.02	0.02	3.13
1993	0.46	0.54	0.48	0.75	0.72	0.74	0.43	0.11	0.07	0.04	0.03	0.03	4.39
1994	0.03	0.03	0.11	0.32	0.23	0.13	0.12	0.04	0.03	0.02	0.02	0.01	1.08

Afforestation and dryland sugar cane water use for 1995 – TM20.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.12	0.13	0.06	0.03	0.09	0.11	0.04	0.02	0.02	0.01	0.00	0.01	0.64
1921	0.02	0.09	0.10	0.05	0.02	0.09	0.05	0.02	0.01	0.01	0.01	0.01	0.46
1922	0.09	0.11	0.11	0.13	0.12	0.11	0.05	0.02	0.01	0.01	0.00	0.01	0.76
1923	0.01	0.09	0.05	0.09	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.34
1924	0.02	0.08	0.11	0.11	0.06	0.09	0.09	0.04	0.02	0.02	0.01	0.10	0.75
1925	0.11	0.03	0.02	0.10	0.06	0.08	0.03	0.02	0.01	0.01	0.00	0.09	0.55
1926	0.05	0.02	0.09	0.05	0.09	0.11	0.05	0.02	0.01	0.01	0.01	0.01	0.53
1927	0.09	0.03	0.10	0.13	0.06	0.09	0.03	0.01	0.01	0.01	0.01	0.01	0.58
1928	0.00	0.00	0.07	0.12	0.06	0.09	0.05	0.02	0.02	0.02	0.01	0.09	0.55
1929	0.05	0.08	0.04	0.10	0.12	0.11	0.04	0.02	0.02	0.01	0.01	0.01	0.60
1930	0.01	0.02	0.10	0.12	0.05	0.08	0.04	0.02	0.00	0.01	0.01	0.01	0.46
1931	0.01	0.00	0.01	0.10	0.11	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.34
1932	0.00	0.10	0.12	0.05	0.12	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.52
1933	0.01	0.10	0.11	0.11	0.06	0.09	0.10	0.05	0.01	0.02	0.03	0.01	0.69
1934	0.02	0.09	0.10	0.05	0.11	0.11	0.05	0.02	0.01	0.01	0.01	0.01	0.56
1935	0.00	0.01	0.00	0.09	0.11	0.10	0.04	0.02	0.01	0.01	0.01	0.01	0.41
1936	0.02	0.09	0.05	0.10	0.11	0.06	0.02	0.01	0.01	0.01	0.00	0.01	0.48
1937	0.00	0.01	0.10	0.11	0.12	0.06	0.08	0.03	0.01	0.02	0.02	0.01	0.57
1938	0.10	0.06	0.09	0.11	0.11	0.10	0.05	0.02	0.01	0.01	0.00	0.02	0.69
1939	0.02	0.07	0.05	0.09	0.11	0.10	0.05	0.08	0.05	0.02	0.01	0.02	0.67
1940	0.02	0.09	0.11	0.13	0.12	0.11	0.05	0.02	0.01	0.01	0.01	0.01	0.68
1941	0.01	0.03	0.02	0.09	0.11	0.11	0.05	0.02	0.01	0.01	0.01	0.01	0.47
1942	0.01	0.09	0.11	0.11	0.11	0.05	0.10	0.09	0.03	0.07	0.08	0.03	0.89
1943	0.10	0.11	0.11	0.00	0.00	0.06	0.02	0.01	0.01	0.01	0.01	0.10	0.53
1944	0.05	0.02	0.01	0.02	0.09	0.11	0.04	0.02	0.01	0.01	0.00	0.00	0.38
1945	0.01	0.00	0.01	0.09	0.11	0.11	0.05	0.02	0.02	0.01	0.01	0.00	0.43
1946	0.01	0.10	0.06	0.02	0.09	0.11	0.04	0.01	0.01	0.01	0.01	0.01	0.48
1947	0.01	0.09	0.10	0.11	0.11	0.11	0.05	0.03	0.01	0.01	0.00	0.01	0.64
1948	0.00	0.01	0.09	0.12	0.13	0.11	0.04	0.02	0.01	0.01	0.01	0.01	0.55
1949	0.01	0.09	0.11	0.06	0.03	0.09	0.09	0.05	0.02	0.01	0.02	0.01	0.57
1950	0.01	0.02	0.00	0.05	0.11	0.05	0.03	0.02	0.01	0.01	0.02	0.02	0.34
1951	0.02	0.01	0.10	0.11	0.10	0.10	0.04	0.02	0.02	0.01	0.01	0.01	0.55
1952	0.02	0.08	0.10	0.05	0.10	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.47
1953	0.01	0.02	0.10	0.05	0.09	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.39
1954	0.09	0.10	0.05	0.09	0.10	0.05	0.02	0.01	0.01	0.01	0.00	0.01	0.53
1955	0.00	0.00	0.09	0.05	0.10	0.11	0.04	0.02	0.01	0.01	0.01	0.01	0.44
1956	0.01	0.09	0.11	0.11	0.11	0.11	0.06	0.02	0.01	0.01	0.02	0.08	0.74
1957	0.09	0.05	0.08	0.10	0.11	0.05	0.09	0.04	0.01	0.01	0.01	0.01	0.65
1958	0.01	0.08	0.10	0.10	0.10	0.00	0.00	0.05	0.02	0.01	0.01	0.01	0.49
1959	0.01	0.07	0.11	0.05	0.08	0.05	0.08	0.04	0.01	0.01	0.01	0.01	0.52
1960	0.02	0.08	0.10	0.05	0.09	0.10	0.05	0.02	0.01	0.00	0.01	0.00	0.53
1961	0.01	0.09	0.11	0.11	0.11	0.11	0.09	0.04	0.01	0.01	0.01	0.00	0.71
1962	0.01	0.10	0.11	0.10	0.05	0.10	0.05	0.02	0.01	0.02	0.02	0.01	0.60
1963	0.09	0.11	0.05	0.10	0.06	0.10	0.05	0.01	0.01	0.01	0.01	0.07	0.67
1964	0.10	0.10	0.11	0.13	0.06	0.02	0.02	0.01	0.09	0.04	0.02	0.02	0.72
1965	0.01	0.02	0.02	0.09	0.10	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.33
1966	0.01	0.11	0.12	0.11	0.12	0.11	0.11	0.05	0.02	0.01	0.01	0.01	0.77
1967	0.01	0.08	0.10	0.11	0.06	0.03	0.01	0.01	0.00	0.01	0.00	0.01	0.42
1968	0.00	0.02	0.09	0.10	0.11	0.11	0.06	0.03	0.01	0.00	0.01	0.01	0.54
1969	0.09	0.05	0.09	0.11	0.10	0.04	0.02	0.01	0.01	0.01	0.09	0.09	0.69
1970	0.08	0.03	0.02	0.03	0.03	0.03	0.01	0.02	0.01	0.01	0.02	0.01	0.29
1971	0.07	0.05	0.03	0.09	0.10	0.10	0.05	0.02	0.01	0.01	0.01	0.00	0.54
1972	0.01	0.10	0.05	0.03	0.09	0.10	0.11	0.04	0.01	0.01	0.01	0.02	0.58
1973	0.02	0.09	0.10	0.11	0.11	0.10	0.06	0.02	0.01	0.01	0.01	0.01	0.64
1974	0.01	0.09	0.11	0.11	0.11	0.06	0.03	0.01	0.01	0.01	0.01	0.09	0.67
1975	0.03	0.09	0.11	0.11	0.12	0.12	0.05	0.02	0.02	0.02	0.01	0.02	0.73
1976	0.09	0.04	0.03	0.00	0.00	0.10	0.06	0.02	0.01	0.00	0.01	0.02	0.37
1977	0.02	0.02	0.07	0.10	0.11	0.11	0.11	0.05	0.02	0.01	0.00	0.02	0.64
1978	0.07	0.10	0.11	0.12	0.06	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.59
1979	0.01	0.01	0.02	0.10	0.11	0.11	0.05	0.02	0.02	0.01	0.00	0.02	0.45
1980	0.01	0.09	0.10	0.10	0.11	0.05	0.02	0.01	0.01	0.01	0.02	0.01	0.54
1981	0.01	0.09	0.05	0.07	0.04	0.10	0.05	0.02	0.01	0.01	0.00	0.01	0.44
1982	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.12
1983	0.01	0.09	0.11	0.12	0.06	0.09	0.05	0.01	0.01	0.01	0.01	0.01	0.57
1984	0.01	0.01	0.01	0.09	0.11	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.35
1985	0.00	0.02	0.10	0.11	0.11	0.05	0.03	0.02	0.01	0.00	0.01	0.01	0.48
1986	0.07	0.09	0.10	0.11	0.11	0.11	0.05	0.02	0.01	0.01	0.02	0.09	0.79
1987	0.05	0.07	0.05	0.03	0.09	0.10	0.05	0.02	0.02	0.01	0.01	0.01	0.50
1988	0.02	0.09	0.10	0.12	0.12	0.11	0.05	0.02	0.01	0.01	0.00	0.00	0.64
1989	0.00	0.10	0.13	0.12	0.05	0.10	0.05	0.02	0.01	0.01	0.01	0.01	0.58
1990	0.01	0.01	0.10	0.12	0.11	0.10	0.03	0.02	0.02	0.00	0.01	0.01	0.53
1991	0.09	0.10	0.11	0.05	0.11	0.05	0.02	0.01	0.01	0.00	0.01	0.01	0.57
1992	0.00	0.00	0.02	0.03	0.09	0.11	0.04	0.01	0.01	0.00	0.01	0.01	0.33
1993	0.03	0.02	0.08	0.10	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.35
1994	0.01	0.00	0.01	0.09	0.05	0.11	0.07	0.02	0.01	0.01	0.01	0.01	0.40

Afforestation and dryland sugar cane water use for 1995 – TM22.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.03	0.03	0.02	0.03	0.06	0.30	0.10	0.01	0.01	0.01	0.01	0.02	0.65
1921	0.02	0.36	0.39	0.10	0.02	0.03	0.02	0.01	0.01	0.02	0.02	0.01	1.03
1922	0.03	0.31	0.13	0.32	0.13	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.96
1923	0.01	0.01	0.02	0.03	0.05	0.03	0.01	0.01	0.00	0.01	0.00	0.01	0.21
1924	0.03	0.37	0.37	0.33	0.11	0.29	0.10	0.01	0.01	0.00	0.01	0.02	1.66
1925	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.02	0.25
1926	0.05	0.05	0.03	0.03	0.05	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.33
1927	0.02	0.02	0.05	0.31	0.11	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.56
1928	0.02	0.01	0.01	0.05	0.03	0.05	0.03	0.01	0.01	0.02	0.02	0.03	0.31
1929	0.03	0.05	0.02	0.05	0.03	0.38	0.14	0.00	0.01	0.00	0.00	0.01	0.72
1930	0.01	0.02	0.02	0.05	0.02	0.02	0.02	0.01	0.00	0.01	0.01	0.01	0.22
1931	0.01	0.01	0.02	0.05	0.38	0.14	0.01	0.01	0.01	0.00	0.00	0.01	0.65
1932	0.01	0.03	0.31	0.11	0.05	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.59
1933	0.01	0.39	0.37	0.34	0.09	0.03	0.03	0.02	0.01	0.01	0.01	0.02	1.35
1934	0.02	0.32	0.39	0.10	0.02	0.05	0.03	0.02	0.02	0.01	0.01	0.00	1.01
1935	0.00	0.01	0.01	0.05	0.37	0.14	0.01	0.02	0.02	0.01	0.00	0.01	0.65
1936	0.02	0.37	0.14	0.02	0.05	0.03	0.01	0.00	0.00	0.01	0.00	0.00	0.65
1937	0.00	0.02	0.05	0.06	0.05	0.02	0.03	0.02	0.01	0.01	0.01	0.00	0.29
1938	0.03	0.02	0.05	0.03	0.33	0.13	0.02	0.01	0.00	0.00	0.01	0.01	0.65
1939	0.03	0.31	0.34	0.10	0.03	0.03	0.02	0.31	0.10	0.01	0.01	0.01	1.33
1940	0.02	0.05	0.34	0.11	0.03	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.68
1941	0.01	0.01	0.01	0.05	0.06	0.31	0.10	0.01	0.00	0.01	0.01	0.01	0.60
1942	0.02	0.34	0.38	0.31	0.09	0.02	0.34	0.13	0.00	0.02	0.26	0.09	2.02
1943	0.31	0.13	0.03	0.03	0.33	0.13	0.01	0.01	0.01	0.00	0.01	0.02	1.03
1944	0.02	0.02	0.02	0.02	0.03	0.38	0.14	0.00	0.00	0.00	0.00	0.00	0.64
1945	0.00	0.00	0.01	0.05	0.06	0.03	0.02	0.00	0.00	0.01	0.00	0.00	0.18
1946	0.01	0.02	0.03	0.05	0.34	0.13	0.02	0.01	0.02	0.02	0.01	0.01	0.69
1947	0.02	0.34	0.14	0.03	0.03	0.29	0.10	0.01	0.00	0.00	0.00	0.00	0.98
1948	0.01	0.02	0.03	0.05	0.06	0.05	0.02	0.01	0.00	0.00	0.00	0.01	0.26
1949	0.01	0.02	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.01	0.01	0.01	0.14
1950	0.01	0.01	0.05	0.33	0.13	0.02	0.02	0.01	0.01	0.00	0.03	0.03	0.67
1951	0.03	0.01	0.05	0.37	0.15	0.03	0.01	0.00	0.01	0.00	0.01	0.00	0.68
1952	0.02	0.03	0.06	0.03	0.36	0.13	0.01	0.01	0.01	0.00	0.01	0.01	0.69
1953	0.01	0.03	0.03	0.03	0.06	0.03	0.01	0.02	0.01	0.00	0.00	0.02	0.28
1954	0.32	0.13	0.02	0.36	0.14	0.02	0.01	0.01	0.01	0.01	0.00	0.01	1.04
1955	0.01	0.01	0.05	0.03	0.05	0.32	0.10	0.00	0.00	0.00	0.00	0.01	0.59
1956	0.01	0.05	0.34	0.40	0.11	0.26	0.09	0.01	0.00	0.00	0.01	0.36	1.65
1957	0.32	0.08	0.02	0.05	0.06	0.02	0.03	0.02	0.00	0.00	0.00	0.01	0.62
1958	0.01	0.03	0.32	0.14	0.00	0.00	0.02	0.33	0.11	0.00	0.00	0.00	0.98
1959	0.02	0.03	0.03	0.03	0.05	0.03	0.05	0.02	0.01	0.00	0.01	0.01	0.31
1960	0.02	0.03	0.34	0.13	0.03	0.03	0.03	0.01	0.01	0.00	0.00	0.01	0.67
1961	0.02	0.05	0.05	0.39	0.15	0.03	0.02	0.02	0.01	0.00	0.01	0.01	0.77
1962	0.01	0.36	0.14	0.03	0.02	0.37	0.13	0.00	0.01	0.02	0.02	0.01	1.13
1963	0.01	0.03	0.02	0.38	0.14	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.71
1964	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.00	0.03	0.03	0.03	0.02	0.32
1965	0.02	0.02	0.03	0.34	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.63
1966	0.01	0.03	0.05	0.37	0.39	0.31	0.09	0.01	0.01	0.01	0.00	0.00	1.29
1967	0.01	0.05	0.05	0.05	0.03	0.02	0.02	0.00	0.01	0.00	0.00	0.01	0.25
1968	0.01	0.02	0.05	0.03	0.05	0.37	0.13	0.01	0.01	0.00	0.01	0.01	0.70
1969	0.05	0.03	0.05	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.33
1970	0.05	0.02	0.03	0.05	0.03	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.32
1971	0.02	0.03	0.03	0.05	0.05	0.36	0.11	0.00	0.01	0.00	0.00	0.00	0.67
1972	0.01	0.02	0.02	0.05	0.40	0.15	0.03	0.01	0.00	0.00	0.01	0.02	0.73
1973	0.02	0.03	0.03	0.39	0.16	0.22	0.09	0.01	0.01	0.01	0.00	0.01	1.00
1974	0.00	0.02	0.03	0.06	0.32	0.10	0.01	0.00	0.00	0.00	0.00	0.03	0.59
1975	0.02	0.03	0.34	0.40	0.36	0.33	0.09	0.01	0.01	0.01	0.00	0.01	1.63
1976	0.05	0.03	0.02	0.05	0.02	0.05	0.03	0.02	0.00	0.00	0.00	0.01	0.29
1977	0.03	0.03	0.36	0.40	0.10	0.03	0.05	0.02	0.01	0.01	0.00	0.02	1.08
1978	0.05	0.05	0.36	0.34	0.09	0.02	0.01	0.02	0.02	0.01	0.01	0.01	1.00
1979	0.02	0.01	0.02	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.18
1980	0.02	0.03	0.05	0.05	0.25	0.09	0.01	0.01	0.01	0.00	0.01	0.01	0.55
1981	0.01	0.03	0.02	0.03	0.02	0.33	0.11	0.00	0.00	0.00	0.00	0.01	0.59
1982	0.05	0.03	0.02	0.02	0.02	0.03	0.02	0.01	0.00	0.01	0.01	0.01	0.25
1983	0.02	0.38	0.15	0.03	0.03	0.05	0.03	0.01	0.00	0.00	0.01	0.01	0.73
1984	0.02	0.02	0.02	0.41	0.39	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.98
1985	0.05	0.05	0.29	0.32	0.09	0.02	0.01	0.00	0.00	0.01	0.01	0.00	0.85
1986	0.02	0.03	0.03	0.31	0.32	0.32	0.08	0.01	0.01	0.01	0.03	0.36	1.55
1987	0.13	0.02	0.02	0.03	0.03	0.25	0.09	0.01	0.01	0.01	0.01	0.00	0.63
1988	0.02	0.02	0.34	0.13	0.31	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.95
1989	0.01	0.36	0.14	0.02	0.03	0.05	0.03	0.01	0.01	0.00	0.01	0.01	0.69
1990	0.02	0.02	0.05	0.34	0.32	0.08	0.01	0.01	0.01	0.01	0.00	0.01	0.90
1991	0.05	0.03	0.02	0.02	0.05	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.23
1992	0.01	0.02	0.02	0.03	0.05	0.06	0.02	0.01	0.01	0.00	0.00	0.01	0.25
1993	0.05	0.03	0.00	0.00	0.00	0.02	0.02	0.01	0.00	0.01	0.01	0.01	0.17
1994	0.01	0.01	0.02	0.05	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.00	0.22

Afforestation and dryland sugar cane water use for 1995 – TM23.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.73	0.23	0.07	0.13	0.52	0.62	0.17	0.02	0.02	0.01	0.01	0.07	2.59
1921	0.09	0.64	0.75	0.23	0.08	0.08	0.03	0.02	0.05	0.03	0.06	0.04	2.11
1922	0.48	0.42	0.59	0.73	0.66	0.20	0.03	0.01	0.01	0.02	0.02	0.01	3.17
1923	0.01	0.05	0.06	0.55	0.19	0.05	0.02	0.02	0.01	0.01	0.01	0.06	1.04
1924	0.09	0.62	0.71	0.70	0.70	0.74	0.24	0.03	0.01	0.01	0.01	0.06	3.89
1925	0.13	0.05	0.05	0.09	0.09	0.09	0.02	0.01	0.03	0.02	0.01	0.58	1.15
1926	0.59	0.20	0.53	0.24	0.34	0.43	0.12	0.01	0.00	0.01	0.04	0.03	2.53
1927	0.09	0.06	0.76	0.86	0.23	0.39	0.10	0.00	0.01	0.00	0.01	0.04	2.55
1928	0.08	0.06	0.06	0.68	0.26	0.63	0.22	0.02	0.05	0.08	0.04	0.02	2.20
1929	0.28	0.41	0.14	0.70	0.28	0.63	0.23	0.02	0.01	0.01	0.01	0.03	2.74
1930	0.07	0.07	0.10	0.59	0.22	0.07	0.06	0.03	0.01	0.03	0.03	0.01	1.28
1931	0.05	0.03	0.07	0.64	0.78	0.67	0.17	0.06	0.04	0.01	0.00	0.03	2.54
1932	0.05	0.71	0.84	0.23	0.70	0.29	0.04	0.01	0.00	0.06	0.04	0.01	2.97
1933	0.03	0.72	0.83	0.78	0.24	0.56	0.24	0.05	0.02	0.03	0.06	0.04	3.58
1934	0.07	0.60	0.75	0.20	0.20	0.41	0.15	0.03	0.07	0.03	0.01	0.01	2.54
1935	0.02	0.03	0.05	0.76	0.82	0.66	0.16	0.40	0.09	0.00	0.00	0.01	3.00
1936	0.06	0.66	0.26	0.08	0.69	0.26	0.02	0.01	0.01	0.01	0.00	0.01	2.06
1937	0.03	0.07	0.62	0.79	0.69	0.19	0.57	0.19	0.02	0.06	0.05	0.02	3.30
1938	0.43	0.13	0.66	0.26	0.48	0.21	0.04	0.04	0.02	0.01	0.02	0.07	2.37
1939	0.11	0.53	0.68	0.21	0.43	0.58	0.16	0.54	0.22	0.02	0.01	0.05	3.52
1940	0.07	0.67	0.76	0.24	0.55	0.68	0.21	0.02	0.01	0.01	0.01	0.01	3.23
1941	0.06	0.07	0.05	0.74	0.76	0.67	0.20	0.03	0.02	0.01	0.03	0.04	2.70
1942	0.08	0.61	0.74	0.78	0.25	0.09	0.62	0.23	0.00	0.29	0.27	0.07	4.02
1943	0.67	0.70	0.22	0.08	0.61	0.24	0.03	0.01	0.02	0.01	0.01	0.57	3.17
1944	0.22	0.06	0.03	0.07	0.11	0.62	0.21	0.02	0.01	0.01	0.00	0.00	1.37
1945	0.01	0.01	0.05	0.77	0.74	0.22	0.03	0.01	0.01	0.00	0.01	0.01	1.85
1946	0.05	0.20	0.09	0.09	0.45	0.60	0.19	0.02	0.03	0.03	0.01	0.03	1.79
1947	0.07	0.62	0.76	0.69	0.62	0.61	0.20	0.03	0.01	0.01	0.00	0.01	3.63
1948	0.04	0.07	0.10	0.30	0.50	0.64	0.20	0.02	0.01	0.01	0.01	0.03	1.93
1949	0.03	0.09	0.63	0.25	0.08	0.57	0.22	0.03	0.01	0.01	0.05	0.03	2.03
1950	0.02	0.05	0.71	0.75	0.23	0.08	0.06	0.02	0.01	0.00	0.28	0.13	2.33
1951	0.06	0.03	0.72	0.83	0.73	0.24	0.03	0.02	0.01	0.02	0.02	0.01	2.73
1952	0.06	0.10	0.56	0.23	0.63	0.22	0.03	0.02	0.01	0.00	0.05	0.03	1.94
1953	0.06	0.08	0.11	0.07	0.52	0.20	0.05	0.06	0.03	0.01	0.00	0.06	1.26
1954	0.57	0.28	0.06	0.62	0.59	0.13	0.03	0.03	0.01	0.01	0.01	0.02	2.35
1955	0.05	0.06	0.73	0.24	0.79	0.75	0.18	0.01	0.01	0.01	0.01	0.03	2.86
1956	0.06	0.68	0.79	0.75	0.25	0.51	0.20	0.02	0.01	0.01	0.04	0.63	3.94
1957	0.68	0.21	0.07	0.67	0.76	0.20	0.56	0.19	0.01	0.01	0.00	0.02	3.37
1958	0.03	0.66	0.72	0.74	0.74	0.22	0.06	0.58	0.19	0.01	0.01	0.01	3.98
1959	0.07	0.09	0.09	0.06	0.66	0.26	0.56	0.18	0.01	0.00	0.01	0.03	2.04
1960	0.07	0.26	0.48	0.21	0.57	0.68	0.48	0.07	0.00	0.01	0.01	0.05	2.89
1961	0.05	0.60	0.27	0.62	0.65	0.62	0.21	0.03	0.01	0.00	0.02	0.02	3.09
1962	0.03	0.68	0.72	0.71	0.21	0.66	0.24	0.01	0.01	0.06	0.03	0.01	3.38
1963	0.09	0.22	0.07	0.66	0.26	0.09	0.07	0.03	0.03	0.02	0.01	0.07	1.63
1964	0.59	0.24	0.06	0.08	0.07	0.03	0.02	0.02	0.57	0.20	0.05	0.05	1.98
1965	0.06	0.07	0.09	0.64	0.26	0.03	0.02	0.05	0.03	0.01	0.03	0.02	1.32
1966	0.05	0.30	0.52	0.70	0.72	0.63	0.53	0.14	0.01	0.01	0.01	0.01	3.62
1967	0.06	0.72	0.29	0.65	0.25	0.07	0.05	0.02	0.01	0.01	0.03	0.03	2.18
1968	0.04	0.08	0.67	0.28	0.23	0.44	0.16	0.05	0.02	0.02	0.02	0.03	2.04
1969	0.66	0.26	0.63	0.28	0.10	0.05	0.02	0.02	0.02	0.01	0.08	0.50	2.62
1970	0.31	0.06	0.56	0.51	0.12	0.05	0.05	0.06	0.03	0.04	0.07	0.04	1.90
1971	0.08	0.10	0.13	0.51	0.52	0.41	0.10	0.02	0.02	0.01	0.01	0.01	1.91
1972	0.05	0.10	0.06	0.67	0.77	0.24	0.52	0.17	0.01	0.01	0.05	0.09	2.74
1973	0.06	0.08	0.07	0.63	0.74	0.70	0.21	0.03	0.02	0.02	0.01	0.01	2.57
1974	0.01	0.10	0.12	0.59	0.71	0.21	0.05	0.02	0.00	0.01	0.00	0.71	2.52
1975	0.25	0.64	0.76	0.75	0.72	0.71	0.20	0.03	0.02	0.01	0.01	0.03	4.13
1976	0.64	0.24	0.08	0.63	0.22	0.65	0.25	0.02	0.01	0.01	0.01	0.06	2.82
1977	0.29	0.10	0.59	0.75	0.23	0.57	0.64	0.16	0.01	0.01	0.01	0.07	3.44
1978	0.61	0.58	0.45	0.70	0.40	0.08	0.02	0.06	0.03	0.02	0.05	0.04	3.04
1979	0.04	0.03	0.06	0.28	0.12	0.05	0.03	0.02	0.01	0.00	0.00	0.30	0.93
1980	0.09	0.59	0.69	0.76	0.75	0.21	0.03	0.02	0.02	0.01	0.05	0.06	3.26
1981	0.03	0.66	0.25	0.13	0.06	0.54	0.20	0.02	0.01	0.01	0.01	0.06	1.95
1982	0.62	0.24	0.09	0.07	0.03	0.06	0.03	0.01	0.01	0.02	0.03	0.02	1.23
1983	0.06	0.67	0.64	0.51	0.17	0.58	0.22	0.02	0.02	0.01	0.02	0.02	2.94
1984	0.09	0.07	0.07	0.71	0.81	0.24	0.02	0.00	0.00	0.00	0.01	0.01	2.02
1985	0.71	0.77	0.69	0.76	0.25	0.07	0.04	0.01	0.02	0.01	0.02	0.02	3.37
1986	0.09	0.09	0.59	0.81	0.78	0.68	0.18	0.01	0.02	0.02	0.53	0.67	4.47
1987	0.21	0.15	0.07	0.17	0.49	0.64	0.18	0.02	0.04	0.03	0.02	0.01	2.05
1988	0.06	0.10	0.61	0.25	0.59	0.21	0.02	0.01	0.01	0.01	0.00	0.01	1.86
1989	0.05	0.66	0.70	0.21	0.62	0.71	0.20	0.02	0.01	0.01	0.04	0.03	3.25
1990	0.07	0.07	0.72	0.79	0.75	0.24	0.03	0.02	0.01	0.01	0.01	0.02	2.74
1991	0.69	0.26	0.07	0.05	0.75	0.28	0.02	0.01	0.01	0.01	0.01	0.01	2.17
1992	0.05	0.07	0.10	0.07	0.67	0.71	0.18	0.02	0.01	0.01	0.02	0.02	1.93
1993	0.70	0.26	0.74	0.82	0.22	0.63	0.22	0.01	0.01	0.01	0.03	0.02	3.65
1994	0.05	0.02	0.09	0.61	0.20	0.06	0.07	0.03	0.06	0.03	0.01	0.01	1.25

Afforestation and dryland sugar cane water use for 1995 – TM24.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.10	0.04	0.01	0.01	0.09	0.11	0.04	0.01	0.00	0.00	0.00	0.01	0.42
1921	0.01	0.09	0.12	0.10	0.09	0.10	0.04	0.00	0.00	0.00	0.01	0.01	0.57
1922	0.08	0.10	0.10	0.11	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.46
1923	0.00	0.00	0.00	0.11	0.13	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.31
1924	0.01	0.09	0.12	0.05	0.08	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.50
1925	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.08
1926	0.01	0.01	0.01	0.01	0.09	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.29
1927	0.01	0.01	0.09	0.06	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.21
1928	0.01	0.01	0.01	0.01	0.01	0.09	0.05	0.00	0.00	0.01	0.00	0.08	0.28
1929	0.05	0.09	0.06	0.08	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.33
1930	0.00	0.00	0.10	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
1931	0.00	0.01	0.01	0.01	0.09	0.11	0.04	0.01	0.01	0.00	0.00	0.00	0.28
1932	0.00	0.01	0.09	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.18
1933	0.00	0.11	0.13	0.11	0.04	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.45
1934	0.00	0.09	0.12	0.05	0.08	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.50
1935	0.00	0.00	0.01	0.11	0.13	0.10	0.04	0.08	0.05	0.00	0.00	0.00	0.52
1936	0.00	0.11	0.06	0.10	0.12	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.45
1937	0.00	0.00	0.11	0.07	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.24
1938	0.09	0.05	0.10	0.11	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.51
1939	0.00	0.10	0.13	0.05	0.07	0.04	0.01	0.08	0.05	0.01	0.00	0.00	0.55
1940	0.01	0.01	0.09	0.06	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.25
1941	0.00	0.01	0.01	0.09	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.29
1942	0.01	0.09	0.12	0.11	0.04	0.08	0.10	0.04	0.00	0.07	0.09	0.03	0.78
1943	0.09	0.11	0.11	0.10	0.10	0.04	0.01	0.00	0.01	0.01	0.00	0.00	0.58
1944	0.00	0.00	0.00	0.01	0.01	0.10	0.06	0.01	0.00	0.00	0.00	0.00	0.18
1945	0.00	0.00	0.00	0.10	0.06	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.29
1946	0.01	0.08	0.05	0.01	0.09	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.32
1947	0.00	0.10	0.13	0.11	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.41
1948	0.01	0.01	0.01	0.09	0.12	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.31
1949	0.01	0.01	0.08	0.05	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.21
1950	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.09
1951	0.01	0.01	0.01	0.09	0.05	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.20
1952	0.00	0.09	0.06	0.09	0.11	0.04	0.01	0.00	0.00	0.00	0.01	0.01	0.42
1953	0.00	0.01	0.01	0.01	0.09	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.29
1954	0.01	0.08	0.04	0.10	0.12	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.41
1955	0.01	0.01	0.01	0.01	0.09	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.29
1956	0.01	0.10	0.12	0.10	0.09	0.10	0.09	0.03	0.00	0.07	0.04	0.06	0.83
1957	0.10	0.04	0.01	0.10	0.12	0.10	0.10	0.04	0.00	0.00	0.00	0.00	0.61
1958	0.01	0.01	0.08	0.05	0.09	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.31
1959	0.01	0.09	0.06	0.01	0.08	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.31
1960	0.01	0.01	0.09	0.05	0.01	0.09	0.05	0.01	0.00	0.00	0.00	0.00	0.31
1961	0.00	0.01	0.01	0.09	0.12	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.29
1962	0.00	0.01	0.01	0.10	0.06	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.21
1963	0.01	0.08	0.05	0.09	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.30
1964	0.00	0.00	0.06	0.10	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.33
1965	0.01	0.01	0.01	0.09	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.20
1966	0.01	0.01	0.09	0.12	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.38
1967	0.00	0.01	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.07
1968	0.00	0.01	0.02	0.08	0.05	0.08	0.05	0.01	0.00	0.00	0.00	0.00	0.30
1969	0.08	0.05	0.01	0.01	0.08	0.04	0.01	0.00	0.00	0.00	0.01	0.01	0.30
1970	0.01	0.01	0.01	0.11	0.07	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.26
1971	0.01	0.01	0.10	0.07	0.08	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.42
1972	0.00	0.01	0.01	0.01	0.08	0.05	0.01	0.01	0.00	0.00	0.01	0.01	0.20
1973	0.01	0.09	0.05	0.09	0.11	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.41
1974	0.00	0.10	0.12	0.11	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.08	0.58
1975	0.05	0.01	0.08	0.11	0.10	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.51
1976	0.01	0.01	0.01	0.09	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.21
1977	0.01	0.01	0.10	0.12	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.40
1978	0.01	0.01	0.01	0.01	0.07	0.04	0.00	0.00	0.00	0.00	0.01	0.01	0.19
1979	0.01	0.01	0.01	0.09	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.28
1980	0.01	0.01	0.01	0.02	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.18
1981	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.06
1982	0.08	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.19
1983	0.01	0.09	0.12	0.11	0.04	0.08	0.05	0.00	0.00	0.00	0.01	0.01	0.51
1984	0.09	0.06	0.01	0.11	0.13	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.44
1985	0.08	0.11	0.10	0.10	0.11	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.57
1986	0.01	0.01	0.02	0.08	0.12	0.05	0.01	0.00	0.00	0.00	0.00	0.09	0.38
1987	0.11	0.10	0.10	0.04	0.06	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.55
1988	0.01	0.01	0.10	0.12	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.40
1989	0.01	0.10	0.13	0.05	0.01	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.43
1990	0.00	0.00	0.01	0.10	0.12	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.28
1991	0.10	0.06	0.08	0.05	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.43
1992	0.00	0.01	0.01	0.01	0.10	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.19
1993	0.11	0.07	0.02	0.08	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.43
1994	0.01	0.01	0.09	0.12	0.05	0.07	0.04	0.01	0.00	0.00	0.00	0.00	0.39

Afforestation and dryland sugar cane water use for 1995 – TM25.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.17	0.08	0.03	0.03	0.13	0.19	0.08	0.01	0.00	0.00	0.00	0.11	0.83
1921	0.07	0.15	0.20	0.19	0.18	0.19	0.08	0.01	0.01	0.01	0.02	0.07	1.17
1922	0.11	0.17	0.19	0.20	0.19	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.94
1923	0.01	0.01	0.01	0.15	0.20	0.18	0.07	0.01	0.00	0.00	0.00	0.05	0.70
1924	0.03	0.12	0.19	0.20	0.19	0.20	0.13	0.03	0.00	0.00	0.00	0.01	1.11
1925	0.03	0.10	0.06	0.12	0.09	0.04	0.01	0.00	0.01	0.00	0.00	0.11	0.57
1926	0.08	0.12	0.17	0.17	0.19	0.19	0.07	0.01	0.00	0.01	0.01	0.00	1.01
1927	0.12	0.07	0.14	0.18	0.16	0.18	0.07	0.01	0.00	0.00	0.00	0.02	0.95
1928	0.02	0.01	0.12	0.20	0.09	0.15	0.08	0.01	0.02	0.02	0.01	0.12	0.84
1929	0.08	0.13	0.18	0.19	0.10	0.02	0.02	0.01	0.00	0.01	0.01	0.01	0.75
1930	0.01	0.01	0.15	0.22	0.18	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.66
1931	0.01	0.02	0.02	0.15	0.20	0.18	0.07	0.07	0.03	0.00	0.00	0.00	0.75
1932	0.01	0.04	0.12	0.07	0.02	0.13	0.08	0.01	0.00	0.01	0.01	0.00	0.49
1933	0.00	0.15	0.20	0.21	0.10	0.13	0.08	0.02	0.01	0.02	0.02	0.01	0.95
1934	0.02	0.13	0.20	0.20	0.20	0.18	0.07	0.01	0.00	0.00	0.00	0.00	1.01
1935	0.01	0.01	0.02	0.15	0.20	0.19	0.07	0.13	0.07	0.01	0.00	0.00	0.86
1936	0.02	0.14	0.08	0.16	0.21	0.08	0.02	0.01	0.00	0.00	0.00	0.01	0.72
1937	0.01	0.01	0.15	0.21	0.17	0.07	0.02	0.01	0.00	0.00	0.00	0.01	0.65
1938	0.13	0.08	0.15	0.19	0.20	0.19	0.07	0.03	0.02	0.02	0.01	0.01	1.07
1939	0.01	0.14	0.20	0.18	0.18	0.07	0.01	0.12	0.09	0.02	0.00	0.02	1.05
1940	0.02	0.12	0.20	0.18	0.18	0.17	0.16	0.06	0.00	0.00	0.00	0.00	1.10
1941	0.01	0.02	0.13	0.20	0.20	0.15	0.05	0.01	0.01	0.00	0.00	0.09	0.88
1942	0.12	0.13	0.18	0.21	0.10	0.13	0.19	0.08	0.01	0.13	0.17	0.06	1.50
1943	0.14	0.19	0.19	0.19	0.20	0.09	0.01	0.00	0.05	0.02	0.00	0.12	1.20
1944	0.17	0.07	0.01	0.02	0.05	0.12	0.07	0.01	0.00	0.00	0.00	0.00	0.51
1945	0.00	0.00	0.00	0.15	0.20	0.19	0.07	0.01	0.00	0.00	0.00	0.00	0.62
1946	0.11	0.18	0.08	0.03	0.15	0.17	0.07	0.01	0.01	0.01	0.00	0.00	0.83
1947	0.01	0.14	0.20	0.20	0.18	0.17	0.07	0.01	0.00	0.00	0.00	0.01	0.99
1948	0.10	0.07	0.03	0.15	0.20	0.18	0.15	0.05	0.00	0.00	0.00	0.01	0.95
1949	0.13	0.17	0.19	0.20	0.18	0.08	0.10	0.06	0.01	0.00	0.00	0.00	1.12
1950	0.02	0.03	0.13	0.08	0.11	0.07	0.03	0.01	0.00	0.01	0.10	0.05	0.62
1951	0.10	0.06	0.14	0.20	0.08	0.02	0.02	0.01	0.00	0.12	0.07	0.01	0.81
1952	0.01	0.13	0.13	0.14	0.19	0.09	0.03	0.01	0.00	0.00	0.02	0.01	0.75
1953	0.01	0.12	0.08	0.03	0.15	0.18	0.07	0.02	0.01	0.00	0.00	0.02	0.69
1954	0.11	0.18	0.08	0.15	0.21	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.89
1955	0.11	0.08	0.07	0.05	0.13	0.18	0.07	0.01	0.00	0.00	0.00	0.01	0.72
1956	0.03	0.12	0.19	0.19	0.18	0.18	0.17	0.06	0.01	0.10	0.07	0.11	1.42
1957	0.16	0.07	0.02	0.14	0.20	0.18	0.17	0.06	0.01	0.00	0.00	0.01	1.03
1958	0.11	0.17	0.19	0.12	0.13	0.07	0.02	0.02	0.01	0.01	0.00	0.00	0.85
1959	0.13	0.19	0.18	0.09	0.13	0.08	0.12	0.07	0.01	0.00	0.00	0.01	1.00
1960	0.08	0.12	0.18	0.08	0.02	0.13	0.15	0.06	0.01	0.00	0.00	0.01	0.83
1961	0.01	0.12	0.08	0.12	0.18	0.08	0.01	0.01	0.00	0.00	0.01	0.01	0.64
1962	0.01	0.09	0.06	0.14	0.07	0.11	0.06	0.01	0.01	0.06	0.04	0.00	0.66
1963	0.07	0.13	0.06	0.14	0.10	0.03	0.03	0.01	0.02	0.01	0.00	0.01	0.61
1964	0.14	0.17	0.17	0.19	0.19	0.07	0.01	0.00	0.02	0.01	0.01	0.01	0.98
1965	0.11	0.12	0.05	0.15	0.11	0.02	0.02	0.01	0.00	0.00	0.01	0.01	0.60
1966	0.02	0.11	0.18	0.21	0.19	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.84
1967	0.01	0.12	0.17	0.08	0.01	0.11	0.07	0.01	0.00	0.00	0.01	0.00	0.59
1968	0.00	0.13	0.18	0.19	0.18	0.18	0.16	0.05	0.01	0.00	0.00	0.00	1.08
1969	0.13	0.08	0.13	0.20	0.19	0.07	0.01	0.01	0.00	0.00	0.02	0.02	0.87
1970	0.11	0.08	0.02	0.15	0.09	0.02	0.09	0.13	0.05	0.01	0.01	0.01	0.78
1971	0.03	0.03	0.14	0.18	0.19	0.20	0.08	0.01	0.00	0.00	0.00	0.00	0.85
1972	0.02	0.13	0.08	0.09	0.13	0.06	0.10	0.06	0.00	0.00	0.02	0.03	0.72
1973	0.01	0.13	0.11	0.13	0.19	0.09	0.07	0.03	0.00	0.01	0.00	0.00	0.78
1974	0.01	0.14	0.21	0.20	0.21	0.09	0.03	0.01	0.00	0.00	0.00	0.12	1.01
1975	0.07	0.13	0.20	0.21	0.20	0.19	0.09	0.06	0.03	0.00	0.00	0.00	1.19
1976	0.12	0.08	0.13	0.20	0.09	0.14	0.08	0.01	0.00	0.00	0.00	0.01	0.85
1977	0.04	0.02	0.14	0.21	0.19	0.18	0.08	0.01	0.00	0.00	0.02	0.03	0.94
1978	0.10	0.06	0.11	0.18	0.18	0.07	0.01	0.00	0.00	0.01	0.09	0.06	0.87
1979	0.01	0.02	0.12	0.20	0.20	0.08	0.01	0.00	0.00	0.00	0.00	0.09	0.74
1980	0.06	0.03	0.12	0.17	0.18	0.07	0.01	0.00	0.01	0.00	0.01	0.02	0.68
1981	0.02	0.02	0.02	0.13	0.08	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.35
1982	0.13	0.07	0.02	0.12	0.07	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.49
1983	0.14	0.20	0.21	0.21	0.10	0.13	0.08	0.01	0.00	0.01	0.07	0.03	1.18
1984	0.13	0.09	0.03	0.15	0.21	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.69
1985	0.13	0.18	0.18	0.20	0.20	0.13	0.04	0.01	0.00	0.00	0.00	0.00	1.08
1986	0.04	0.06	0.11	0.17	0.20	0.09	0.02	0.01	0.00	0.00	0.02	0.13	0.84
1987	0.17	0.18	0.18	0.18	0.17	0.17	0.07	0.01	0.00	0.00	0.00	0.00	1.13
1988	0.11	0.07	0.15	0.19	0.20	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.84
1989	0.02	0.12	0.19	0.09	0.13	0.18	0.08	0.01	0.00	0.00	0.00	0.00	0.82
1990	0.00	0.00	0.14	0.21	0.20	0.10	0.02	0.00	0.02	0.01	0.00	0.01	0.71
1991	0.13	0.12	0.14	0.08	0.14	0.08	0.01	0.00	0.00	0.00	0.02	0.01	0.75
1992	0.01	0.01	0.02	0.02	0.15	0.09	0.01	0.00	0.00	0.00	0.00	0.01	0.33
1993	0.14	0.12	0.12	0.19	0.19	0.17	0.06	0.01	0.00	0.00	0.01	0.00	1.00
1994	0.04	0.03	0.13	0.20	0.09	0.12	0.07	0.01	0.00	0.00	0.00	0.00	0.71

Afforestation and dryland sugar cane water use for 1995 – TM27.AFF Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.67	0.27	0.05	0.04	0.03	0.56	0.33	0.02	0.00	0.01	0.01	0.01	1.99
1921	0.02	0.64	0.77	0.27	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02	1.84
1922	0.60	0.74	0.66	0.28	0.44	0.24	0.02	0.00	0.00	0.01	0.01	0.00	3.00
1923	0.01	0.02	0.06	0.57	0.34	0.46	0.26	0.02	0.01	0.00	0.00	0.01	1.75
1924	0.04	0.63	0.37	0.07	0.50	0.68	0.27	0.03	0.01	0.01	0.00	0.02	2.61
1925	0.02	0.04	0.04	0.06	0.05	0.54	0.30	0.02	0.02	0.02	0.01	0.57	1.70
1926	0.33	0.04	0.04	0.03	0.52	0.32	0.03	0.00	0.00	0.02	0.02	0.01	1.38
1927	0.03	0.02	0.04	0.05	0.05	0.04	0.02	0.01	0.00	0.00	0.01	0.02	0.30
1928	0.03	0.02	0.05	0.05	0.02	0.68	0.39	0.02	0.02	0.02	0.02	0.04	1.36
1929	0.51	0.53	0.14	0.47	0.29	0.04	0.01	0.01	0.00	0.01	0.01	0.02	2.04
1930	0.01	0.01	0.05	0.57	0.33	0.03	0.02	0.01	0.01	0.01	0.00	0.00	1.06
1931	0.00	0.02	0.02	0.02	0.74	0.82	0.25	0.04	0.04	0.02	0.00	0.00	1.96
1932	0.00	0.00	0.69	0.41	0.04	0.02	0.01	0.01	0.00	0.01	0.01	0.01	1.22
1933	0.01	0.64	0.80	0.69	0.27	0.05	0.03	0.02	0.01	0.01	0.02	0.02	2.57
1934	0.02	0.06	0.54	0.31	0.05	0.04	0.03	0.02	0.01	0.00	0.00	0.00	1.08
1935	0.01	0.01	0.04	0.66	0.39	0.47	0.26	0.58	0.33	0.02	0.01	0.01	2.77
1936	0.03	0.60	0.34	0.62	0.72	0.24	0.02	0.01	0.00	0.00	0.00	0.01	2.58
1937	0.01	0.01	0.04	0.06	0.05	0.05	0.05	0.03	0.02	0.02	0.01	0.01	0.36
1938	0.04	0.04	0.61	0.78	0.69	0.64	0.23	0.02	0.01	0.02	0.02	0.01	3.11
1939	0.02	0.60	0.35	0.03	0.04	0.03	0.02	0.61	0.36	0.03	0.00	0.01	2.10
1940	0.02	0.04	0.06	0.05	0.12	0.04	0.02	0.02	0.01	0.00	0.00	0.01	0.39
1941	0.01	0.02	0.04	0.65	0.74	0.62	0.24	0.02	0.02	0.02	0.01	0.02	2.39
1942	0.03	0.66	0.40	0.06	0.43	0.65	0.60	0.23	0.02	0.48	0.57	0.19	4.31
1943	0.48	0.68	0.66	0.70	0.65	0.24	0.02	0.00	0.05	0.06	0.02	0.03	3.62
1944	0.06	0.04	0.01	0.02	0.58	0.72	0.25	0.02	0.01	0.00	0.00	0.00	1.72
1945	0.00	0.01	0.01	0.04	0.05	0.06	0.04	0.01	0.01	0.00	0.00	0.01	0.22
1946	0.03	0.05	0.04	0.02	0.57	0.34	0.03	0.01	0.01	0.02	0.01	0.00	1.15
1947	0.01	0.70	0.81	0.27	0.61	0.36	0.04	0.01	0.00	0.00	0.00	0.01	2.82
1948	0.04	0.04	0.03	0.66	0.79	0.27	0.35	0.16	0.00	0.00	0.00	0.00	2.33
1949	0.04	0.05	0.03	0.01	0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.25
1950	0.01	0.04	0.05	0.04	0.02	0.03	0.04	0.03	0.01	0.00	0.04	0.04	0.33
1951	0.04	0.02	0.58	0.81	0.30	0.04	0.03	0.02	0.01	0.03	0.02	0.01	1.92
1952	0.00	0.05	0.06	0.03	0.63	0.37	0.04	0.02	0.01	0.00	0.01	0.01	1.22
1953	0.01	0.19	0.10	0.01	0.69	0.40	0.03	0.02	0.01	0.01	0.00	0.01	1.48
1954	0.05	0.51	0.29	0.60	0.75	0.27	0.03	0.01	0.00	0.00	0.00	0.00	2.51
1955	0.04	0.05	0.05	0.02	0.70	0.75	0.23	0.03	0.02	0.01	0.00	0.01	1.90
1956	0.05	0.50	0.70	0.28	0.05	0.05	0.45	0.25	0.02	0.51	0.29	0.47	3.61
1957	0.63	0.23	0.02	0.04	0.05	0.03	0.56	0.32	0.02	0.00	0.00	0.01	1.90
1958	0.03	0.07	0.46	0.27	0.05	0.03	0.02	0.02	0.02	0.01	0.00	0.01	0.99
1959	0.04	0.48	0.29	0.04	0.04	0.04	0.04	0.03	0.02	0.00	0.01	0.02	1.04
1960	0.05	0.58	0.76	0.27	0.55	0.32	0.06	0.03	0.02	0.01	0.01	0.02	2.66
1961	0.03	0.05	0.05	0.60	0.44	0.06	0.00	0.00	0.00	0.00	0.01	0.01	1.25
1962	0.03	0.62	0.81	0.70	0.26	0.03	0.03	0.02	0.02	0.60	0.34	0.02	3.48
1963	0.03	0.50	0.28	0.59	0.35	0.04	0.01	0.01	0.01	0.01	0.01	0.01	1.84
1964	0.70	0.42	0.06	0.58	0.34	0.04	0.01	0.01	0.01	0.02	0.02	0.02	2.21
1965	0.04	0.06	0.04	0.58	0.36	0.04	0.01	0.01	0.01	0.01	0.01	0.02	1.18
1966	0.03	0.03	0.04	0.60	0.72	0.26	0.03	0.01	0.00	0.00	0.00	0.00	1.74
1967	0.02	0.61	0.37	0.05	0.02	0.03	0.02	0.01	0.00	0.00	0.01	0.01	1.14
1968	0.01	0.03	0.06	0.07	0.04	0.50	0.30	0.03	0.01	0.00	0.00	0.01	1.06
1969	0.57	0.34	0.05	0.05	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.02	1.18
1970	0.05	0.05	0.03	0.56	0.32	0.02	0.04	0.05	0.03	0.01	0.01	0.01	1.17
1971	0.03	0.04	0.06	0.48	0.69	0.28	0.03	0.01	0.01	0.01	0.00	0.00	1.65
1972	0.01	0.03	0.04	0.04	0.66	0.38	0.05	0.02	0.01	0.00	0.03	0.04	1.31
1973	0.03	0.04	0.04	0.47	0.24	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.92
1974	0.01	0.61	0.77	0.72	0.66	0.24	0.05	0.03	0.01	0.00	0.00	0.04	3.14
1975	0.04	0.05	0.52	0.70	0.29	0.44	0.26	0.04	0.02	0.01	0.00	0.00	2.37
1976	0.13	0.07	0.49	0.69	0.26	0.05	0.03	0.01	0.00	0.00	0.00	0.01	1.73
1977	0.04	0.06	0.06	0.52	0.69	0.25	0.03	0.02	0.01	0.00	0.01	0.03	1.71
1978	0.54	0.67	0.24	0.05	0.05	0.03	0.01	0.01	0.01	0.01	0.04	0.05	1.71
1979	0.04	0.03	0.04	0.66	0.73	0.23	0.02	0.00	0.00	0.00	0.00	0.01	1.77
1980	0.01	0.00	0.27	0.59	0.61	0.24	0.03	0.01	0.01	0.01	0.01	0.03	1.84
1981	0.03	0.02	0.02	0.59	0.35	0.05	0.02	0.01	0.00	0.00	0.00	0.00	1.10
1982	0.04	0.03	0.02	0.04	0.03	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.30
1983	0.03	0.60	0.78	0.70	0.29	0.06	0.04	0.01	0.01	0.02	0.03	0.03	2.58
1984	0.04	0.03	0.02	0.05	0.62	0.35	0.02	0.00	0.00	0.00	0.00	0.00	1.13
1985	0.65	0.40	0.07	0.48	0.67	0.27	0.04	0.01	0.01	0.01	0.00	0.00	2.59
1986	0.01	0.03	0.68	0.83	0.29	0.05	0.03	0.01	0.00	0.01	0.02	0.59	2.56
1987	0.67	0.61	0.27	0.52	0.29	0.03	0.02	0.01	0.01	0.02	0.01	0.01	2.49
1988	0.04	0.05	0.55	0.33	0.48	0.27	0.03	0.01	0.01	0.01	0.00	0.00	1.78
1989	0.02	0.60	0.37	0.05	0.04	0.05	0.05	0.03	0.01	0.00	0.00	0.00	1.23
1990	0.01	0.01	0.03	0.69	0.80	0.27	0.02	0.01	0.01	0.01	0.00	0.00	1.86
1991	0.17	0.08	0.55	0.33	0.06	0.03	0.01	0.01	0.00	0.00	0.00	0.00	1.26
1992	0.01	0.02	0.05	0.05	0.56	0.33	0.03	0.01	0.00	0.00	0.00	0.01	1.07
1993	0.67	0.40	0.05	0.50	0.67	0.26	0.04	0.01	0.00	0.00	0.00	0.01	2.61
1994	0.02	0.02	0.04	0.07	0.04	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.29

Afforestation and dryland sugar cane water use for 1995 – TM28.AFF   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.69	0.28	0.05	0.04	0.03	0.57	0.33	0.02	0.00	0.00	0.00	0.01	2.04
1921	0.03	0.64	0.77	0.27	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02	1.86
1922	0.61	0.75	0.67	0.28	0.45	0.25	0.02	0.00	0.00	0.01	0.01	0.01	3.04
1923	0.01	0.02	0.06	0.58	0.34	0.46	0.26	0.02	0.01	0.00	0.00	0.01	1.78
1924	0.03	0.58	0.35	0.47	0.69	0.68	0.27	0.03	0.01	0.00	0.00	0.01	3.12
1925	0.04	0.03	0.04	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.51	0.84
1926	0.30	0.05	0.04	0.04	0.45	0.38	0.09	0.01	0.00	0.01	0.02	0.01	1.40
1927	0.03	0.03	0.05	0.07	0.05	0.04	0.02	0.01	0.01	0.00	0.01	0.02	0.34
1928	0.04	0.03	0.48	0.26	0.01	0.63	0.37	0.02	0.01	0.02	0.02	0.04	1.94
1929	0.49	0.67	0.26	0.57	0.33	0.04	0.02	0.01	0.01	0.01	0.01	0.02	2.44
1930	0.02	0.02	0.06	0.57	0.33	0.03	0.02	0.01	0.01	0.01	0.01	0.00	1.07
1931	0.01	0.02	0.03	0.03	0.71	0.81	0.26	0.05	0.03	0.01	0.01	0.00	1.97
1932	0.00	0.01	0.67	0.40	0.04	0.02	0.02	0.01	0.00	0.01	0.01	0.00	1.19
1933	0.01	0.68	0.82	0.69	0.27	0.05	0.03	0.02	0.01	0.01	0.03	0.02	2.66
1934	0.02	0.11	0.35	0.19	0.05	0.05	0.04	0.02	0.01	0.00	0.00	0.00	0.84
1935	0.01	0.01	0.04	0.67	0.64	0.32	0.09	0.54	0.31	0.02	0.00	0.01	2.66
1936	0.03	0.60	0.34	0.66	0.76	0.25	0.02	0.01	0.00	0.00	0.00	0.01	2.68
1937	0.01	0.02	0.05	0.06	0.05	0.05	0.05	0.03	0.02	0.02	0.02	0.01	0.40
1938	0.04	0.05	0.61	0.79	0.70	0.61	0.22	0.02	0.01	0.02	0.02	0.02	3.12
1939	0.02	0.61	0.36	0.04	0.04	0.03	0.02	0.61	0.36	0.03	0.00	0.01	2.13
1940	0.02	0.04	0.16	0.08	0.46	0.27	0.06	0.03	0.01	0.00	0.00	0.01	1.12
1941	0.02	0.03	0.04	0.64	0.75	0.63	0.24	0.02	0.02	0.01	0.01	0.02	2.42
1942	0.03	0.64	0.77	0.59	0.27	0.15	0.42	0.21	0.02	0.47	0.57	0.19	4.34
1943	0.53	0.68	0.61	0.68	0.67	0.25	0.02	0.00	0.04	0.05	0.02	0.03	3.58
1944	0.06	0.04	0.02	0.04	0.21	0.33	0.13	0.01	0.01	0.00	0.00	0.00	0.85
1945	0.00	0.00	0.01	0.04	0.05	0.06	0.04	0.01	0.01	0.00	0.00	0.00	0.21
1946	0.04	0.06	0.05	0.04	0.58	0.34	0.04	0.01	0.01	0.02	0.01	0.01	1.18
1947	0.02	0.67	0.76	0.26	0.57	0.34	0.04	0.01	0.01	0.00	0.00	0.01	2.67
1948	0.04	0.05	0.04	0.61	0.78	0.29	0.05	0.02	0.01	0.00	0.00	0.01	1.90
1949	0.05	0.05	0.18	0.09	0.02	0.05	0.04	0.02	0.01	0.01	0.01	0.01	0.53
1950	0.01	0.01	0.36	0.21	0.03	0.17	0.08	0.00	0.01	0.00	0.04	0.04	0.96
1951	0.05	0.03	0.58	0.75	0.27	0.04	0.03	0.02	0.01	0.01	0.01	0.00	1.80
1952	0.01	0.04	0.07	0.04	0.61	0.36	0.04	0.02	0.01	0.00	0.01	0.01	1.21
1953	0.01	0.37	0.20	0.01	0.67	0.39	0.04	0.02	0.02	0.01	0.00	0.01	1.75
1954	0.05	0.56	0.32	0.67	0.79	0.27	0.03	0.01	0.00	0.00	0.00	0.00	2.71
1955	0.04	0.05	0.06	0.04	0.70	0.79	0.24	0.03	0.01	0.01	0.00	0.01	1.99
1956	0.05	0.52	0.71	0.29	0.06	0.44	0.55	0.19	0.02	0.47	0.27	0.47	4.03
1957	0.62	0.23	0.02	0.11	0.07	0.02	0.05	0.04	0.01	0.00	0.00	0.01	1.17
1958	0.04	0.52	0.69	0.26	0.28	0.13	0.00	0.02	0.02	0.01	0.00	0.01	1.99
1959	0.04	0.07	0.48	0.27	0.05	0.04	0.04	0.03	0.01	0.01	0.01	0.01	1.06
1960	0.05	0.57	0.75	0.27	0.53	0.31	0.06	0.04	0.02	0.01	0.01	0.02	2.64
1961	0.03	0.04	0.04	0.06	0.06	0.04	0.02	0.01	0.01	0.00	0.01	0.01	0.33
1962	0.03	0.61	0.81	0.31	0.04	0.02	0.03	0.02	0.02	0.60	0.35	0.02	2.86
1963	0.03	0.20	0.10	0.50	0.30	0.04	0.02	0.01	0.01	0.00	0.00	0.01	1.20
1964	0.66	0.40	0.22	0.11	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	1.49
1965	0.03	0.05	0.04	0.62	0.71	0.23	0.02	0.01	0.01	0.01	0.01	0.02	1.76
1966	0.02	0.02	0.16	0.41	0.59	0.26	0.04	0.01	0.01	0.00	0.00	0.00	1.53
1967	0.03	0.57	0.34	0.06	0.02	0.04	0.03	0.01	0.00	0.00	0.01	0.01	1.13
1968	0.01	0.03	0.07	0.06	0.04	0.53	0.31	0.03	0.01	0.01	0.00	0.01	1.09
1969	0.57	0.34	0.05	0.05	0.05	0.04	0.01	0.01	0.01	0.01	0.01	0.02	1.17
1970	0.05	0.06	0.05	0.57	0.33	0.03	0.05	0.06	0.03	0.01	0.01	0.01	1.26
1971	0.04	0.05	0.54	0.70	0.64	0.26	0.03	0.02	0.02	0.01	0.01	0.00	2.31
1972	0.01	0.04	0.05	0.05	0.60	0.35	0.06	0.03	0.01	0.00	0.02	0.04	1.27
1973	0.03	0.04	0.05	0.61	0.36	0.05	0.04	0.02	0.01	0.02	0.01	0.01	1.25
1974	0.01	0.61	0.77	0.67	0.65	0.26	0.35	0.16	0.00	0.00	0.00	0.03	3.52
1975	0.03	0.08	0.35	0.61	0.28	0.45	0.26	0.04	0.02	0.01	0.00	0.01	2.13
1976	0.05	0.05	0.55	0.72	0.27	0.19	0.08	0.00	0.00	0.00	0.00	0.01	1.93
1977	0.03	0.04	0.05	0.62	0.37	0.05	0.02	0.02	0.01	0.00	0.01	0.02	1.25
1978	0.55	0.33	0.05	0.06	0.05	0.03	0.02	0.01	0.01	0.01	0.04	0.05	1.21
1979	0.04	0.03	0.03	0.57	0.35	0.04	0.01	0.01	0.00	0.00	0.00	0.01	1.09
1980	0.02	0.04	0.28	0.35	0.14	0.02	0.01	0.01	0.02	0.02	0.02	0.04	0.97
1981	0.04	0.04	0.03	0.05	0.05	0.37	0.18	0.00	0.00	0.00	0.00	0.00	0.76
1982	0.04	0.04	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.31
1983	0.02	0.64	0.78	0.67	0.27	0.45	0.27	0.03	0.01	0.02	0.04	0.03	3.23
1984	0.04	0.25	0.13	0.02	0.59	0.34	0.02	0.00	0.00	0.00	0.00	0.00	1.41
1985	0.68	0.41	0.06	0.57	0.68	0.24	0.03	0.01	0.01	0.01	0.00	0.00	2.70
1986	0.01	0.03	0.61	0.76	0.27	0.49	0.27	0.02	0.01	0.01	0.02	0.60	3.09
1987	0.66	0.56	0.67	0.69	0.27	0.04	0.02	0.01	0.01	0.03	0.02	0.01	2.99
1988	0.04	0.07	0.52	0.31	0.57	0.33	0.04	0.01	0.01	0.01	0.00	0.00	1.90
1989	0.03	0.62	0.37	0.05	0.03	0.03	0.04	0.03	0.01	0.00	0.01	0.00	1.23
1990	0.01	0.02	0.05	0.62	0.75	0.27	0.03	0.01	0.02	0.02	0.01	0.01	1.81
1991	0.04	0.06	0.06	0.06	0.48	0.27	0.02	0.00	0.00	0.00	0.00	0.00	1.01
1992	0.01	0.03	0.07	0.05	0.04	0.04	0.02	0.01	0.00	0.00	0.00	0.01	0.27
1993	0.68	0.41	0.46	0.63	0.26	0.45	0.25	0.02	0.00	0.00	0.01	0.00	3.17
1994	0.03	0.04	0.03	0.04	0.02	0.60	0.35	0.02	0.01	0.00	0.00	0.00	1.14

Afforestation and dryland sugar cane water use for 1995 – TM29.AFF Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.05	0.07	0.06	0.06	0.03	0.07	0.05	0.02	0.01	0.00	0.00	0.02	0.45
1921	0.05	0.87	0.32	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.03	1.48
1922	0.05	0.09	0.08	0.08	0.07	0.03	0.02	0.01	0.00	0.00	0.00	0.01	0.43
1923	0.00	0.02	0.03	0.05	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.24
1924	0.05	1.03	1.06	0.90	0.25	0.87	0.30	0.02	0.00	0.01	0.01	0.02	4.53
1925	0.05	0.04	0.06	0.04	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.04	0.38
1926	0.85	0.32	0.04	0.04	0.03	0.07	0.04	0.02	0.01	0.01	0.03	0.02	1.48
1927	0.02	0.02	0.05	1.10	0.37	0.03	0.02	0.01	0.01	0.00	0.01	0.01	1.66
1928	0.02	0.02	0.02	0.02	0.04	0.07	0.05	0.02	0.02	0.03	0.02	0.03	0.34
1929	0.04	0.06	0.05	0.07	0.06	0.05	0.05	0.02	0.01	0.01	0.01	0.02	0.44
1930	0.03	0.03	0.05	0.07	0.06	0.04	0.03	0.02	0.01	0.01	0.01	0.00	0.36
1931	0.01	0.02	0.03	0.03	1.26	0.98	0.20	0.03	0.03	0.01	0.01	0.01	2.62
1932	0.02	0.07	0.07	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.30
1933	0.01	0.07	0.92	1.08	0.28	0.04	0.06	0.05	0.02	0.01	0.02	0.02	2.58
1934	0.04	0.06	0.09	0.05	0.04	0.07	0.06	0.03	0.03	0.02	0.01	0.01	0.51
1935	0.01	0.02	0.02	0.09	1.01	0.36	0.03	0.05	0.03	0.01	0.00	0.01	1.62
1936	0.02	0.09	0.05	0.03	0.06	0.07	0.03	0.01	0.01	0.00	0.00	0.01	0.37
1937	0.01	0.02	0.09	0.09	0.81	0.28	0.04	0.03	0.02	0.06	0.03	0.01	1.48
1938	0.02	0.04	0.09	0.09	0.91	0.31	0.01	0.02	0.02	0.01	0.01	0.03	1.56
1939	0.03	0.30	0.03	0.00	0.02	0.03	0.02	1.15	0.40	0.01	0.01	0.03	2.03
1940	0.04	0.07	0.93	0.32	0.05	0.07	0.09	0.04	0.01	0.01	0.00	0.01	1.63
1941	0.01	0.02	0.03	0.07	0.94	0.90	0.20	0.01	0.01	0.01	0.01	0.02	2.21
1942	0.04	0.09	0.99	0.36	0.06	0.05	1.01	0.36	0.02	0.06	0.71	0.24	3.98
1943	0.89	0.99	0.26	0.03	0.06	0.05	0.03	0.01	0.02	0.02	0.01	0.05	2.40
1944	0.05	0.04	0.04	0.04	0.03	1.04	0.36	0.01	0.01	0.01	0.00	0.00	1.63
1945	0.01	0.01	0.03	0.06	0.05	0.04	0.02	0.01	0.00	0.00	0.00	0.01	0.23
1946	0.07	0.07	0.05	0.06	0.09	0.08	0.05	0.02	0.03	0.03	0.01	0.01	0.57
1947	0.03	1.04	0.37	0.05	0.04	0.09	0.06	0.03	0.01	0.01	0.00	0.01	1.73
1948	0.02	0.06	0.08	0.10	0.72	0.25	0.04	0.02	0.01	0.01	0.01	0.01	1.33
1949	0.03	0.09	0.85	0.29	0.02	0.05	0.03	0.02	0.01	0.01	0.01	0.01	1.41
1950	0.02	0.03	0.09	0.08	0.04	0.05	0.03	0.01	0.01	0.01	0.07	0.06	0.49
1951	0.05	0.02	0.05	0.95	0.33	0.03	0.03	0.02	0.02	0.02	0.01	0.01	1.55
1952	0.01	0.05	0.07	0.07	0.87	0.30	0.02	0.01	0.01	0.01	0.04	0.03	1.50
1953	0.02	0.07	0.06	0.06	0.06	0.06	0.05	0.06	0.04	0.02	0.01	0.02	0.52
1954	0.91	0.33	0.03	0.98	0.36	0.06	0.04	0.02	0.01	0.00	0.00	0.00	2.75
1955	0.02	0.05	0.09	0.03	1.03	0.37	0.01	0.01	0.01	0.00	0.01	0.01	1.63
1956	0.04	0.07	1.00	0.95	0.23	0.03	0.05	0.03	0.01	0.02	0.03	0.83	3.30
1957	0.86	0.20	0.02	0.05	0.06	0.04	0.07	0.05	0.01	0.01	0.00	0.01	1.37
1958	0.02	0.05	0.09	0.81	0.93	0.23	0.02	0.06	0.05	0.02	0.01	0.01	2.27
1959	0.04	0.06	0.04	0.06	0.07	0.06	0.06	0.03	0.01	0.00	0.01	0.01	0.45
1960	0.03	0.06	0.93	0.34	0.05	0.05	0.05	0.03	0.01	0.01	0.01	0.02	1.57
1961	0.02	0.05	0.04	0.05	0.05	0.06	0.05	0.02	0.01	0.01	0.01	0.01	0.38
1962	0.02	0.05	0.07	0.07	0.04	1.00	0.34	0.01	0.01	0.05	0.05	0.01	1.72
1963	0.03	0.08	0.03	1.17	0.40	0.02	0.03	0.02	0.01	0.01	0.02	0.02	1.83
1964	0.05	0.05	0.05	0.03	0.02	0.02	0.02	0.01	0.04	0.05	0.05	0.03	0.41
1965	0.04	0.06	0.06	0.99	0.34	0.01	0.02	0.02	0.02	0.01	0.01	0.01	1.58
1966	0.01	0.05	0.06	1.10	0.97	0.82	0.23	0.01	0.01	0.01	0.01	0.00	3.27
1967	0.02	0.06	0.03	0.05	0.05	0.07	0.04	0.02	0.01	0.00	0.01	0.01	0.36
1968	0.02	0.02	0.06	0.05	0.05	1.05	0.36	0.02	0.01	0.01	0.01	0.01	1.65
1969	0.05	0.03	0.07	0.05	0.05	0.04	0.02	0.02	0.02	0.01	0.02	0.05	0.43
1970	0.06	0.05	0.05	0.03	0.03	0.04	0.04	0.99	0.33	0.01	0.03	0.02	1.68
1971	0.05	0.06	0.07	0.07	0.05	0.05	0.03	0.03	0.03	0.02	0.01	0.01	0.45
1972	0.02	0.04	0.03	0.07	1.03	0.36	0.03	0.02	0.01	0.01	0.03	0.06	1.71
1973	0.03	0.03	0.03	1.12	0.39	0.05	0.03	0.01	0.01	0.02	0.01	0.00	1.75
1974	0.00	0.05	0.10	0.10	0.07	0.02	0.04	0.03	0.01	0.01	0.00	0.87	1.29
1975	0.29	0.04	0.06	1.04	0.96	0.90	0.24	0.02	0.01	0.01	0.00	0.01	3.58
1976	0.07	0.07	0.05	0.08	0.07	0.07	0.03	0.01	0.01	0.01	0.01	0.02	0.49
1977	0.08	0.09	0.05	1.09	0.38	0.06	0.05	0.03	0.01	0.00	0.01	0.02	1.86
1978	0.95	0.33	0.05	0.06	0.07	0.04	0.03	0.02	0.01	0.01	0.02	0.03	1.62
1979	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.18
1980	0.03	0.04	0.05	0.10	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.34
1981	0.02	0.74	0.17	0.00	0.03	0.08	0.05	0.01	0.01	0.01	0.00	0.01	1.12
1982	0.08	0.06	0.04	0.03	0.02	0.02	0.04	0.03	0.01	0.01	0.01	0.01	0.36
1983	0.01	0.07	0.93	0.98	0.26	0.03	0.06	0.03	0.01	0.02	0.03	0.02	2.47
1984	0.87	0.30	0.03	0.07	0.98	0.33	0.01	0.00	0.00	0.00	0.00	0.00	2.58
1985	0.04	0.05	0.07	1.01	0.34	0.89	0.90	0.21	0.01	0.01	0.01	0.01	3.54
1986	0.03	0.04	1.02	1.03	0.87	0.25	0.02	0.01	0.01	0.01	0.05	0.99	4.32
1987	0.35	0.05	0.06	0.06	0.06	0.07	0.03	0.01	0.02	0.03	0.03	0.02	0.82
1988	0.03	0.06	0.90	0.32	0.06	0.04	0.02	0.02	0.02	0.01	0.01	0.01	1.50
1989	0.02	0.99	0.97	0.23	0.02	0.07	0.06	0.03	0.01	0.00	0.02	0.01	2.44
1990	0.02	0.05	0.08	0.13	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.33
1991	0.07	0.05	0.06	0.05	0.98	0.34	0.01	0.01	0.01	0.00	0.00	0.00	1.58
1992	0.03	0.03	0.03	0.02	0.03	0.05	0.03	0.01	0.01	0.00	0.01	0.02	0.29
1993	1.14	0.39	0.03	0.04	0.03	0.05	0.03	0.01	0.01	0.02	0.03	0.02	1.79
1994	0.02	0.02	0.05	0.06	0.03	0.03	0.04	0.06	0.09	0.05	0.01	0.01	0.46

Afforestation and dryland sugar cane water use for 1995 – TM30.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	1.05	0.42	0.08	0.04	0.73	0.44	0.06	0.03	0.03	0.01	0.01	0.04	2.95
1921	0.06	0.72	0.97	0.35	0.05	0.09	0.07	0.05	0.05	0.04	0.06	0.07	2.60
1922	0.04	0.69	0.41	0.85	0.49	0.08	0.04	0.02	0.01	0.02	0.02	0.01	2.68
1923	0.00	0.03	0.07	0.09	0.09	0.06	0.03	0.02	0.01	0.01	0.01	0.05	0.47
1924	0.10	0.66	0.41	0.09	0.09	0.69	0.41	0.04	0.02	0.01	0.01	0.03	2.56
1925	0.66	0.39	0.04	0.03	0.07	0.85	0.47	0.07	0.06	0.03	0.02	0.04	2.74
1926	0.65	0.40	0.10	0.08	0.09	0.73	0.41	0.03	0.01	0.02	0.05	0.05	2.61
1927	0.08	0.07	0.09	0.73	0.44	0.09	0.06	0.03	0.01	0.00	0.02	0.06	1.68
1928	0.09	0.06	0.03	0.07	0.09	0.80	0.46	0.03	0.06	0.09	0.06	0.08	1.92
1929	0.58	0.36	0.05	0.09	0.07	0.03	0.03	0.03	0.01	0.01	0.03	0.09	1.39
1930	0.09	0.09	0.09	0.09	0.09	0.08	0.04	0.03	0.02	0.01	0.01	0.02	0.65
1931	0.04	0.08	0.11	0.10	0.75	0.91	0.33	0.55	0.31	0.03	0.01	0.02	3.24
1932	0.05	0.08	0.11	0.09	0.07	0.06	0.06	0.02	0.01	0.03	0.03	0.02	0.61
1933	0.03	0.79	1.04	0.88	0.36	0.65	0.39	0.07	0.03	0.03	0.06	0.05	4.38
1934	0.03	0.09	0.73	0.45	0.09	0.09	0.08	0.07	0.54	0.30	0.03	0.01	2.51
1935	0.04	0.04	0.06	0.12	0.76	0.95	0.35	0.57	0.33	0.03	0.01	0.03	3.28
1936	0.07	0.72	0.41	0.06	0.80	0.47	0.05	0.01	0.01	0.02	0.02	0.03	2.66
1937	0.05	0.07	0.78	1.00	0.89	0.34	0.09	0.07	0.03	0.08	0.07	0.04	3.51
1938	0.08	0.09	0.63	0.38	0.65	0.79	0.29	0.05	0.03	0.03	0.05	0.08	3.17
1939	0.09	0.70	0.84	0.31	0.06	0.04	0.04	0.85	0.80	0.22	0.02	0.03	4.00
1940	0.05	0.79	0.98	0.35	0.05	0.05	0.09	0.08	0.03	0.01	0.02	0.03	2.54
1941	0.06	0.08	0.06	0.08	0.10	0.69	0.40	0.04	0.03	0.02	0.04	0.09	1.68
1942	0.11	0.63	0.87	0.35	0.09	0.09	0.69	0.40	0.03	0.56	0.66	0.21	4.70
1943	0.00	0.22	0.29	0.05	0.76	0.96	0.33	0.03	0.04	0.06	0.04	0.69	3.48
1944	0.42	0.08	0.05	0.04	0.09	0.79	0.44	0.03	0.02	0.01	0.00	0.01	1.99
1945	0.05	0.05	0.04	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.19
1946	0.06	0.12	0.11	0.10	0.61	0.85	0.35	0.04	0.05	0.04	0.03	0.03	2.41
1947	0.06	0.73	0.93	0.37	0.09	0.60	0.35	0.04	0.02	0.01	0.01	0.01	3.23
1948	0.05	0.08	0.09	0.10	0.12	0.10	0.60	0.34	0.03	0.02	0.01	0.03	1.56
1949	0.09	0.66	0.91	0.38	0.09	0.66	0.38	0.03	0.02	0.01	0.03	0.03	3.28
1950	0.05	0.05	0.84	0.51	0.06	0.05	0.04	0.03	0.02	0.01	0.74	0.44	2.84
1951	0.51	0.28	0.09	0.11	0.09	0.09	0.06	0.05	0.03	0.03	0.03	0.02	1.40
1952	0.03	0.77	0.99	0.38	0.58	0.34	0.05	0.02	0.02	0.01	0.02	0.05	3.24
1953	0.07	0.64	0.80	0.75	0.34	0.09	0.07	0.09	0.05	0.03	0.03	0.08	3.02
1954	0.67	0.78	0.27	0.87	0.54	0.63	0.37	0.05	0.02	0.02	0.01	0.03	4.25
1955	0.66	0.87	0.78	0.29	0.95	0.59	0.07	0.03	0.02	0.02	0.03	0.05	4.35
1956	0.07	0.65	0.88	0.37	0.11	0.09	0.09	0.04	0.02	0.03	0.04	0.73	3.12
1957	0.84	0.31	0.09	0.66	0.82	0.30	0.64	0.36	0.03	0.01	0.01	0.03	4.09
1958	0.05	0.10	0.10	0.09	0.10	0.05	0.02	0.10	0.09	0.03	0.03	0.04	0.82
1959	0.66	0.40	0.09	0.05	0.09	0.09	0.11	0.07	0.03	0.01	0.02	0.04	1.66
1960	0.08	0.73	0.93	0.81	0.33	0.07	0.75	0.42	0.06	0.03	0.02	0.05	4.29
1961	0.09	0.11	0.09	0.08	0.07	0.11	0.09	0.04	0.02	0.01	0.05	0.05	0.81
1962	0.09	0.66	0.41	0.11	0.07	0.68	0.41	0.03	0.04	0.60	0.34	0.03	3.47
1963	0.05	0.09	0.08	0.85	0.50	0.05	0.04	0.05	0.03	0.03	0.03	0.03	1.84
1964	0.70	0.42	0.09	0.05	0.06	0.03	0.03	0.04	0.09	0.10	0.09	0.08	1.79
1965	0.09	0.09	0.07	0.67	0.40	0.03	0.03	0.06	0.05	0.03	0.03	0.04	1.60
1966	0.07	0.09	0.09	0.80	0.91	0.79	0.34	0.05	0.01	0.02	0.02	0.02	3.21
1967	0.08	0.00	0.00	0.00	0.04	0.09	0.06	0.03	0.02	0.01	0.06	0.09	0.47
1968	0.08	0.08	0.77	0.45	0.06	0.92	0.56	0.09	0.03	0.03	0.02	0.04	3.13
1969	0.72	0.44	0.09	0.07	0.06	0.05	0.04	0.07	0.07	0.03	0.03	0.09	1.75
1970	0.65	0.39	0.07	0.08	0.09	0.09	0.09	0.66	0.37	0.05	0.06	0.09	2.68
1971	0.09	0.09	0.57	0.35	0.68	0.83	0.29	0.09	0.08	0.05	0.03	0.03	3.18
1972	0.04	0.09	0.10	0.09	0.74	0.46	0.09	0.03	0.01	0.02	0.09	0.65	2.43
1973	0.38	0.08	0.07	0.66	0.87	0.34	0.05	0.05	0.03	0.03	0.03	0.02	2.61
1974	0.02	0.08	0.12	0.76	0.94	0.34	0.06	0.04	0.03	0.02	0.03	0.81	3.24
1975	0.48	0.09	0.60	0.86	0.83	0.84	0.36	0.07	0.03	0.01	0.03	0.04	4.25
1976	0.10	0.12	0.07	0.72	0.92	0.37	0.06	0.02	0.01	0.00	0.02	0.07	2.48
1977	0.66	0.39	0.07	0.09	0.10	0.64	0.40	0.05	0.02	0.01	0.03	0.08	2.55
1978	0.66	0.40	0.09	0.08	0.07	0.05	0.04	0.03	0.03	0.03	0.05	0.07	1.59
1979	0.09	0.08	0.07	0.06	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.76	1.19
1980	0.46	0.10	0.07	0.75	0.90	0.30	0.03	0.07	0.08	0.04	0.07	0.10	2.98
1981	0.08	0.69	0.40	0.11	0.09	0.72	0.42	0.05	0.02	0.01	0.01	0.02	2.61
1982	0.79	0.47	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.06	0.06	1.68
1983	0.07	0.76	0.47	0.66	0.88	0.39	0.09	0.05	0.03	0.08	0.09	0.05	3.62
1984	0.07	0.09	0.07	0.69	0.93	0.35	0.03	0.01	0.01	0.02	0.01	0.01	2.27
1985	0.76	0.48	0.11	0.09	0.06	0.09	0.09	0.03	0.02	0.03	0.02	0.03	1.80
1986	0.10	0.11	0.66	0.90	0.38	0.62	0.35	0.04	0.08	0.07	0.09	0.23	3.63
1987	0.41	0.63	0.31	0.08	0.73	0.97	0.35	0.03	0.03	0.04	0.06	0.06	3.71
1988	0.09	0.60	0.91	0.37	0.83	0.47	0.04	0.03	0.03	0.03	0.02	0.02	3.43
1989	0.07	0.75	0.46	0.07	0.06	0.73	0.43	0.05	0.02	0.01	0.03	0.04	2.73
1990	0.09	0.09	0.76	1.03	0.91	0.89	0.34	0.03	0.02	0.03	0.02	0.05	4.25
1991	0.10	0.08	0.04	0.04	0.05	0.05	0.06	0.04	0.02	0.01	0.01	0.02	0.53
1992	0.03	0.09	0.09	0.05	0.08	0.09	0.06	0.03	0.01	0.01	0.02	0.04	0.59
1993	0.74	0.43	0.09	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.80	0.46	2.56
1994	0.06	0.04	0.06	0.07	0.04	0.09	0.11	0.11	0.09	0.06	0.02	0.02	0.79

Afforestation and dryland sugar cane water use for 1995 – TM31.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.31	0.13	0.04	0.02	0.02	0.24	0.13	0.01	0.00	0.00	0.00	0.00	0.92
1921	0.02	0.25	0.32	0.11	0.03	0.03	0.02	0.01	0.01	0.00	0.02	0.02	0.84
1922	0.25	0.31	0.29	0.13	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.00	1.03
1923	0.01	0.01	0.03	0.25	0.19	0.09	0.04	0.01	0.01	0.00	0.00	0.02	0.66
1924	0.02	0.26	0.19	0.03	0.01	0.22	0.13	0.03	0.01	0.00	0.00	0.01	0.93
1925	0.02	0.22	0.12	0.02	0.23	0.14	0.02	0.01	0.01	0.01	0.00	0.02	0.83
1926	0.02	0.03	0.02	0.02	0.20	0.12	0.02	0.01	0.00	0.01	0.01	0.00	0.46
1927	0.26	0.17	0.21	0.12	0.23	0.27	0.09	0.01	0.01	0.00	0.00	0.01	1.39
1928	0.03	0.03	0.26	0.16	0.04	0.21	0.12	0.01	0.00	0.00	0.00	0.03	0.89
1929	0.20	0.28	0.29	0.31	0.14	0.02	0.01	0.01	0.00	0.00	0.01	0.00	1.27
1930	0.00	0.01	0.18	0.13	0.20	0.11	0.03	0.02	0.00	0.01	0.01	0.01	0.70
1931	0.00	0.01	0.02	0.02	0.30	0.36	0.12	0.01	0.01	0.01	0.00	0.00	0.86
1932	0.01	0.02	0.12	0.06	0.22	0.13	0.02	0.01	0.00	0.00	0.00	0.00	0.60
1933	0.01	0.27	0.34	0.30	0.12	0.03	0.02	0.02	0.01	0.01	0.02	0.01	1.16
1934	0.01	0.25	0.34	0.14	0.10	0.23	0.11	0.01	0.00	0.00	0.00	0.00	1.20
1935	0.01	0.01	0.02	0.22	0.14	0.22	0.12	0.24	0.14	0.01	0.00	0.00	1.11
1936	0.02	0.25	0.15	0.24	0.31	0.12	0.01	0.00	0.00	0.00	0.00	0.01	1.11
1937	0.25	0.15	0.26	0.16	0.02	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.94
1938	0.25	0.15	0.29	0.33	0.29	0.26	0.09	0.01	0.01	0.01	0.00	0.00	1.69
1939	0.01	0.25	0.34	0.14	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.83
1940	0.01	0.25	0.15	0.23	0.30	0.12	0.18	0.10	0.01	0.00	0.00	0.00	1.35
1941	0.01	0.01	0.02	0.27	0.17	0.19	0.11	0.03	0.03	0.01	0.01	0.02	0.87
1942	0.04	0.21	0.30	0.29	0.29	0.26	0.27	0.12	0.01	0.02	0.03	0.02	1.85
1943	0.23	0.13	0.04	0.03	0.25	0.15	0.02	0.00	0.03	0.03	0.01	0.03	0.96
1944	0.20	0.12	0.02	0.01	0.04	0.24	0.13	0.01	0.00	0.00	0.00	0.00	0.78
1945	0.00	0.01	0.01	0.24	0.29	0.27	0.10	0.01	0.00	0.00	0.00	0.00	0.93
1946	0.03	0.22	0.13	0.03	0.24	0.15	0.02	0.01	0.00	0.00	0.01	0.00	0.84
1947	0.01	0.30	0.35	0.29	0.12	0.08	0.03	0.00	0.00	0.00	0.00	0.01	1.18
1948	0.02	0.03	0.03	0.29	0.18	0.06	0.08	0.03	0.00	0.00	0.00	0.01	0.72
1949	0.03	0.22	0.13	0.04	0.04	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.55
1950	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.02	0.02	0.17
1951	0.25	0.14	0.04	0.23	0.13	0.03	0.02	0.01	0.01	0.03	0.03	0.01	0.91
1952	0.01	0.28	0.17	0.03	0.26	0.16	0.03	0.01	0.00	0.00	0.00	0.00	0.96
1953	0.01	0.24	0.16	0.04	0.20	0.25	0.09	0.02	0.01	0.01	0.01	0.02	1.05
1954	0.14	0.06	0.00	0.19	0.29	0.26	0.10	0.01	0.00	0.00	0.00	0.00	1.06
1955	0.02	0.22	0.14	0.03	0.26	0.32	0.11	0.02	0.01	0.00	0.00	0.01	1.14
1956	0.15	0.14	0.23	0.13	0.20	0.13	0.02	0.01	0.01	0.02	0.00	0.15	1.17
1957	0.25	0.10	0.21	0.31	0.12	0.02	0.03	0.02	0.01	0.00	0.00	0.01	1.08
1958	0.03	0.20	0.29	0.12	0.03	0.02	0.02	0.02	0.01	0.01	0.00	0.01	0.76
1959	0.04	0.23	0.14	0.03	0.04	0.03	0.04	0.02	0.00	0.00	0.00	0.01	0.57
1960	0.03	0.26	0.33	0.12	0.03	0.03	0.08	0.05	0.01	0.01	0.00	0.02	0.97
1961	0.03	0.23	0.31	0.13	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.77
1962	0.01	0.28	0.34	0.30	0.12	0.03	0.02	0.01	0.02	0.23	0.13	0.01	1.50
1963	0.01	0.28	0.16	0.31	0.17	0.02	0.02	0.02	0.01	0.00	0.00	0.00	1.01
1964	0.25	0.16	0.04	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.58
1965	0.02	0.23	0.14	0.03	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.57
1966	0.03	0.03	0.26	0.33	0.29	0.11	0.02	0.01	0.00	0.01	0.01	0.01	1.08
1967	0.02	0.24	0.15	0.03	0.01	0.23	0.13	0.01	0.00	0.00	0.01	0.01	0.84
1968	0.01	0.25	0.17	0.21	0.12	0.25	0.15	0.02	0.01	0.00	0.00	0.01	1.20
1969	0.23	0.14	0.23	0.14	0.04	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.84
1970	0.22	0.14	0.02	0.04	0.04	0.02	0.24	0.14	0.01	0.00	0.00	0.01	0.88
1971	0.02	0.23	0.31	0.30	0.29	0.25	0.10	0.01	0.01	0.00	0.00	0.00	1.52
1972	0.00	0.17	0.09	0.19	0.29	0.12	0.00	0.00	0.00	0.00	0.02	0.04	0.92
1973	0.03	0.18	0.12	0.06	0.09	0.06	0.03	0.02	0.01	0.01	0.01	0.00	0.62
1974	0.01	0.24	0.32	0.30	0.30	0.12	0.02	0.01	0.00	0.00	0.00	0.02	1.34
1975	0.02	0.24	0.26	0.10	0.18	0.25	0.11	0.02	0.01	0.00	0.00	0.00	1.21
1976	0.05	0.02	0.14	0.27	0.26	0.10	0.02	0.00	0.00	0.00	0.00	0.01	0.88
1977	0.03	0.04	0.15	0.11	0.20	0.11	0.02	0.01	0.00	0.00	0.01	0.02	0.70
1978	0.23	0.15	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.03	0.54
1979	0.02	0.03	0.03	0.20	0.28	0.11	0.01	0.00	0.00	0.00	0.00	0.01	0.70
1980	0.01	0.26	0.17	0.23	0.30	0.13	0.01	0.00	0.00	0.00	0.01	0.02	1.14
1981	0.03	0.02	0.03	0.26	0.15	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.52
1982	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.18
1983	0.22	0.30	0.28	0.30	0.13	0.19	0.10	0.01	0.00	0.01	0.03	0.02	1.60
1984	0.02	0.02	0.02	0.24	0.32	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.76
1985	0.22	0.14	0.04	0.20	0.28	0.12	0.02	0.01	0.01	0.00	0.00	0.00	1.04
1986	0.01	0.03	0.25	0.15	0.04	0.02	0.01	0.00	0.00	0.00	0.01	0.22	0.76
1987	0.28	0.26	0.11	0.25	0.15	0.03	0.01	0.00	0.00	0.00	0.00	0.01	1.11
1988	0.26	0.16	0.23	0.33	0.31	0.12	0.02	0.01	0.02	0.01	0.00	0.00	1.46
1989	0.01	0.25	0.31	0.12	0.04	0.21	0.13	0.02	0.00	0.00	0.00	0.00	1.09
1990	0.01	0.01	0.02	0.11	0.23	0.28	0.11	0.01	0.01	0.01	0.00	0.00	0.79
1991	0.24	0.14	0.26	0.15	0.24	0.14	0.01	0.00	0.00	0.00	0.00	0.00	1.18
1992	0.01	0.02	0.26	0.15	0.23	0.14	0.03	0.01	0.00	0.00	0.00	0.00	0.85
1993	0.25	0.16	0.02	0.23	0.18	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.97
1994	0.02	0.02	0.03	0.04	0.03	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.22

Afforestation and dryland sugar cane water use for 1995 – TM32.AFF Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SET	TOTAL
1920	0.09	0.78	1.05	0.40	0.05	0.10	0.09	0.03	0.02	0.01	0.01	0.04	2.69
1921	0.08	0.92	0.56	0.06	0.04	0.08	0.05	0.05	0.06	0.04	0.06	0.05	2.06
1922	0.10	0.03	0.00	0.21	0.23	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.70
1923	0.01	0.09	0.85	0.48	0.11	0.08	0.05	0.03	0.03	0.01	0.01	0.03	1.77
1924	0.09	0.87	1.04	1.08	0.47	0.87	0.52	0.06	0.02	0.03	0.03	0.07	5.13
1925	0.12	0.09	0.10	0.09	0.04	0.10	0.08	0.04	0.06	0.06	0.03	0.09	0.91
1926	0.80	0.98	0.37	0.06	0.13	0.79	0.44	0.03	0.01	0.03	0.07	0.04	3.75
1927	0.07	0.06	0.11	0.89	0.50	0.07	0.03	0.03	0.01	0.00	0.01	0.03	1.80
1928	0.05	0.05	0.04	0.06	0.07	0.14	0.10	0.03	0.04	0.07	0.05	0.06	0.77
1929	0.10	0.71	0.42	0.85	0.50	0.07	0.08	0.04	0.01	0.01	0.01	0.05	2.85
1930	0.08	0.09	0.09	0.83	0.47	0.05	0.03	0.03	0.01	0.01	0.00	0.01	1.70
1931	0.04	0.07	0.08	0.06	1.04	1.22	0.40	0.09	0.08	0.03	0.01	0.03	3.15
1932	0.03	0.09	0.15	0.07	0.07	0.05	0.03	0.01	0.00	0.03	0.03	0.02	0.58
1933	0.02	1.00	1.24	1.20	0.48	0.11	0.12	0.09	0.04	0.03	0.07	0.05	4.44
1934	0.10	0.13	0.78	0.45	0.09	0.09	0.07	0.04	0.04	0.03	0.02	0.01	1.86
1935	0.02	0.04	0.05	0.12	0.00	0.07	0.04	0.08	0.08	0.03	0.01	0.02	0.55
1936	0.07	0.90	0.52	0.06	0.93	0.55	0.06	0.02	0.01	0.01	0.01	0.01	3.13
1937	0.02	0.04	0.98	1.23	1.15	0.47	0.10	0.06	0.04	0.09	0.09	0.04	4.32
1938	0.06	0.07	0.13	0.15	0.84	0.52	0.07	0.05	0.03	0.03	0.03	0.08	2.05
1939	0.09	0.89	0.56	0.10	0.05	0.06	0.06	0.99	0.59	0.06	0.01	0.06	3.53
1940	0.07	0.77	1.09	0.43	0.10	0.09	0.14	0.08	0.02	0.00	0.00	0.02	2.82
1941	0.05	0.06	0.07	0.12	0.84	0.52	0.08	0.03	0.02	0.02	0.02	0.05	1.86
1942	0.12	0.71	1.03	0.46	0.13	0.08	0.96	0.56	0.05	0.09	0.70	0.38	5.28
1943	0.75	1.03	0.42	0.06	0.13	0.11	0.05	0.02	0.05	0.05	0.03	0.09	2.80
1944	0.13	0.09	0.07	0.09	0.09	0.98	0.55	0.04	0.02	0.01	0.00	0.01	2.08
1945	0.02	0.02	0.05	0.15	0.10	0.07	0.05	0.03	0.01	0.01	0.00	0.01	0.52
1946	0.82	0.52	0.09	0.10	0.14	0.12	0.07	0.03	0.05	0.05	0.03	0.03	2.06
1947	0.06	0.92	0.58	0.11	0.11	0.82	0.47	0.04	0.02	0.00	0.01	0.01	3.15
1948	0.05	0.09	0.15	0.82	1.09	0.46	0.11	0.04	0.01	0.01	0.01	0.02	2.86
1949	0.08	0.92	1.24	0.50	0.09	0.12	0.09	0.04	0.02	0.01	0.02	0.02	3.14
1950	0.04	0.07	0.91	0.55	0.08	0.06	0.05	0.03	0.02	0.01	0.88	0.52	3.21
1951	0.11	0.05	0.11	0.82	0.47	0.09	0.07	0.04	0.03	0.03	0.03	0.02	1.89
1952	0.03	0.12	0.75	0.45	0.79	0.46	0.06	0.03	0.02	0.02	0.04	0.06	2.82
1953	0.07	0.86	0.53	0.10	0.09	0.09	0.07	0.10	0.08	0.03	0.02	0.06	2.11
1954	0.84	1.06	0.37	0.96	0.59	0.66	0.40	0.05	0.02	0.01	0.01	0.00	4.97
1955	0.08	0.80	1.08	0.40	1.15	0.68	0.07	0.02	0.02	0.02	0.01	0.03	4.35
1956	0.09	0.84	1.10	0.45	0.09	0.09	0.09	0.06	0.03	0.03	0.04	0.89	3.80
1957	1.06	0.38	0.07	0.09	0.15	0.09	0.11	0.08	0.03	0.01	0.00	0.01	2.07
1958	0.04	0.11	0.15	0.90	1.24	0.46	0.04	0.06	0.05	0.03	0.02	0.03	3.15
1959	0.10	0.10	0.12	0.11	0.13	0.12	0.12	0.06	0.02	0.01	0.01	0.03	0.93
1960	0.07	0.12	0.82	0.51	0.12	0.08	0.09	0.07	0.03	0.02	0.01	0.03	1.97
1961	0.07	0.11	0.11	0.09	0.08	0.11	0.10	0.05	0.02	0.01	0.03	0.03	0.82
1962	0.07	0.14	0.15	0.11	0.07	0.95	0.57	0.05	0.02	0.90	0.52	0.03	3.56
1963	0.03	0.13	0.09	1.15	0.67	0.06	0.03	0.03	0.03	0.02	0.03	0.04	2.32
1964	0.11	0.11	0.09	0.08	0.05	0.03	0.03	0.04	0.08	0.08	0.07	0.08	0.85
1965	0.08	0.11	0.10	0.96	0.58	0.06	0.03	0.05	0.03	0.01	0.02	0.03	2.06
1966	0.06	0.13	0.13	0.83	1.20	1.11	0.44	0.06	0.02	0.02	0.02	0.02	4.02
1967	0.06	0.13	0.09	0.09	0.09	0.11	0.08	0.03	0.02	0.00	0.02	0.03	0.76
1968	0.05	0.07	0.90	0.53	0.07	0.98	0.59	0.08	0.03	0.03	0.02	0.03	3.37
1969	0.78	0.46	0.12	0.09	0.07	0.05	0.04	0.06	0.04	0.03	0.03	0.10	1.89
1970	0.77	0.46	0.09	0.07	0.08	0.07	0.09	0.92	0.52	0.05	0.07	0.05	3.23
1971	0.07	0.09	0.12	0.13	0.13	0.11	0.07	0.06	0.06	0.04	0.02	0.01	0.91
1972	0.05	0.08	0.07	0.10	0.94	0.57	0.09	0.05	0.01	0.00	0.05	0.70	2.70
1973	0.40	0.09	0.08	1.03	0.62	0.10	0.07	0.03	0.03	0.03	0.03	0.01	2.52
1974	0.01	0.09	0.14	0.76	0.47	0.09	0.06	0.06	0.03	0.01	0.01	0.89	2.60
1975	0.53	0.12	0.77	1.09	1.08	1.09	0.45	0.07	0.03	0.01	0.01	0.02	5.25
1976	0.10	0.14	0.09	0.85	1.15	0.46	0.07	0.03	0.01	0.01	0.01	0.04	2.94
1977	0.85	0.53	0.10	0.82	0.51	0.10	0.08	0.04	0.02	0.00	0.02	0.06	3.13
1978	0.92	0.55	0.14	0.12	0.11	0.07	0.04	0.03	0.02	0.00	0.00	0.03	2.04
1979	0.07	0.05	0.06	0.05	0.03	0.02	0.03	0.02	0.02	0.01	0.01	0.06	0.42
1980	0.08	0.09	0.08	0.11	0.09	0.04	0.03	0.03	0.04	0.03	0.03	0.07	0.71
1981	0.07	0.87	0.50	0.09	0.09	0.91	0.53	0.05	0.02	0.01	0.01	0.01	3.16
1982	0.94	0.57	0.08	0.06	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.03	1.89
1983	0.06	0.94	0.59	0.83	1.03	0.40	0.09	0.05	0.03	0.06	0.08	0.07	4.23
1984	0.09	0.10	0.06	0.09	0.93	0.52	0.04	0.01	0.01	0.01	0.01	0.01	1.88
1985	0.87	0.53	0.12	0.09	0.09	0.09	0.09	0.04	0.03	0.03	0.01	0.02	2.00
1986	0.09	0.11	0.89	1.23	0.49	0.13	0.07	0.03	0.05	0.05	0.08	0.90	4.11
1987	0.55	0.10	0.11	0.09	0.81	0.52	0.07	0.02	0.02	0.04	0.06	0.06	2.45
1988	0.10	0.77	1.08	0.42	0.93	0.53	0.04	0.02	0.03	0.02	0.02	0.01	3.96
1989	0.04	0.92	0.56	0.07	0.07	0.10	0.09	0.05	0.03	0.01	0.04	0.04	2.03
1990	0.08	0.09	0.15	0.89	1.11	0.95	0.34	0.04	0.02	0.02	0.01	0.03	3.73
1991	0.12	0.09	0.07	0.08	0.09	0.07	0.03	0.03	0.01	0.01	0.01	0.01	0.61
1992	0.03	0.06	0.08	0.05	0.07	0.09	0.05	0.03	0.01	0.00	0.01	0.03	0.51
1993	0.92	0.54	0.09	0.09	0.06	0.10	0.07	0.03	0.02	0.01	0.05	0.05	2.03
1994	0.08	0.05	0.06	0.09	0.05	0.05	0.06	0.09	0.10	0.07	0.03	0.02	0.76

APPENDIX K

IRRIGATION TIME SERIES

First and second phase irrigation water use for 2030 – CHELD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.05	.27	.22	.44	.14	.00	.16	.13	.15	.19	.28	.06	2.08
1921	.41	.00	.00	.23	.23	.00	.23	.10	.05	.18	.08	.21	1.72
1922	.05	.00	.00	.08	.35	.63	.31	.18	.10	.12	.31	.59	2.71
1923	.42	.41	.33	.00	.20	.23	.15	.17	.15	.19	.26	.20	2.70
1924	.41	.03	.00	.31	.13	.00	.00	.15	.13	.17	.31	.32	1.97
1925	.29	.12	.25	.36	.44	.33	.25	.15	.00	.19	.32	.03	2.73
1926	.39	.15	.07	.28	.07	.09	.28	.18	.15	.07	.26	.57	2.56
1927	.17	.38	.00	.29	.39	.21	.19	.17	.15	.19	.23	.28	2.64
1928	.39	.38	.06	.29	.60	.00	.29	.17	.00	.03	.29	.00	2.51
1929	.33	.00	.03	.02	.52	.54	.04	.18	.14	.11	.24	.39	2.54
1930	.47	.44	.00	.00	.27	.46	.18	.19	.15	.14	.32	.58	3.20
1931	.46	.26	.24	.27	.08	.15	.24	.01	.13	.18	.32	.46	2.80
1932	.48	.21	.00	.65	.54	.21	.08	.19	.14	.09	.31	.57	3.48
1933	.53	.00	.00	.00	.52	.21	.12	.08	.15	.04	.12	.57	2.35
1934	.34	.03	.00	.31	.10	.14	.08	.15	.12	.19	.29	.43	2.19
1935	.47	.43	.20	.00	.17	.00	.25	.00	.15	.19	.32	.51	2.68
1936	.32	.00	.37	.00	.10	.49	.09	.19	.14	.19	.31	.41	2.62
1937	.53	.40	.00	.32	.39	.52	.02	.16	.00	.09	.22	.49	3.15
1938	.00	.34	.00	.23	.01	.25	.31	.04	.14	.05	.26	.42	2.06
1939	.41	.00	.00	.26	.21	.64	.12	.00	.00	.19	.31	.23	2.38
1940	.48	.06	.00	.28	.15	.17	.00	.19	.15	.18	.31	.46	2.44
1941	.42	.32	.05	.00	.05	.31	.09	.10	.06	.19	.21	.19	1.99
1942	.26	.00	.00	.00	.53	.08	.00	.10	.14	.00	.00	.53	1.64
1943	.00	.04	.00	.23	.00	.47	.32	.19	.00	.19	.32	.00	1.75
1944	.09	.38	.33	.52	.43	.02	.07	.17	.14	.19	.31	.55	3.22
1945	.64	.49	.48	.07	.33	.03	.28	.18	.15	.19	.32	.55	3.69
1946	.18	.06	.17	.51	.00	.29	.09	.19	.01	.17	.30	.47	2.46
1947	.42	.00	.00	.04	.37	.24	.22	.14	.15	.19	.32	.33	2.42
1948	.15	.24	.21	.00	.09	.25	.00	.18	.14	.19	.32	.40	2.17
1949	.16	.11	.00	.32	.37	.41	.00	.08	.13	.18	.21	.52	2.50
1950	.30	.28	.00	.44	.23	.38	.04	.15	.13	.08	.05	.52	2.61
1951	.22	.47	.00	.08	.69	.46	.09	.16	.15	.00	.31	.55	3.17
1952	.47	.01	.12	.00	.01	.40	.03	.19	.11	.19	.02	.50	2.05
1953	.45	.07	.19	.45	.00	.14	.23	.04	.10	.19	.32	.27	2.44
1954	.11	.00	.29	.03	.04	.33	.13	.18	.13	.19	.30	.54	2.29
1955	.18	.26	.11	.45	.11	.07	.29	.04	.14	.19	.31	.35	2.50
1956	.28	.00	.00	.23	.21	.06	.00	.17	.05	.00	.16	.04	1.20
1957	.02	.40	.22	.05	.16	.09	.00	.18	.14	.19	.32	.29	2.07
1958	.22	.14	.00	.42	.09	.42	.10	.05	.15	.14	.31	.44	2.48
1959	.14	.01	.07	.46	.19	.45	.00	.16	.15	.19	.20	.43	2.45
1960	.24	.13	.00	.68	.53	.07	.00	.12	.13	.19	.32	.33	2.72
1961	.44	.09	.13	.10	.13	.47	.16	.19	.15	.19	.20	.42	2.65
1962	.53	.18	.15	.04	.79	.27	.19	.15	.00	.00	.32	.59	3.21
1963	.23	.06	.29	.10	.48	.42	.02	.19	.01	.19	.24	.33	2.53
1964	.00	.12	.00	.10	.21	.70	.11	.18	.00	.13	.21	.42	2.20
1965	.20	.20	.22	.00	.45	.72	.05	.13	.14	.19	.19	.36	2.86
1966	.35	.12	.00	.00	.24	.37	.01	.17	.15	.19	.31	.52	2.44
1967	.42	.07	.03	.51	.76	.26	.16	.16	.15	.19	.12	.55	3.37
1968	.60	.13	.03	.16	.36	.02	.00	.13	.12	.13	.32	.46	2.46
1969	.02	.36	.05	.31	.16	.62	.10	.12	.12	.14	.08	.37	2.45
1970	.09	.26	.28	.00	.46	.39	.00	.01	.14	.12	.19	.43	2.38
1971	.28	.28	.00	.28	.09	.00	.21	.12	.13	.19	.30	.59	2.46
1972	.28	.13	.29	.39	.21	.47	.00	.18	.15	.19	.00	.24	2.53
1973	.49	.02	.13	.10	.06	.40	.00	.17	.05	.13	.26	.53	2.32
1974	.50	.00	.00	.11	.00	.53	.01	.17	.15	.19	.31	.00	1.97
1975	.50	.06	.00	.00	.17	.00	.02	.02	.15	.19	.31	.47	1.88
1976	.05	.30	.00	.04	.61	.19	.20	.17	.15	.19	.31	.37	2.58
1977	.27	.41	.00	.00	.21	.22	.03	.19	.15	.19	.14	.27	2.08
1978	.16	.23	.01	.33	.22	.63	.18	.16	.13	.05	.06	.24	2.40
1979	.53	.25	.03	.00	.07	.50	.22	.18	.15	.19	.30	.17	2.58
1980	.42	.23	.02	.25	.17	.66	.19	.18	.06	.19	.16	.23	2.76
1981	.39	.32	.29	.16	.69	.31	.27	.16	.14	.16	.32	.46	3.69
1982	.02	.46	.22	.35	.66	.38	.16	.09	.12	.16	.21	.55	3.38
1983	.12	.00	.00	.02	.49	.03	.13	.19	.08	.12	.06	.48	1.72
1984	.00	.30	.15	.00	.00	.64	.33	.18	.13	.18	.31	.44	2.67
1985	.02	.06	.00	.01	.08	.32	.05	.19	.08	.19	.29	.51	1.81
1986	.26	.21	.01	.16	.09	.45	.11	.18	.11	.19	.08	.00	1.85
1987	.06	.03	.00	.25	.26	.13	.22	.16	.06	.17	.31	.47	2.12
1988	.09	.32	.00	.22	.00	.46	.30	.17	.08	.19	.31	.58	2.72
1989	.27	.00	.00	.52	.34	.07	.08	.17	.15	.18	.25	.59	2.61
1990	.51	.52	.00	.07	.01	.35	.32	.16	.01	.19	.31	.40	2.86
1991	.00	.22	.00	.46	.00	.51	.19	.19	.15	.19	.12	.57	2.59
1992	.44	.23	.16	.60	.00	.49	.20	.19	.15	.19	.24	.47	3.36
1993	.00	.22	.02	.00	.19	.27	.14	.17	.15	.14	.22	.51	2.03
1994	.26	.40	.00	.08	.48	.11	.11	.15	.15	.19	.31	.59	2.83

First and second phase irrigation water use for 2030 – HARL.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.69	.00	.00	.00	.00	.00	1.03	.34	.92	.96	1.57	1.13	6.66
1921	1.32	.00	.00	.00	.00	.00	.90	.74	.34	1.16	.78	1.99	7.23
1922	.81	.00	.00	.00	.00	.00	1.05	1.10	.92	1.05	1.47	2.09	8.50
1923	2.14	.00	.00	.00	.00	.00	1.15	.82	.95	1.16	1.28	1.19	8.69
1924	1.33	.00	.00	.00	.00	.00	.12	.94	.90	.92	1.62	.59	6.41
1925	1.02	.00	.00	.00	.00	.00	1.08	.71	.48	1.18	1.58	.61	6.67
1926	1.32	.00	.00	.00	.00	.00	.99	1.05	.95	1.03	.87	2.07	8.28
1927	.82	.24	.00	.00	.00	.00	1.05	.80	.95	1.16	1.36	1.52	7.91
1928	1.16	.09	.00	.00	.00	.00	.53	.78	.12	.35	1.53	.58	5.13
1929	1.18	.00	.00	.00	.00	.00	.87	1.03	.88	1.11	1.28	1.76	8.11
1930	1.67	.00	.00	.00	.00	.00	.57	1.07	.94	.53	1.61	2.19	8.57
1931	1.54	.25	.00	.00	.00	.00	1.17	.34	.88	1.17	1.61	1.33	8.29
1932	1.87	.00	.00	.00	.00	.00	.89	1.10	.86	.47	1.60	2.17	8.95
1933	1.83	.00	.00	.00	.00	.00	.19	.31	.95	.46	.74	1.76	6.23
1934	1.33	.00	.00	.00	.00	.00	.58	.75	.26	1.18	1.40	2.08	7.58
1935	2.09	.09	.00	.00	.00	.00	1.25	.06	.90	1.15	1.61	1.83	8.97
1936	1.33	.00	.00	.00	.00	.01	1.28	1.06	.73	1.15	1.58	2.01	9.13
1937	1.83	.00	.00	.00	.00	.11	.00	1.07	.59	.38	1.36	1.90	7.24
1938	.58	.00	.00	.00	.00	.00	.80	.48	.95	.89	1.36	1.25	6.31
1939	1.26	.00	.00	.00	.00	.00	.68	.00	.12	1.16	1.54	1.18	5.94
1940	1.61	.00	.00	.00	.00	.00	.52	1.10	.92	1.00	1.59	2.03	8.78
1941	1.40	.00	.00	.00	.00	.00	.51	.78	.87	.90	1.09	1.72	7.28
1942	1.44	.00	.00	.00	.00	.00	.00	.04	.83	.02	.00	2.08	4.42
1943	.00	.00	.00	.00	.00	.00	1.21	.95	.40	1.18	1.57	.25	5.56
1944	1.73	.00	.00	.00	.00	.00	.90	.88	.92	1.18	1.57	2.16	9.35
1945	2.09	.77	.00	.00	.00	.00	1.02	.98	.94	1.16	1.60	2.10	10.65
1946	1.46	.00	.00	.00	.00	.00	.66	1.02	.18	.95	1.58	1.65	7.50
1947	1.36	.00	.00	.00	.00	.00	.34	.86	.95	1.17	1.59	1.90	8.16
1948	1.61	.00	.00	.00	.00	.00	.69	.71	.93	1.13	1.54	1.49	8.11
1949	1.91	.00	.00	.00	.00	.00	.16	.50	.94	.80	.74	1.98	7.02
1950	1.94	.00	.00	.00	.00	.00	.54	1.03	.89	1.18	.24	1.46	7.28
1951	1.40	.53	.00	.00	.00	.00	.77	.80	.83	.79	1.13	1.93	8.17
1952	1.31	.00	.00	.00	.00	.21	.74	1.02	.87	1.18	.81	1.83	7.98
1953	1.41	.00	.00	.00	.00	.06	.67	.29	.87	1.15	1.58	1.23	7.25
1954	.63	.00	.00	.00	.00	.00	.56	.78	.85	1.18	1.54	1.74	7.27
1955	1.75	.05	.00	.00	.00	.00	1.00	.91	.93	1.17	1.40	1.64	8.85
1956	1.61	.00	.00	.00	.00	.00	.46	.92	.85	.82	.84	.00	5.50
1957	.43	.00	.00	.00	.00	.24	.00	.95	.89	1.16	1.59	1.66	6.92
1958	1.78	.00	.00	.00	.00	.02	.46	.00	.93	.98	1.33	1.98	7.47
1959	1.35	.00	.00	.00	.00	.00	.00	.98	.95	1.11	1.35	1.57	7.31
1960	1.50	.00	.00	.00	.00	.00	.21	1.03	.80	1.04	1.39	1.44	7.42
1961	1.95	.00	.00	.00	.00	.00	.18	.89	.95	1.18	1.12	2.11	8.38
1962	1.82	.00	.00	.00	.00	.00	.87	.96	.66	.30	1.57	2.14	8.32
1963	.77	.00	.00	.00	.00	.00	.41	1.00	.34	1.03	1.51	.89	5.96
1964	.46	.00	.00	.00	.00	.71	.75	.78	.00	.84	.68	1.43	5.63
1965	1.73	.00	.00	.00	.00	.79	.65	.49	.82	1.18	.99	1.96	8.61
1966	1.62	.00	.00	.00	.00	.00	.03	.95	.87	1.01	1.54	2.14	8.18
1967	1.42	.00	.00	.00	.00	.00	.79	1.00	.94	1.16	1.06	1.83	8.19
1968	1.81	.00	.00	.00	.00	.00	.44	.32	.82	.95	1.38	1.59	7.32
1969	.65	.00	.00	.00	.00	.35	1.08	.82	.75	1.14	.16	.98	5.94
1970	1.10	.00	.00	.00	.00	.01	.65	.29	.86	.59	.74	1.98	6.23
1971	1.06	.00	.00	.00	.00	.00	1.03	.49	.90	1.05	1.49	2.13	8.16
1972	1.53	.00	.00	.00	.00	.00	.00	.95	.92	1.03	.66	1.07	6.17
1973	1.78	.00	.00	.00	.00	.00	.31	.84	.62	.92	1.51	2.16	8.13
1974	1.87	.00	.00	.00	.00	.08	.55	1.09	.95	1.16	1.57	.23	7.50
1975	1.96	.00	.00	.00	.00	.00	.82	.54	.95	1.08	1.42	1.40	8.17
1976	.68	.02	.00	.00	.00	.00	.45	1.05	.87	1.18	1.36	1.10	6.71
1977	1.20	.00	.00	.00	.00	.00	.00	.99	.86	1.14	1.32	1.13	6.64
1978	.87	.00	.00	.00	.00	.00	.83	.20	.91	.70	.82	1.77	6.10
1979	1.73	.16	.00	.00	.00	.07	.93	1.00	.95	1.18	1.47	.79	8.28
1980	1.89	.00	.00	.00	.00	.21	.77	.90	.71	1.15	.67	1.70	8.00
1981	2.16	.00	.00	.00	.00	.00	.77	.99	.87	1.13	1.53	1.56	9.02
1982	1.18	.05	.00	.00	.00	.00	.76	.90	.89	.70	1.26	1.95	7.68
1983	1.32	.00	.00	.00	.00	.00	.63	1.00	.73	1.05	1.19	1.99	7.91
1984	1.18	.22	.00	.00	.00	.00	1.34	1.02	.77	1.15	1.58	1.93	9.19
1985	.23	.00	.00	.00	.00	.00	.54	1.10	.69	1.18	.97	1.96	6.67
1986	.92	.00	.00	.00	.00	.00	.87	1.01	.63	1.00	.38	.00	4.81
1987	1.36	.00	.00	.00	.00	.00	.71	.64	.22	1.05	1.36	1.83	7.18
1988	1.21	.00	.00	.00	.00	.16	1.14	.89	.84	1.16	1.60	2.14	9.14
1989	1.59	.00	.00	.00	.00	.00	.92	1.03	.90	1.18	.90	1.94	8.46
1990	1.49	.19	.00	.00	.00	.00	1.21	.94	.83	1.17	1.49	1.59	8.92
1991	.23	.00	.00	.00	.00	.26	1.00	1.10	.95	1.18	1.45	1.99	8.16
1992	1.76	.04	.00	.00	.00	.00	.81	.94	.95	1.18	1.43	1.91	9.03
1993	.79	.00	.00	.00	.00	.00	.79	1.01	.90	.90	1.29	2.18	7.87
1994	1.36	.68	.00	.00	.00	.00	.39	.92	.47	1.15	1.47	2.01	8.47

First and second phase irrigation water use for 2030 – KLIP.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.60	3.81	5.31	5.87	.22	2.01	3.49	1.89	2.29	2.64	2.58	.09	31.79
1921	3.83	.00	1.94	1.54	3.76	3.32	3.68	1.67	1.48	2.56	.12	3.46	27.34
1922	1.04	1.42	4.62	2.69	1.04	4.21	3.54	2.33	2.09	1.51	2.37	3.48	30.33
1923	4.07	3.66	4.30	3.24	1.61	2.38	3.34	1.71	2.28	2.63	2.20	.87	32.30
1924	1.59	.03	.50	3.44	2.20	.00	1.09	1.75	2.13	2.32	2.58	.94	18.58
1925	2.37	3.78	3.35	.22	3.88	2.85	3.43	1.80	1.58	2.62	2.58	.06	28.53
1926	1.80	1.83	2.96	3.54	1.85	.86	3.37	2.36	2.29	2.24	1.76	3.53	28.39
1927	1.59	4.22	2.26	4.14	3.60	1.95	3.24	2.14	2.29	2.58	2.25	1.67	31.93
1928	2.92	3.69	.38	2.44	2.76	.76	2.32	2.15	.32	.90	2.25	.04	20.92
1929	2.35	.03	3.08	.94	3.29	.12	2.07	2.36	2.06	2.28	2.25	1.34	22.16
1930	3.66	3.28	1.15	1.48	3.20	3.17	2.58	2.38	2.27	1.71	2.58	3.69	31.15
1931	2.85	4.30	1.98	3.32	.00	1.86	3.19	.63	2.20	2.52	2.54	2.25	27.65
1932	3.40	3.10	2.65	6.52	3.15	2.59	1.91	2.37	2.28	1.01	2.58	3.59	35.14
1933	4.20	.00	.05	.33	3.31	1.08	.16	1.04	2.26	2.27	.33	3.55	18.56
1934	2.99	.13	.00	6.55	2.31	1.73	3.27	1.99	1.70	2.64	2.27	3.32	28.91
1935	4.60	2.41	4.59	4.01	1.14	2.58	3.57	.00	2.28	2.64	2.58	3.34	33.74
1936	2.99	.01	2.46	3.03	.13	3.47	2.72	2.38	2.21	2.53	2.58	3.25	27.77
1937	3.73	3.64	1.97	2.33	3.72	3.33	.45	2.38	1.01	1.34	1.77	3.19	28.86
1938	2.73	3.01	2.75	3.63	.09	1.29	3.52	.95	2.29	1.79	2.24	2.45	26.73
1939	2.79	.56	2.81	5.01	3.40	1.69	2.45	.71	.09	2.64	2.43	2.03	26.59
1940	3.77	3.31	3.18	2.57	2.84	1.81	1.32	2.38	2.29	2.61	2.58	3.02	31.69
1941	2.93	4.30	4.37	3.88	1.13	.75	1.29	2.27	2.08	2.51	1.59	2.31	29.42
1942	3.74	.00	1.02	.65	4.48	1.35	.00	.05	2.21	.67	.00	3.41	17.59
1943	.01	.76	1.61	3.40	1.08	1.92	3.70	1.83	1.30	2.64	2.58	.04	20.88
1944	3.43	2.32	5.69	4.87	3.24	.00	3.12	2.24	2.08	2.64	2.58	3.68	35.88
1945	4.78	4.14	4.68	4.07	1.34	2.00	2.63	2.27	2.29	2.63	2.52	3.67	37.01
1946	1.28	.94	4.08	5.59	.52	.65	2.55	2.38	.92	2.61	2.58	2.62	26.73
1947	1.95	2.15	1.70	.12	3.35	.99	1.19	1.94	2.29	2.64	2.58	2.98	23.89
1948	2.70	3.60	2.12	3.24	1.79	1.45	1.73	2.36	2.28	2.63	1.94	2.99	28.83
1949	3.64	1.89	3.85	5.18	4.26	.22	2.49	.91	2.28	2.48	1.68	2.09	30.97
1950	3.29	3.16	.12	5.11	3.79	2.48	2.25	2.19	2.09	2.63	.42	2.61	30.15
1951	3.15	5.01	3.08	.00	3.10	1.52	2.55	2.12	2.20	1.10	2.14	2.95	28.91
1952	2.64	2.66	2.24	3.96	.05	4.29	1.81	2.36	2.28	2.64	1.94	3.54	30.41
1953	3.74	2.42	1.51	5.29	.00	3.28	2.82	1.12	2.09	2.64	2.58	1.56	29.06
1954	1.64	.00	3.07	.22	.78	3.22	2.79	1.76	2.29	2.64	2.58	3.57	24.57
1955	3.97	3.55	1.85	6.65	1.44	.42	3.21	2.20	2.29	2.64	2.58	2.43	33.21
1956	4.22	1.59	.00	1.96	4.76	.25	1.57	2.38	2.11	1.24	.89	.00	20.96
1957	.04	3.54	4.00	2.73	1.97	3.57	.13	2.34	2.29	2.64	2.58	2.23	28.06
1958	3.49	1.08	2.41	4.17	2.56	4.58	1.90	.01	2.29	2.39	2.58	3.61	31.06
1959	1.32	2.16	3.37	5.20	1.51	.22	.55	2.26	2.29	2.51	2.13	3.16	26.68
1960	3.03	2.29	1.72	5.98	3.62	1.81	1.29	1.66	2.16	2.64	2.40	2.13	30.72
1961	4.35	2.60	3.38	.67	2.91	2.92	1.48	1.89	2.29	2.64	2.09	3.13	30.37
1962	4.59	.80	2.08	.30	4.90	1.72	2.33	2.25	1.20	1.73	2.58	3.68	28.16
1963	2.27	1.81	5.65	1.94	4.81	1.37	1.70	2.38	1.29	2.56	2.13	1.41	29.32
1964	.30	2.75	3.65	4.49	3.68	4.75	2.49	2.19	.15	2.15	.56	1.58	28.72
1965	4.19	2.97	3.63	.09	3.12	5.03	3.01	1.73	1.78	2.64	2.05	3.43	33.66
1966	3.76	1.95	1.13	.00	1.37	.56	.04	1.40	2.29	2.40	2.51	3.55	20.95
1967	3.97	3.88	4.14	5.25	4.45	3.19	3.11	2.32	2.29	2.47	1.69	3.49	40.23
1968	4.22	3.90	3.80	4.55	4.25	.86	2.17	.77	2.19	2.57	2.54	3.24	35.08
1969	.85	3.95	2.55	3.75	2.45	4.58	3.35	1.80	1.84	2.56	.15	1.18	29.00
1970	2.80	3.51	4.80	.79	3.57	3.60	2.61	1.22	2.28	1.55	1.79	3.43	31.94
1971	2.38	3.13	2.03	2.75	2.97	.24	2.78	1.49	2.19	2.59	2.08	3.67	28.30
1972	2.89	1.76	4.89	4.62	1.88	3.27	.59	2.33	2.29	2.60	.07	1.75	28.93
1973	4.41	.97	1.80	2.07	.11	.63	1.41	1.90	1.72	2.47	2.10	3.57	23.16
1974	4.16	1.46	.84	2.43	.37	2.12	2.06	2.26	2.27	2.64	2.47	.06	23.15
1975	4.31	.64	.63	.55	1.18	.00	1.64	.75	2.29	2.64	2.40	2.17	19.19
1976	1.62	2.14	3.18	2.06	5.06	2.29	2.01	2.36	2.27	2.64	2.49	1.02	29.15
1977	.90	1.99	3.02	.02	3.19	.81	2.04	2.30	2.29	2.64	1.61	1.59	22.39
1978	.65	3.30	.04	5.51	.00	2.89	2.52	1.60	2.26	1.69	.10	2.86	23.42
1979	3.40	2.90	3.11	3.46	1.31	2.93	2.51	2.01	2.28	2.64	2.37	.46	29.40
1980	3.84	.30	.02	1.04	.00	4.41	2.95	2.23	1.16	2.64	1.07	2.21	21.87
1981	4.02	2.16	3.82	2.10	5.09	2.39	3.39	2.30	2.21	2.32	2.42	2.71	34.94
1982	1.18	4.18	2.94	1.97	5.02	3.01	2.91	1.69	2.03	2.13	2.13	3.59	32.79
1983	1.66	1.19	2.34	3.81	5.08	1.34	1.76	2.36	1.98	2.44	.71	3.26	27.92
1984	2.71	4.62	4.90	.89	.07	4.68	3.72	2.21	2.10	2.63	2.58	3.23	34.35
1985	.04	1.08	2.35	2.29	3.58	1.81	1.85	2.38	1.36	2.64	1.57	3.51	24.46
1986	.11	2.38	.03	3.87	.00	.00	3.29	2.38	1.63	2.59	.04	.00	16.33
1987	3.48	2.40	2.70	3.77	.61	.58	2.63	2.28	.90	1.33	2.57	2.90	26.16
1988	2.17	2.17	.61	3.98	.00	3.24	3.00	1.70	1.82	2.62	2.54	3.67	27.52
1989	3.04	.00	1.51	5.54	3.43	2.54	1.55	2.20	2.27	2.63	.93	3.36	29.00
1990	3.52	5.01	1.14	.38	1.55	2.92	3.69	2.32	1.74	2.64	2.58	3.03	30.52
1991	.00	2.45	.96	5.23	.13	3.00	3.22	2.38	2.29	2.64	1.84	3.66	27.80
1992	4.02	3.31	2.90	4.97	2.37	1.37	2.23	2.30	2.29	2.64	2.53	2.88	33.81
1993	.03	2.26	.83	2.43	.62	1.66	2.26	2.25	2.29	2.26	2.02	3.65	22.55
1994	3.57	4.97	3.44	3.76	3.01	1.27	2.95	1.92	2.26	2.64	2.58	2.65	35.02

First and second phase irrigation water use for 2030 – LOCHS.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.07	2.36	2.38	1.49	.63	.03	1.48	.72	1.16	.99	1.64	.65	14.61
1921	2.04	.00	.81	1.46	1.22	2.04	1.91	1.26	.40	1.18	.62	1.82	14.76
1922	1.26	1.13	1.49	1.16	1.51	2.10	1.45	1.58	1.11	.40	1.57	1.99	16.74
1923	2.37	2.08	2.65	.98	1.19	1.05	1.73	1.18	1.16	1.11	1.21	.91	17.63
1924	1.45	.51	.69	.63	.66	.00	.00	1.31	1.11	.94	1.64	.86	9.80
1925	1.39	2.63	3.07	.99	1.78	1.46	1.66	1.35	.50	1.21	1.64	.15	17.85
1926	.92	1.90	.96	1.16	1.54	1.08	1.89	1.58	1.15	1.12	.86	2.06	16.22
1927	.88	2.99	.63	.95	2.53	1.08	1.96	1.33	1.16	1.20	1.29	.86	16.87
1928	1.72	2.75	1.61	.72	1.37	.67	1.61	1.36	.38	.01	1.43	.09	13.71
1929	1.80	1.54	2.59	.90	1.49	.15	1.13	1.59	1.01	1.09	1.39	1.48	16.17
1930	1.93	2.47	2.37	1.30	2.25	1.74	1.11	1.57	1.15	.74	1.64	2.16	20.42
1931	1.65	2.99	1.94	1.33	.35	1.37	1.56	.61	1.06	1.21	1.64	1.49	17.19
1932	2.39	.68	1.19	2.68	.34	.52	1.40	1.59	1.10	.51	1.63	2.09	16.11
1933	1.98	.00	1.58	.00	1.66	1.40	1.04	.74	1.16	.67	.75	1.82	12.81
1934	1.45	.27	.74	2.85	.57	1.23	1.11	1.30	.90	1.20	1.52	2.01	15.16
1935	2.56	2.52	2.07	.04	.00	1.60	1.95	.03	1.16	1.21	1.60	1.66	16.41
1936	1.86	.89	2.08	2.26	.82	1.95	1.89	1.59	1.07	1.21	1.63	1.89	19.14
1937	2.38	1.91	1.26	1.47	1.31	2.06	.21	1.55	.65	.25	1.31	1.78	16.13
1938	1.19	2.55	1.64	2.05	.00	1.37	1.39	.83	1.16	.83	1.18	1.18	15.38
1939	1.26	.79	1.32	2.05	1.14	1.07	1.71	.00	.23	1.18	1.61	1.12	13.49
1940	2.47	1.76	.65	1.61	.00	.00	.85	1.59	1.16	1.09	1.64	2.01	14.82
1941	1.60	2.81	2.14	.62	.60	.46	1.21	1.15	1.09	1.02	1.12	1.58	15.38
1942	1.92	.45	1.05	.00	1.66	1.00	.00	.45	1.06	.00	.00	2.06	9.63
1943	.00	1.22	2.00	2.03	.31	2.01	1.88	1.33	.60	1.21	1.62	.33	14.54
1944	2.18	2.09	2.95	2.27	1.31	.10	1.64	1.18	1.09	1.21	1.63	2.14	19.80
1945	2.60	2.89	2.37	1.26	1.32	1.18	1.61	1.47	1.16	1.20	1.61	2.06	20.74
1946	1.23	1.56	2.23	2.04	.01	.81	1.42	1.58	.09	1.14	1.64	1.35	15.09
1947	1.30	.82	.82	.98	1.13	.89	.98	1.46	1.16	1.21	1.60	1.86	14.21
1948	2.14	2.14	1.51	.95	.83	.08	1.23	1.28	1.14	1.18	1.63	1.41	15.53
1949	2.05	1.45	1.24	2.54	2.00	.73	1.34	1.14	1.09	.87	.89	1.91	17.25
1950	2.16	2.58	1.04	1.04	1.53	.97	1.26	1.47	1.08	1.19	.22	1.19	15.72
1951	1.97	3.19	.96	.00	1.40	.99	1.79	1.40	1.16	.58	1.35	1.82	16.61
1952	1.28	1.94	.26	2.56	.26	1.90	1.33	1.54	1.13	1.14	.74	2.01	16.09
1953	1.85	1.17	1.65	2.29	.92	1.57	1.11	.70	1.10	1.21	1.62	.78	15.97
1954	1.21	1.03	1.34	.00	1.06	.37	1.27	1.19	1.14	1.21	1.64	1.95	13.40
1955	2.27	2.72	.86	2.88	.54	.00	1.84	1.50	1.16	1.15	1.53	1.42	17.88
1956	2.33	1.67	.00	.22	1.07	.55	1.07	1.33	1.11	.53	.65	.00	10.53
1957	.16	2.65	1.84	1.03	1.06	1.77	.64	1.50	1.15	1.16	1.64	1.70	16.29
1958	1.93	1.71	2.25	1.66	.37	2.10	.99	.00	1.15	.87	1.46	2.02	16.53
1959	.89	1.54	1.61	2.13	.94	.56	.92	1.50	1.16	1.12	1.33	1.54	15.23
1960	1.68	1.16	.27	2.49	1.25	.82	1.09	1.37	1.09	1.21	1.31	1.36	15.09
1961	2.46	2.06	1.74	.00	.71	.59	.46	1.42	1.16	1.21	1.23	1.97	15.01
1962	1.98	.80	1.56	1.30	2.03	.45	1.38	1.48	.84	.66	1.64	2.06	16.18
1963	1.40	1.02	2.31	.76	1.98	1.09	1.39	1.49	.64	1.14	1.59	.51	15.32
1964	.47	1.74	2.21	2.31	2.08	2.26	1.44	1.22	.10	.68	.51	1.39	16.41
1965	2.24	2.18	1.64	.01	1.70	2.53	1.25	1.09	1.03	1.21	1.14	1.84	17.86
1966	2.02	1.08	1.72	.00	.00	.41	.30	1.30	1.15	.98	1.59	2.06	12.61
1967	2.01	1.28	1.69	1.83	2.18	1.55	1.60	1.52	1.16	1.15	1.26	1.93	19.16
1968	2.34	2.26	1.44	2.26	1.19	.10	1.31	.57	1.11	1.16	1.56	1.39	16.72
1969	1.12	2.83	1.40	1.48	.36	2.35	2.01	1.38	.94	1.20	.24	.71	16.03
1970	1.67	2.28	2.20	.86	1.99	2.12	1.38	.70	1.14	.59	.96	2.06	17.96
1971	1.63	1.92	1.98	1.10	1.56	.00	1.56	.98	1.13	1.08	1.44	2.05	16.42
1972	1.67	.92	2.83	1.51	.76	.96	.79	1.49	1.16	1.07	.18	.95	14.29
1973	2.62	1.41	1.43	.00	1.51	1.18	.62	1.49	.66	.97	1.36	2.13	15.38
1974	2.39	1.53	.67	.15	.19	1.67	1.14	1.29	1.16	1.21	1.55	.00	12.94
1975	2.49	.70	.33	.54	.27	.00	1.55	.90	1.16	1.11	1.63	1.53	12.22
1976	1.23	2.07	1.95	.46	2.44	1.09	1.00	1.54	1.13	1.18	1.55	1.23	16.88
1977	.40	2.11	1.45	.80	2.02	.86	.63	1.58	1.14	1.21	1.21	.88	14.31
1978	1.22	2.18	.19	1.16	1.49	1.45	1.46	.84	1.16	.75	.59	1.79	14.28
1979	2.18	2.65	1.87	1.58	1.97	1.91	1.65	1.47	1.16	1.21	1.54	.97	20.16
1980	2.49	1.54	.00	.00	.70	2.01	1.69	1.53	.68	1.21	.71	1.70	14.26
1981	2.41	.99	2.66	1.14	2.21	1.13	1.71	1.54	1.04	1.13	1.57	1.65	19.17
1982	.88	2.85	2.20	1.70	2.48	1.39	1.27	1.12	1.10	.71	1.37	1.96	19.02
1983	1.64	.93	1.54	1.96	2.40	1.08	.72	1.57	.82	1.06	.65	1.96	16.34
1984	1.52	2.38	1.86	.71	.69	1.60	2.09	1.49	1.04	1.21	1.64	1.91	18.14
1985	.80	1.06	1.63	1.59	1.29	1.73	1.60	1.59	.70	1.21	.97	1.99	16.16
1986	1.13	1.95	1.81	1.50	.75	.39	1.97	1.56	.97	1.18	.22	.00	13.42
1987	1.82	2.31	2.14	.84	.00	.76	1.51	1.19	.30	.85	1.47	1.74	14.94
1988	2.23	2.37	1.01	1.66	.52	2.00	1.80	1.44	1.01	1.15	1.63	2.14	18.97
1989	1.94	.78	1.75	2.22	2.15	1.49	1.13	1.55	1.05	1.21	.90	2.10	18.28
1990	2.00	3.07	.38	.00	1.61	2.24	1.99	1.54	.87	1.21	1.64	1.79	18.33
1991	.00	2.10	.00	2.05	.88	1.24	1.19	1.59	1.16	1.19	1.43	2.09	14.93
1992	2.14	2.16	.59	1.42	.52	1.23	1.64	1.37	1.16	1.21	1.64	1.50	16.56
1993	.00	2.09	1.34	1.39	.93	.71	1.37	1.36	1.16	1.01	1.26	2.16	14.77
1994	1.94	3.21	1.26	1.38	2.33	.94	1.74	1.42	1.10	1.15	1.61	2.00	20.09

First and second phase irrigation water use for 2030 – MAND.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.25	.91	.47	2.79	2.56	2.99	1.23	.77	.79	.92	1.24	1.18	16.09
1921	2.12	.00	.00	3.47	3.44	2.05	1.42	.62	.46	.89	.65	2.01	17.14
1922	2.51	.00	1.19	.00	3.74	3.10	1.32	1.04	.79	.77	1.29	2.34	18.08
1923	2.53	1.06	.28	1.97	3.28	3.48	1.24	.98	.68	1.02	1.21	1.04	18.76
1924	1.55	.00	.00	1.65	3.23	.00	.85	.87	.74	.88	1.29	1.51	12.58
1925	.99	1.59	1.16	2.68	3.29	.00	1.83	.42	.34	1.02	1.34	1.05	15.72
1926	1.03	.63	.00	2.41	3.12	.00	1.51	.98	.79	.71	.83	2.02	14.03
1927	1.40	1.52	.00	.48	3.13	2.60	1.00	.96	.78	1.00	.93	1.17	14.98
1928	1.83	1.71	1.32	1.78	3.38	.00	1.57	.97	.00	.63	1.17	.84	15.20
1929	1.10	.59	1.64	.49	4.47	3.09	1.31	1.00	.79	.94	.80	1.18	17.41
1930	1.80	.62	.00	2.14	3.27	3.18	1.18	.99	.75	.86	1.27	1.84	17.90
1931	2.00	.78	.00	1.95	.00	.51	.95	.12	.58	.96	1.29	1.71	10.84
1932	1.90	.72	.00	2.13	3.49	2.89	1.32	1.03	.74	.66	1.29	2.09	18.26
1933	2.01	.00	.00	.00	3.42	1.41	.61	.56	.63	.73	.71	2.07	12.15
1934	2.09	.34	.00	1.84	3.14	2.61	.89	.48	.00	.96	1.19	2.14	15.68
1935	1.93	1.31	.74	.76	1.11	1.28	1.24	.08	.69	.89	1.33	1.33	12.68
1936	1.61	.00	1.71	2.29	2.43	3.16	1.47	1.03	.60	.89	1.17	1.81	18.19
1937	1.86	1.17	.00	.39	2.54	3.83	.00	.97	.47	.26	1.14	1.93	14.56
1938	1.16	.86	.00	1.63	2.03	1.89	1.13	.56	.74	.52	1.10	.93	12.54
1939	1.83	.00	.00	2.38	3.79	3.04	1.06	.00	.00	1.01	1.29	1.26	15.67
1940	2.20	.00	.00	2.93	3.60	3.13	.14	1.02	.70	.95	1.14	1.54	17.36
1941	2.07	.90	1.14	1.62	3.34	1.60	1.11	.80	.59	.93	.79	1.04	15.92
1942	1.53	.00	.00	2.37	3.19	2.64	.00	.83	.55	.04	.21	2.08	13.44
1943	.12	.00	.00	3.55	2.36	1.35	1.46	.96	.00	.92	1.19	.10	11.99
1944	1.63	.86	.88	2.34	3.20	.00	1.63	.76	.75	1.00	1.27	2.10	16.42
1945	1.52	2.00	.54	.56	3.52	3.01	1.33	.90	.77	1.01	1.31	1.90	18.36
1946	1.40	.34	.00	1.12	2.75	1.30	.57	.91	.08	.92	1.20	1.73	12.33
1947	1.57	.00	.00	1.29	3.24	1.64	.78	.88	.77	1.01	1.22	1.99	14.40
1948	1.79	.81	.14	1.18	3.11	2.32	.00	.91	.59	.92	1.26	1.61	14.63
1949	1.12	.00	.00	1.70	3.43	1.52	1.20	.87	.71	1.01	.89	1.94	14.39
1950	1.78	1.63	.00	2.20	3.91	2.86	1.38	.94	.66	.98	.00	1.66	18.00
1951	1.13	2.03	.00	1.19	3.51	2.38	1.17	.68	.69	.67	1.23	2.16	16.83
1952	2.01	.00	.00	1.59	2.85	3.11	1.26	.95	.65	.99	.92	1.51	15.84
1953	1.91	.17	.00	1.06	3.11	2.55	.44	.38	.59	.93	1.19	.68	13.01
1954	.00	.44	1.29	.00	3.23	1.45	.50	.86	.61	1.01	1.28	1.55	12.21
1955	.98	.00	.00	4.07	1.21	2.30	1.41	.82	.60	.88	1.02	1.43	14.71
1956	1.83	.16	.00	1.52	2.95	2.17	.18	.89	.65	.75	1.12	.00	12.22
1957	.50	.93	.00	.52	2.90	3.44	.00	.95	.67	.98	1.24	1.25	13.39
1958	2.19	.15	.11	1.31	3.08	3.94	1.37	.02	.76	.99	.89	1.55	16.37
1959	.97	.87	.10	2.77	2.99	2.60	.00	.86	.69	.94	1.05	1.45	15.28
1960	1.64	.00	.00	1.01	3.52	2.86	.00	.94	.18	.92	1.21	1.21	13.49
1961	1.61	.47	.28	2.15	3.57	2.04	1.05	.89	.79	.99	.64	2.07	16.54
1962	1.40	.01	.00	1.36	3.62	1.36	.88	1.02	.01	.09	1.28	2.07	13.09
1963	1.71	.43	1.22	.00	3.85	3.89	.43	.97	.59	.88	1.13	1.49	16.61
1964	.85	1.32	.11	2.97	3.55	3.93	1.06	.71	.00	.69	.72	1.37	17.28
1965	1.48	.89	.06	.60	3.63	4.20	.64	.64	.60	.97	.98	1.61	16.30
1966	1.83	.80	.00	.00	2.85	.79	.29	.96	.65	.69	1.29	1.96	12.11
1967	1.32	.34	1.05	1.19	3.52	2.02	1.31	.98	.67	1.00	.53	1.36	15.30
1968	1.85	.95	.00	2.77	3.66	.04	.43	.50	.62	.84	1.26	1.14	14.06
1969	.65	.83	.00	2.85	3.47	3.60	1.18	.47	.52	.96	1.03	.82	16.36
1970	.44	.63	.61	1.37	3.28	2.24	.65	.00	.78	.48	.78	1.32	12.58
1971	1.37	.65	.00	1.96	1.70	1.88	1.21	.21	.38	.67	1.22	1.94	13.17
1972	1.77	.67	.06	1.33	2.31	2.32	.60	.98	.72	.90	.34	.00	11.99
1973	1.53	.50	.00	.00	2.19	2.97	.93	.69	.56	.84	1.24	2.17	13.61
1974	2.47	.26	.00	.00	2.18	3.19	.75	.82	.64	.93	1.15	.00	12.39
1975	2.03	.61	.00	.00	2.73	.00	.17	.60	.79	.89	1.02	1.58	10.43
1976	1.14	.64	.71	.38	1.85	2.03	1.21	.95	.70	1.00	.87	1.15	12.62
1977	.93	.89	.43	1.06	3.33	1.62	.18	1.00	.61	.91	.82	1.23	13.01
1978	.49	.79	.00	1.83	3.59	3.16	1.17	.78	.71	.67	.85	1.52	15.56
1979	1.72	1.29	.04	2.73	4.16	3.64	1.29	.91	.74	.98	1.04	.00	18.54
1980	2.16	.23	.75	.00	2.87	3.80	1.23	.30	.55	.83	.59	1.05	14.37
1981	2.01	.00	1.22	.70	3.63	1.17	.79	.85	.76	.94	1.30	1.65	15.01
1982	.38	1.39	1.08	2.32	4.03	3.34	1.41	.84	.72	.62	.73	2.19	19.04
1983	1.55	.00	.00	.00	1.54	2.10	.23	.77	.57	.14	.73	2.08	9.71
1984	1.34	.73	.61	.59	.95	3.51	1.71	1.00	.62	.96	1.27	1.92	15.19
1985	.00	.71	.00	1.79	3.66	1.98	.90	1.02	.47	.97	1.11	1.76	14.37
1986	1.09	.84	.00	.00	3.12	1.33	1.35	.62	.00	.89	.44	.00	9.69
1987	1.50	.16	.00	2.00	.93	1.16	1.55	.69	.41	.75	.80	1.58	11.55
1988	1.54	.22	.00	2.84	1.97	3.68	1.15	.76	.57	.98	1.21	1.76	16.68
1989	1.39	.00	.00	3.03	3.30	1.42	.46	.84	.69	1.01	.72	1.99	14.85
1990	1.17	.89	.00	.00	1.53	1.13	1.65	.78	.58	.85	1.22	1.24	11.03
1991	1.22	1.86	.59	3.12	3.33	3.68	.87	1.04	.76	.99	1.20	1.90	20.57
1992	2.04	.51	.68	3.03	3.19	2.74	1.28	.96	.77	1.02	1.05	1.28	18.54
1993	.00	1.25	.00	.90	4.05	1.65	1.64	1.02	.76	.62	.00	2.07	13.95
1994	1.93	1.24	.49	2.09	4.10	1.76	.46	.35	.03	.85	1.19	2.01	16.50

First and second phase irrigation water use for 2030 – MEARNS.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.43	.00	.00	.00	.00	.00	.64	.21	.57	.59	.97	.69	4.08
1921	.81	.00	.00	.00	.00	.00	.55	.46	.21	.71	.48	1.22	4.44
1922	.50	.00	.00	.00	.00	.00	.64	.67	.57	.65	.91	1.28	5.21
1923	1.31	.00	.00	.00	.00	.00	.70	.50	.59	.71	.79	.73	5.33
1924	.81	.00	.00	.00	.00	.00	.07	.57	.55	.57	.99	.37	3.94
1925	.63	.00	.00	.00	.00	.00	.66	.44	.30	.73	.97	.37	4.09
1926	.81	.00	.00	.00	.00	.00	.61	.64	.58	.64	.53	1.27	5.08
1927	.51	.14	.00	.00	.00	.00	.65	.49	.59	.71	.84	.94	4.86
1928	.71	.05	.00	.00	.00	.00	.32	.48	.07	.22	.94	.35	3.15
1929	.73	.00	.00	.00	.00	.00	.53	.63	.54	.68	.79	1.08	4.98
1930	1.02	.00	.00	.00	.00	.00	.35	.66	.58	.32	.98	1.34	5.26
1931	.94	.15	.00	.00	.00	.00	.72	.21	.54	.71	.99	.82	5.08
1932	1.15	.00	.00	.00	.00	.00	.55	.67	.52	.29	.98	1.33	5.50
1933	1.12	.00	.00	.00	.00	.00	.11	.19	.58	.28	.45	1.08	3.82
1934	.82	.00	.00	.00	.00	.00	.36	.46	.16	.72	.86	1.27	4.65
1935	1.28	.05	.00	.00	.00	.00	.76	.03	.55	.71	.98	1.13	5.50
1936	.82	.00	.00	.00	.00	.00	.78	.65	.44	.70	.97	1.23	5.61
1937	1.13	.00	.00	.00	.00	.07	.00	.65	.37	.23	.83	1.17	4.45
1938	.35	.00	.00	.00	.00	.00	.49	.30	.59	.55	.84	.76	3.88
1939	.77	.00	.00	.00	.00	.00	.42	.00	.08	.71	.94	.72	3.64
1940	.99	.00	.00	.00	.00	.00	.32	.68	.57	.61	.98	1.25	5.39
1941	.86	.00	.00	.00	.00	.00	.31	.48	.53	.56	.67	1.06	4.46
1942	.89	.00	.00	.00	.00	.00	.00	.03	.51	.02	.00	1.28	2.72
1943	.00	.00	.00	.00	.00	.00	.74	.58	.25	.73	.97	.15	3.42
1944	1.06	.00	.00	.00	.00	.00	.55	.54	.56	.73	.97	1.33	5.73
1945	1.28	.47	.00	.00	.00	.00	.62	.60	.58	.71	.98	1.29	6.54
1946	.89	.00	.00	.00	.00	.00	.41	.63	.11	.58	.97	1.02	4.61
1947	.83	.00	.00	.00	.00	.00	.21	.52	.59	.72	.97	1.16	5.01
1948	.99	.00	.00	.00	.00	.00	.43	.44	.57	.70	.94	.92	4.98
1949	1.17	.00	.00	.00	.00	.00	.10	.30	.57	.49	.45	1.22	4.31
1950	1.19	.00	.00	.00	.00	.00	.33	.64	.54	.73	.15	.89	4.47
1951	.86	.32	.00	.00	.00	.00	.47	.49	.51	.48	.69	1.19	5.02
1952	.81	.00	.00	.00	.00	.13	.46	.63	.54	.72	.49	1.13	4.90
1953	.86	.00	.00	.00	.00	.03	.41	.18	.53	.71	.97	.75	4.45
1954	.38	.00	.00	.00	.00	.00	.35	.48	.52	.72	.94	1.06	4.46
1955	1.07	.03	.00	.00	.00	.00	.61	.56	.57	.72	.86	1.01	5.43
1956	.99	.00	.00	.00	.00	.00	.29	.56	.52	.50	.51	.00	3.37
1957	.27	.00	.00	.00	.00	.14	.00	.58	.55	.71	.98	1.02	4.25
1958	1.09	.00	.00	.00	.00	.01	.28	.00	.57	.60	.81	1.21	4.58
1959	.83	.00	.00	.00	.00	.00	.00	.60	.58	.68	.83	.97	4.49
1960	.92	.00	.00	.00	.00	.00	.13	.64	.49	.64	.86	.89	4.56
1961	1.20	.00	.00	.00	.00	.00	.11	.54	.58	.73	.68	1.30	5.14
1962	1.12	.00	.00	.00	.00	.00	.53	.59	.41	.18	.97	1.31	5.11
1963	.47	.00	.00	.00	.00	.00	.25	.61	.21	.64	.93	.55	3.65
1964	.28	.00	.00	.00	.00	.43	.46	.48	.00	.51	.41	.87	3.46
1965	1.06	.00	.00	.00	.00	.49	.40	.30	.50	.72	.61	1.21	5.29
1966	1.00	.00	.00	.00	.00	.00	.02	.59	.54	.62	.95	1.32	5.02
1967	.87	.00	.00	.00	.00	.00	.49	.61	.57	.71	.65	1.12	5.03
1968	1.11	.00	.00	.00	.00	.00	.27	.20	.51	.59	.85	.97	4.49
1969	.40	.00	.00	.00	.00	.21	.67	.51	.46	.70	.10	.60	3.64
1970	.68	.00	.00	.00	.00	.00	.40	.18	.53	.37	.46	1.21	3.82
1971	.65	.00	.00	.00	.00	.00	.63	.30	.56	.65	.91	1.31	5.00
1972	.94	.00	.00	.00	.00	.00	.00	.59	.57	.64	.41	.65	3.79
1973	1.10	.00	.00	.00	.00	.00	.19	.51	.38	.56	.92	1.32	4.99
1974	1.14	.00	.00	.00	.00	.05	.34	.67	.59	.71	.96	.14	4.60
1975	1.20	.00	.00	.00	.00	.00	.50	.33	.59	.66	.87	.86	5.01
1976	.41	.02	.00	.00	.00	.00	.27	.65	.53	.72	.84	.68	4.12
1977	.74	.00	.00	.00	.00	.00	.00	.61	.52	.70	.81	.70	4.08
1978	.53	.00	.00	.00	.00	.00	.51	.12	.56	.43	.51	1.08	3.74
1979	1.06	.10	.00	.00	.00	.04	.57	.61	.59	.72	.91	.48	5.08
1980	1.16	.00	.00	.00	.00	.13	.47	.56	.43	.71	.41	1.04	4.91
1981	1.33	.00	.00	.00	.00	.00	.47	.61	.54	.70	.94	.95	5.53
1982	.72	.03	.00	.00	.00	.00	.46	.55	.55	.43	.77	1.20	4.72
1983	.81	.00	.00	.00	.00	.00	.38	.62	.44	.65	.73	1.22	4.85
1984	.73	.13	.00	.00	.00	.00	.82	.63	.47	.70	.97	1.19	5.64
1985	.14	.00	.00	.00	.00	.00	.33	.68	.43	.72	.59	1.21	4.10
1986	.56	.00	.00	.00	.00	.00	.53	.62	.39	.62	.23	.00	2.95
1987	.84	.00	.00	.00	.00	.00	.44	.40	.13	.65	.84	1.12	4.41
1988	.75	.00	.00	.00	.00	.10	.70	.55	.51	.71	.98	1.31	5.61
1989	.97	.00	.00	.00	.00	.00	.57	.63	.55	.72	.56	1.19	5.19
1990	.92	.12	.00	.00	.00	.00	.74	.58	.51	.71	.92	.98	5.47
1991	.14	.00	.00	.00	.00	.16	.61	.68	.59	.72	.89	1.22	5.01
1992	1.08	.03	.00	.00	.00	.00	.50	.57	.59	.73	.87	1.18	5.54
1993	.49	.00	.00	.00	.00	.00	.49	.62	.56	.56	.79	1.33	4.83
1994	.84	.41	.00	.00	.00	.00	.24	.57	.29	.71	.91	1.24	5.19

First and second phase irrigation water use for 2030 – MFUN.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.50	1.95	3.12	3.36	5.90	1.75	3.14	2.83	2.65	3.09	4.52	2.55	37.34
1921	4.26	.63	2.21	5.60	5.95	4.18	3.61	1.84	.45	3.26	1.63	4.78	38.40
1922	3.35	1.39	2.65	2.40	3.71	5.06	3.67	3.65	2.43	2.90	4.46	6.27	41.94
1923	7.06	4.02	4.27	4.30	4.73	5.62	4.28	2.37	2.77	3.45	3.98	3.48	50.33
1924	3.80	.00	.09	1.25	4.38	.00	1.60	3.20	2.73	1.80	4.72	2.85	26.42
1925	3.77	4.65	2.96	5.14	6.48	3.54	4.23	1.99	.73	3.43	4.30	1.08	42.30
1926	1.36	2.43	4.49	4.42	5.34	1.98	4.08	2.44	2.78	1.81	2.15	6.27	39.56
1927	4.68	5.56	2.52	.00	6.18	3.60	3.85	3.10	2.79	3.45	3.78	4.15	43.66
1928	5.10	5.65	5.89	4.79	4.90	2.55	3.21	3.39	.29	1.25	4.53	2.45	44.00
1929	4.53	2.80	4.57	1.88	5.44	2.95	2.49	3.56	2.49	3.28	3.16	4.24	41.40
1930	4.97	3.93	3.89	2.27	5.74	4.46	2.58	3.58	2.75	2.35	4.66	6.47	47.65
1931	5.10	5.28	4.28	4.53	.00	1.81	4.62	.13	2.25	3.35	4.70	3.88	39.93
1932	6.49	1.24	3.31	5.60	4.97	5.12	3.71	3.64	2.57	1.24	4.67	6.34	48.88
1933	5.76	1.04	.62	.00	5.75	3.14	1.09	1.46	2.72	1.99	1.93	5.92	31.41
1934	3.12	3.35	1.37	5.79	4.52	2.33	2.40	2.31	.24	3.44	4.42	6.29	39.58
1935	6.73	5.00	5.04	1.34	.93	3.27	3.76	.00	2.56	3.27	4.64	5.18	41.72
1936	4.76	.93	6.02	4.62	3.19	3.47	4.48	3.61	2.42	3.36	4.53	5.69	47.08
1937	6.19	4.10	1.39	2.93	2.21	4.81	.46	3.52	.60	.33	4.20	5.80	36.54
1938	3.89	4.18	1.05	3.27	1.02	4.98	4.10	1.04	2.79	2.15	3.66	3.40	35.51
1939	4.92	.47	1.80	4.24	5.53	5.35	3.53	.00	.10	3.44	4.58	1.96	35.93
1940	6.20	1.12	.00	5.00	3.97	2.58	.43	3.66	2.70	3.14	4.60	5.36	38.76
1941	5.47	4.95	4.44	2.15	1.77	1.39	3.42	2.76	2.12	3.07	2.70	4.50	38.76
1942	3.71	1.82	.00	2.78	3.52	4.69	.00	.11	2.17	.05	.00	6.05	24.91
1943	.00	.00	3.15	5.33	2.95	4.51	4.41	3.46	.86	3.42	4.51	1.06	33.65
1944	5.08	4.06	4.37	4.68	5.54	.01	3.93	2.26	2.64	3.46	4.59	6.29	46.92
1945	7.25	6.77	3.58	3.00	6.25	4.02	4.34	3.37	2.71	3.40	4.60	5.37	54.66
1946	1.90	3.09	4.51	3.15	3.05	2.83	2.37	3.15	.00	3.08	4.42	4.25	35.78
1947	5.03	.00	2.79	3.93	4.87	1.68	1.93	2.69	2.77	3.45	4.47	5.90	39.50
1948	4.11	2.84	2.17	1.80	2.53	3.57	1.10	3.12	2.59	2.78	4.60	5.17	36.38
1949	4.42	1.29	.98	5.06	5.60	3.45	2.42	2.80	2.74	3.00	2.73	6.25	40.73
1950	5.41	4.53	.77	3.97	5.66	3.97	3.30	3.28	2.28	3.47	.11	4.02	40.76
1951	3.96	6.84	2.16	.80	5.74	3.37	2.97	2.52	2.57	1.89	4.01	6.39	43.22
1952	5.25	2.32	2.71	3.54	1.90	4.39	3.38	3.01	1.96	3.45	.69	5.66	38.26
1953	5.68	1.13	3.99	3.47	4.42	4.06	2.24	.30	2.21	3.22	4.50	2.57	37.80
1954	.50	2.45	5.43	.00	3.31	2.64	1.73	2.94	2.57	3.47	4.64	5.35	35.03
1955	4.57	2.50	2.22	7.36	.28	3.87	4.06	2.74	2.58	3.30	4.04	4.09	41.60
1956	4.33	1.90	.00	1.61	5.16	3.61	1.29	3.52	2.47	1.41	2.94	.00	28.24
1957	.19	4.48	5.64	2.78	4.20	5.39	.00	3.47	2.74	3.40	4.60	4.96	41.84
1958	6.15	2.39	1.74	1.58	.00	5.65	2.51	.00	2.78	3.04	3.97	5.76	35.57
1959	2.90	4.03	3.99	3.06	3.88	3.42	.54	3.43	2.76	3.26	4.08	4.74	40.11
1960	4.40	2.84	.61	3.03	4.12	3.97	1.04	2.92	2.13	3.35	4.30	3.79	36.50
1961	6.04	2.61	4.76	3.40	5.44	2.81	2.34	3.13	2.78	3.44	2.34	6.38	45.45
1962	4.95	3.14	2.91	2.81	6.65	.00	2.77	3.44	1.82	.17	4.46	6.40	39.51
1963	3.73	1.59	6.41	.00	6.26	5.13	2.12	3.27	1.23	3.13	4.24	3.41	40.53
1964	3.30	4.43	3.77	6.14	5.78	7.21	3.29	2.27	.00	2.33	2.09	3.94	44.54
1965	4.83	2.48	3.55	.11	5.56	7.47	2.30	2.05	2.63	3.40	3.06	5.96	43.38
1966	5.71	2.23	3.95	.00	2.40	1.01	1.13	3.07	2.61	2.20	4.60	6.11	35.03
1967	4.74	2.50	5.35	2.99	5.36	2.76	3.26	3.42	2.78	3.44	2.63	5.23	44.47
1968	6.31	3.98	3.00	4.36	5.63	.00	2.30	1.71	2.37	2.65	4.13	5.10	41.54
1969	2.35	5.14	2.09	4.81	4.41	5.88	3.83	1.89	2.16	3.42	.96	2.41	39.35
1970	3.48	3.62	4.39	5.48	5.07	4.59	1.98	.28	2.70	1.51	1.52	6.15	40.77
1971	2.86	3.07	2.68	3.09	5.26	3.57	3.92	.83	2.23	2.84	4.46	6.51	41.33
1972	4.75	3.28	5.07	2.45	.00	3.68	1.62	3.45	2.71	3.35	.64	3.03	34.02
1973	6.19	3.79	4.80	.00	4.62	3.09	3.19	2.93	1.13	2.81	4.42	6.63	43.61
1974	7.50	1.71	1.21	1.99	4.25	6.22	1.40	2.84	2.71	3.45	4.34	.11	37.73
1975	7.04	2.11	3.54	.00	2.29	.00	2.96	1.74	2.79	3.34	4.24	5.04	35.08
1976	1.06	3.11	4.02	1.84	3.62	2.71	3.70	2.79	2.74	3.28	4.05	3.32	36.23
1977	1.71	1.94	4.51	.00	5.33	2.75	1.30	3.49	2.65	3.34	3.27	3.35	33.63
1978	.75	4.41	3.32	3.28	3.75	5.31	2.79	1.98	2.78	1.77	2.30	4.46	36.90
1979	6.20	4.89	4.69	4.91	7.00	6.41	3.29	3.17	2.78	3.43	4.27	3.25	54.29
1980	6.10	3.34	4.42	1.32	7.08	6.44	3.74	2.37	1.82	3.37	3.02	4.21	47.23
1981	7.11	.00	5.41	3.02	5.37	1.56	3.95	3.32	2.57	3.10	4.57	4.54	44.51
1982	1.03	3.95	4.78	4.34	7.66	4.14	2.06	2.77	2.73	2.15	3.46	6.04	45.13
1983	5.40	1.17	.45	.00	3.65	4.93	.47	3.14	2.00	1.78	2.46	5.32	30.76
1984	1.05	4.03	3.68	2.61	.00	5.13	5.16	3.40	2.63	3.32	4.58	6.25	41.84
1985	1.93	3.94	1.85	.00	5.99	.00	.96	3.66	1.34	3.44	3.94	5.61	32.65
1986	3.65	3.66	.00	.86	1.92	2.21	4.17	3.30	1.15	3.00	.21	.00	24.12
1987	4.63	2.43	2.67	4.03	3.77	2.52	3.97	3.02	.80	1.27	3.90	4.99	38.01
1988	3.98	2.66	.64	3.92	3.23	5.95	3.94	2.55	2.49	3.40	4.24	6.45	43.46
1989	4.56	.00	1.15	5.43	5.21	2.37	1.49	3.40	2.73	3.45	1.53	6.06	37.38
1990	4.51	3.84	1.92	1.63	5.12	5.27	4.77	2.46	2.40	3.21	4.27	3.33	42.73
1991	2.03	5.31	2.31	4.79	1.16	4.69	3.94	3.66	2.79	3.45	4.04	5.56	43.73
1992	4.12	4.96	4.15	6.37	5.24	4.03	3.60	3.32	2.79	3.46	3.34	4.24	49.62
1993	.53	4.71	3.98	4.18	6.52	2.84	4.36	2.52	2.68	2.44	1.61	6.50	42.87
1994	4.50	6.51	3.14	3.44	7.14	3.58	2.38	.81	.12	3.24	4.15	6.28	45.30

First and second phase irrigation water use for 2030 – MHL.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.56	.00	.00	2.73	5.21	1.58	1.72	1.05	.96	1.21	1.64	1.34	19.00
1921	2.33	.00	.00	4.29	4.33	3.14	1.75	.85	.50	1.09	1.02	2.38	21.68
1922	1.34	.00	.00	.00	4.55	4.47	1.77	1.32	.94	1.13	1.64	2.88	20.02
1923	3.01	.01	.00	3.88	3.56	3.89	1.33	1.08	1.00	1.29	1.49	1.88	22.43
1924	1.64	.00	.00	.00	4.24	.00	1.02	1.06	.97	.76	1.69	1.19	12.58
1925	1.64	1.50	.00	2.66	5.29	1.59	2.08	.77	.25	1.29	1.63	.57	19.27
1926	.00	.00	1.06	2.68	3.30	1.64	2.27	1.02	1.00	.76	1.24	2.54	17.52
1927	2.04	1.96	.00	.00	4.69	3.71	2.06	1.30	1.00	1.28	1.45	2.26	21.75
1928	2.36	1.98	1.96	1.87	4.64	1.57	1.69	1.11	.27	.84	1.64	1.37	21.30
1929	1.61	.00	.10	.00	4.35	3.75	.74	1.31	.95	1.25	1.32	1.58	16.96
1930	2.54	.54	.00	.17	4.65	4.32	1.29	1.32	1.00	1.18	1.70	2.87	21.57
1931	2.02	1.03	.41	3.07	.32	1.43	1.88	.21	.75	1.25	1.68	1.90	15.95
1932	3.01	.00	.00	4.01	4.26	4.40	1.84	1.32	.99	.80	1.69	2.80	25.12
1933	2.64	.00	.00	.00	4.81	2.35	.02	.79	.90	.91	.83	2.73	15.98
1934	1.28	.13	.00	3.09	4.03	2.94	1.31	1.00	.53	1.30	1.69	2.79	20.10
1935	2.80	1.26	1.27	.39	2.23	2.98	1.35	.29	.98	1.28	1.71	2.05	18.58
1936	2.04	.00	1.67	2.63	2.83	3.38	2.04	1.32	.91	1.28	1.65	2.54	22.28
1937	2.78	1.37	.00	.00	2.48	3.82	.00	1.30	.38	.32	1.61	2.61	16.68
1938	1.87	1.52	.00	1.28	1.15	2.27	1.88	.74	1.00	.91	1.32	1.30	15.24
1939	2.23	.00	.00	2.51	4.62	3.53	1.24	.00	.00	1.29	1.67	.93	18.01
1940	2.95	.00	.00	2.89	3.90	3.18	.00	1.31	.97	1.21	1.66	2.20	20.27
1941	2.26	1.75	.00	.94	3.03	2.15	1.50	1.12	.77	1.26	1.22	1.81	17.82
1942	1.45	.00	.00	1.22	3.60	3.76	.00	.76	.74	.04	.00	2.79	14.35
1943	.00	.00	.00	3.58	3.12	3.32	1.96	1.28	.23	1.22	1.64	.51	16.85
1944	1.68	1.40	.00	2.02	4.28	.46	1.84	.99	.98	1.29	1.67	2.74	19.35
1945	2.84	2.83	.00	.23	4.98	2.96	1.78	1.22	.99	1.29	1.70	2.47	23.27
1946	.70	.38	.00	1.06	3.57	2.92	1.20	1.11	.05	1.21	1.64	1.86	15.72
1947	2.27	.00	.00	2.39	3.57	1.29	1.05	1.15	.96	1.29	1.64	2.50	18.12
1948	1.82	1.13	.00	.02	2.93	2.23	.31	1.24	.92	1.06	1.65	2.38	15.68
1949	1.45	.00	.00	1.73	4.57	1.68	1.21	1.14	.96	1.25	1.26	2.63	17.90
1950	2.26	1.53	.00	2.48	4.75	3.40	1.77	1.21	.88	1.29	.00	2.06	21.64
1951	1.43	2.68	.00	.20	4.24	3.01	1.35	1.01	.88	.78	1.60	2.90	20.08
1952	2.23	.00	.00	1.28	1.99	3.62	1.41	1.26	.59	1.30	.94	2.19	16.81
1953	2.52	.00	.00	2.16	4.14	3.44	.96	.35	.81	1.24	1.56	1.13	18.32
1954	.00	.00	1.73	.00	3.66	1.88	.47	1.18	.91	1.30	1.69	2.54	15.36
1955	1.43	.00	.00	5.25	1.11	3.62	1.92	1.08	.90	1.26	1.46	1.87	19.90
1956	1.64	.00	.00	1.62	4.17	3.43	.24	1.24	.88	.71	1.36	.00	15.30
1957	.00	1.00	.49	1.36	3.46	4.06	.00	1.28	.97	1.29	1.67	2.22	17.80
1958	2.46	.00	.00	.00	2.44	4.49	1.35	.47	1.00	1.24	1.29	2.48	17.22
1959	1.29	1.20	.00	2.16	3.44	2.74	.05	1.25	.98	1.19	1.53	1.99	17.80
1960	1.87	.04	.00	.98	4.11	3.39	.28	1.11	.77	1.30	1.68	1.60	17.11
1961	2.42	.00	.00	1.82	4.73	2.00	1.06	1.16	1.00	1.25	.99	2.85	19.28
1962	1.66	.00	.00	1.34	5.21	.33	.92	1.27	.52	.00	1.65	2.80	15.71
1963	2.20	.00	2.12	.00	4.76	4.86	1.04	1.17	.68	1.20	1.55	1.76	21.35
1964	1.25	1.41	.00	3.75	4.45	5.16	1.21	.89	.05	1.04	1.08	1.84	22.13
1965	2.08	.49	.00	.00	4.23	5.29	.80	1.07	.95	1.28	1.35	2.46	20.00
1966	2.29	.00	.00	.00	2.43	1.11	.58	1.22	.93	.96	1.67	2.49	13.67
1967	1.81	.08	1.02	1.44	4.38	2.35	1.56	1.26	.98	1.29	1.19	2.08	19.44
1968	2.55	1.23	.00	2.42	4.69	.33	.49	.93	.88	1.09	1.63	2.01	18.27
1969	.95	1.60	.00	3.31	4.25	4.20	1.46	.76	.82	1.29	.97	1.14	20.74
1970	.98	.38	.52	2.40	4.42	3.55	.41	.00	1.00	.72	.86	2.51	17.77
1971	1.77	1.06	.00	1.45	3.60	2.59	1.61	.50	.75	1.05	1.59	2.75	18.73
1972	1.97	1.07	.61	1.12	1.35	2.70	.73	1.28	.97	1.24	.63	.80	14.48
1973	2.48	.72	.00	.00	4.10	2.90	1.33	1.01	.54	1.14	1.59	2.86	18.68
1974	3.17	.00	.00	.46	3.46	4.53	.50	.99	.96	1.29	1.50	.00	16.88
1975	2.86	.00	.00	.00	2.92	.85	1.05	.90	1.00	1.27	1.46	2.35	14.65
1976	.99	.69	.00	.00	2.93	2.46	1.78	1.11	.98	1.27	1.36	1.58	15.15
1977	.69	.36	.00	.00	4.01	3.03	.70	1.23	.99	1.25	1.17	1.69	15.14
1978	.24	1.25	.00	1.61	3.86	4.09	1.16	1.13	1.00	1.01	1.04	1.65	18.05
1979	2.57	1.82	.00	3.27	5.17	4.80	1.56	1.14	1.00	1.29	1.51	1.46	25.60
1980	2.45	.54	.52	.92	4.60	4.94	1.83	.90	.68	1.24	1.24	1.60	21.45
1981	2.37	.00	1.51	1.48	4.28	.91	.96	1.15	.99	1.21	1.67	2.39	18.92
1982	.03	1.15	.53	2.74	5.35	3.94	1.23	1.14	1.00	.94	1.33	2.91	22.28
1983	1.76	.00	.00	.00	3.32	2.60	.49	1.08	.73	.51	1.11	2.40	14.01
1984	1.58	.99	1.16	.98	1.60	4.21	2.28	1.26	.94	1.18	1.56	2.51	20.27
1985	.46	1.33	.00	2.30	4.36	2.57	1.10	1.26	.69	1.30	1.51	2.41	19.28
1986	1.48	1.02	.00	.00	4.27	1.97	1.75	1.13	.13	1.15	.87	.00	13.78
1987	1.93	.30	.00	2.19	2.97	2.45	1.70	1.22	.65	.73	1.31	1.91	17.35
1988	1.45	.00	.00	2.97	2.49	4.62	1.89	.99	.61	1.29	1.55	2.56	20.43
1989	2.24	.00	.00	3.40	4.08	2.55	.94	1.16	1.00	1.29	.86	2.56	20.08
1990	1.66	1.16	.00	.00	3.09	1.83	2.10	1.04	.80	1.18	1.64	1.52	16.03
1991	1.17	1.96	.00	3.05	3.89	4.25	1.56	1.32	.98	1.26	1.55	2.67	23.66
1992	2.57	1.03	.32	3.42	4.17	3.27	1.78	1.22	1.00	1.30	1.32	2.09	23.50
1993	.00	1.74	.00	2.01	5.06	2.20	1.96	1.20	.98	1.03	.87	2.71	19.77
1994	1.97	2.10	.00	2.05	5.41	2.93	1.26	.60	.05	1.20	1.55	2.78	21.90

First and second phase irrigation water use for 2030 – MNGWENYA.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.76	3.30	3.56	2.07	1.16	.00	2.11	1.20	1.66	1.44	2.35	.89	21.50
1921	3.00	.00	1.25	2.01	1.83	3.16	2.76	1.78	.67	1.69	.93	2.56	21.63
1922	1.89	1.65	2.12	1.93	2.53	3.24	2.12	2.28	1.58	.57	2.26	2.90	25.07
1923	3.40	3.25	3.89	1.52	1.71	1.68	2.56	1.73	1.66	1.59	1.75	1.34	26.09
1924	2.13	.75	1.26	1.04	1.03	.00	.00	1.89	1.61	1.37	2.35	1.30	14.72
1925	2.07	4.02	4.51	1.31	2.83	1.91	2.45	1.97	.75	1.74	2.35	.27	26.19
1926	1.36	2.84	1.71	1.71	2.34	1.61	2.85	2.27	1.66	1.61	1.23	2.98	24.18
1927	1.35	4.31	.98	1.67	3.75	1.70	2.87	1.98	1.66	1.74	1.82	1.02	24.84
1928	2.81	3.99	2.55	1.05	2.17	1.16	2.41	1.93	.70	.00	2.05	.00	20.81
1929	2.76	2.59	3.92	1.68	2.32	.28	1.45	2.28	1.51	1.57	1.98	2.00	24.32
1930	2.92	3.50	3.49	2.01	3.34	2.56	1.77	2.25	1.65	1.25	2.35	3.09	30.18
1931	2.33	4.44	2.78	2.23	.66	2.11	2.15	.84	1.51	1.73	2.35	2.25	25.37
1932	3.51	.98	1.78	3.94	.45	.51	1.97	2.28	1.57	.77	2.35	2.99	23.09
1933	2.82	.00	2.48	.00	2.38	2.17	1.61	1.11	1.66	1.09	1.20	2.64	19.15
1934	2.10	.43	1.38	4.09	1.05	1.90	1.43	1.91	1.34	1.74	2.22	2.93	22.53
1935	3.69	3.61	3.01	.06	.00	2.52	2.88	.06	1.66	1.74	2.28	2.36	23.87
1936	2.77	1.41	3.00	3.44	1.22	2.87	2.74	2.28	1.61	1.74	2.35	2.70	28.10
1937	3.43	2.69	2.02	2.31	1.80	3.11	.32	2.24	.90	.34	1.93	2.57	23.67
1938	2.03	3.78	2.66	3.00	.00	2.07	1.87	1.20	1.66	1.17	1.62	1.77	22.83
1939	1.79	1.07	2.07	3.18	1.62	1.58	2.51	.00	.36	1.71	2.32	1.66	19.86
1940	3.63	2.61	1.13	2.41	.00	.00	1.21	2.28	1.66	1.60	2.35	2.92	21.78
1941	2.37	4.08	3.23	1.07	1.05	.77	1.89	1.67	1.57	1.48	1.67	2.26	23.11
1942	2.90	.68	1.68	.00	2.43	1.39	.00	.71	1.52	.00	.00	3.03	14.34
1943	.00	2.02	2.97	3.07	.56	2.94	2.64	1.92	.89	1.74	2.33	.62	21.69
1944	3.20	3.12	4.28	3.38	1.93	.18	2.44	1.68	1.57	1.74	2.34	3.08	28.93
1945	3.79	4.17	3.42	2.00	2.14	1.81	2.38	2.12	1.66	1.74	2.30	2.94	30.45
1946	1.74	2.41	3.33	2.87	.00	1.31	2.05	2.27	.12	1.61	2.35	1.92	21.97
1947	1.95	1.19	1.24	1.65	1.71	1.48	1.47	2.13	1.66	1.73	2.29	2.66	21.17
1948	3.20	3.03	2.25	1.49	1.17	.03	1.80	1.84	1.65	1.69	2.34	2.11	22.60
1949	2.88	2.29	1.87	3.89	3.09	1.36	1.99	1.74	1.55	1.25	1.39	2.81	26.10
1950	3.06	3.82	1.80	1.49	2.24	1.60	1.77	2.11	1.54	1.69	.28	1.70	23.10
1951	2.93	4.63	1.32	.00	2.10	1.70	2.59	2.05	1.66	.84	1.97	2.67	24.46
1952	1.81	2.91	.41	3.98	.47	2.79	1.95	2.21	1.64	1.62	1.11	2.90	23.82
1953	2.81	1.66	2.61	3.35	1.68	2.38	1.56	1.03	1.58	1.74	2.32	1.09	23.80
1954	1.79	1.64	2.06	.00	1.93	.46	1.99	1.78	1.66	1.74	2.35	2.83	20.22
1955	3.30	3.94	1.39	4.22	.99	.00	2.69	2.15	1.66	1.64	2.23	2.03	26.23
1956	3.42	2.61	.00	.38	1.53	.89	1.66	1.93	1.61	.76	.98	.00	15.77
1957	.22	3.90	2.71	1.72	1.69	2.61	.95	2.19	1.66	1.65	2.35	2.46	24.11
1958	2.78	2.58	3.47	2.56	.69	3.15	1.49	.00	1.65	1.28	2.13	2.91	24.68
1959	1.16	2.32	2.53	3.23	1.61	.91	1.48	2.17	1.66	1.60	1.93	2.22	22.82
1960	2.45	1.64	.51	3.52	1.96	1.36	1.70	1.95	1.57	1.74	1.87	2.00	22.25
1961	3.55	3.07	2.61	.00	1.26	.98	.66	2.04	1.66	1.74	1.81	2.83	22.21
1962	2.85	1.23	2.38	1.98	2.95	.81	1.97	2.14	1.22	.92	2.35	2.95	23.75
1963	2.00	1.52	3.40	1.11	2.86	1.69	2.04	2.15	.95	1.63	2.27	.82	22.44
1964	.88	2.63	3.44	3.56	3.07	3.22	2.18	1.75	.19	.94	.78	2.02	24.66
1965	3.22	3.14	2.27	.02	2.46	3.68	1.76	1.63	1.50	1.74	1.69	2.68	25.79
1966	2.99	1.76	2.65	.00	.00	.76	.55	1.87	1.65	1.38	2.28	2.96	18.85
1967	2.98	1.89	2.44	2.67	3.31	2.36	2.36	2.19	1.66	1.64	1.83	2.81	28.13
1968	3.39	3.40	2.09	3.55	1.76	.19	2.01	.82	1.62	1.66	2.24	2.07	24.78
1969	1.70	4.16	2.15	2.17	.50	3.48	2.93	1.96	1.35	1.74	.44	1.10	23.67
1970	2.51	3.26	3.19	1.33	2.93	3.17	1.97	1.07	1.63	.88	1.42	2.98	26.32
1971	2.47	2.82	2.94	1.61	2.47	.00	2.29	1.42	1.62	1.57	2.07	2.95	24.22
1972	2.53	1.39	4.11	2.35	1.12	1.39	1.21	2.17	1.66	1.56	.25	1.51	21.25
1973	3.84	2.12	2.14	.00	2.57	2.14	.91	2.12	.95	1.43	1.92	3.05	23.20
1974	3.49	2.28	.89	.28	.34	2.45	1.63	1.78	1.65	1.73	2.23	.00	18.76
1975	3.68	.96	.61	1.00	.51	.00	2.30	1.39	1.66	1.56	2.35	2.23	18.25
1976	1.92	2.92	2.85	.65	3.58	1.73	1.62	2.21	1.62	1.69	2.27	1.86	24.92
1977	.45	3.08	2.17	1.48	3.08	1.29	.96	2.27	1.65	1.74	1.74	1.25	21.17
1978	1.89	3.32	.35	1.67	2.32	2.21	2.04	1.43	1.66	1.12	.95	2.61	21.58
1979	3.19	3.91	2.76	2.49	3.01	2.88	2.40	2.10	1.66	1.74	2.25	1.52	29.91
1980	3.62	2.32	.00	.00	1.30	2.96	2.50	2.21	.99	1.74	1.15	2.48	21.27
1981	3.46	1.30	4.03	1.72	3.16	1.94	2.57	2.20	1.49	1.62	2.26	2.80	28.55
1982	1.28	4.09	3.20	2.64	3.64	2.18	1.89	1.62	1.58	1.06	2.02	2.83	28.02
1983	2.50	1.40	2.39	3.10	3.62	1.82	.95	2.27	1.15	1.56	.90	2.81	24.47
1984	2.30	3.47	2.67	1.21	1.27	2.25	3.02	2.16	1.52	1.73	2.35	2.78	26.72
1985	1.36	1.68	2.31	2.53	1.89	2.56	2.37	2.27	1.00	1.74	1.50	2.87	24.08
1986	1.72	2.84	2.70	2.24	1.19	.55	2.87	2.22	1.39	1.68	.41	.00	19.82
1987	2.62	3.30	3.04	1.30	.00	1.37	2.21	1.78	.52	1.23	2.10	2.52	21.99
1988	3.26	3.58	1.62	2.51	.83	3.03	2.65	2.09	1.48	1.65	2.34	3.08	28.12
1989	2.87	1.13	2.48	3.37	3.28	2.31	1.62	2.23	1.51	1.74	1.44	3.07	27.04
1990	2.89	4.64	.71	.00	2.58	3.32	2.84	2.23	1.24	1.74	2.35	2.63	27.18
1991	.00	3.05	.00	2.87	1.40	1.67	1.65	2.28	1.66	1.70	2.06	3.02	21.36
1992	3.11	3.19	1.04	2.17	.90	1.86	2.38	1.97	1.66	1.74	2.35	2.19	24.55
1993	.00	3.09	2.06	2.12	1.47	1.14	2.01	1.96	1.66	1.46	1.83	3.10	21.89
1994	2.84	4.62	1.96	2.12	3.38	1.46	2.52	2.05	1.58	1.66	2.31	2.87	29.36

First and second phase irrigation water use for 2030 – MUNGU.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.59	.90	.89	1.02	.32	.19	.91	.58	.52	.53	.75	.04	7.25
1921	.98	.00	.35	.65	.52	.48	1.02	.44	.27	.48	.14	.74	6.06
1922	.44	.52	.68	.40	.62	1.06	1.03	.68	.42	.40	.72	1.05	8.02
1923	.98	1.11	1.12	.36	.48	.62	.73	.57	.52	.52	.64	.56	8.24
1924	.86	.43	.25	.11	.21	.00	.64	.58	.47	.46	.75	.54	5.29
1925	.55	.74	1.40	.10	.90	.59	.93	.52	.24	.53	.75	.08	7.33
1926	.61	.63	.93	.88	.10	.31	.98	.69	.52	.38	.47	1.00	7.49
1927	.59	1.08	.50	.56	.78	.38	.88	.53	.52	.53	.68	.69	7.71
1928	.81	1.23	.96	.67	.78	.17	.77	.62	.16	.28	.69	.14	7.28
1929	1.03	.26	.78	.24	.48	.65	.77	.68	.49	.47	.57	.73	7.15
1930	.93	1.21	.60	.08	.52	.65	.87	.68	.52	.41	.75	1.06	8.29
1931	.89	1.00	.93	.64	.00	.52	.98	.16	.42	.51	.75	.79	7.60
1932	1.16	.93	.78	1.26	.58	.48	.82	.68	.51	.29	.74	1.02	9.24
1933	1.16	.06	.49	.03	.69	.49	.85	.35	.41	.24	.31	1.03	6.12
1934	.70	.76	.20	.93	.61	.43	.49	.62	.45	.53	.75	.90	7.38
1935	1.15	1.24	1.13	.35	.03	.29	.99	.00	.52	.53	.75	.94	7.92
1936	.75	.10	1.24	.48	.13	.60	.94	.69	.50	.53	.75	.84	7.55
1937	1.14	1.13	.38	.61	.38	.80	.65	.68	.05	.21	.64	.81	7.49
1938	.20	.98	.24	.73	.04	.79	.93	.24	.51	.24	.66	.58	6.15
1939	.95	.00	.62	.70	.73	.69	.81	.00	.23	.53	.74	.58	6.59
1940	.93	.57	.39	.78	.41	.67	.15	.69	.52	.47	.75	.91	7.23
1941	.95	1.18	.53	.33	.24	.33	.73	.56	.45	.53	.51	.68	7.02
1942	.82	.03	.66	.01	.64	.64	.04	.07	.51	.00	.00	.99	4.42
1943	.01	.20	.63	.91	.02	.92	1.02	.68	.06	.53	.75	.06	5.79
1944	.95	1.09	1.01	1.02	.71	.03	.84	.61	.51	.53	.75	1.02	9.07
1945	1.24	1.33	1.44	.65	.93	.41	.96	.62	.52	.53	.75	.95	10.34
1946	.39	.17	1.11	1.15	.03	.56	.83	.67	.11	.52	.73	.78	7.03
1947	.83	.30	.80	.51	.89	.48	.74	.60	.52	.53	.75	.81	7.76
1948	.58	.86	1.01	.22	.39	.64	.46	.64	.48	.52	.75	.79	7.34
1949	.67	.94	.39	1.01	.64	.66	.61	.40	.50	.52	.54	1.01	7.89
1950	.83	.85	.58	1.09	.88	.60	.69	.59	.48	.45	.05	.84	7.95
1951	.88	1.42	.41	.15	.96	.56	.62	.47	.51	.15	.73	1.00	7.84
1952	.94	.60	1.15	.53	.00	.72	.55	.67	.48	.53	.22	.96	7.33
1953	1.10	.23	1.11	1.03	.01	.50	.81	.21	.47	.53	.75	.52	7.28
1954	.24	.01	1.08	.00	.22	.77	.80	.67	.51	.53	.75	1.00	6.58
1955	.65	.78	.97	1.28	.40	.41	1.05	.36	.52	.53	.73	.71	8.38
1956	.81	.28	.03	.26	.68	.52	.67	.68	.36	.00	.41	.00	4.70
1957	.18	1.14	1.20	.62	.44	.47	.05	.69	.52	.53	.75	.73	7.31
1958	.80	.54	.65	.99	.24	.93	.71	.19	.52	.42	.71	.92	7.62
1959	.51	.63	1.11	.61	.56	.58	.36	.66	.52	.53	.52	.81	7.39
1960	.75	.47	.39	1.28	.63	.21	.43	.40	.47	.53	.75	.68	6.99
1961	1.04	.64	1.08	.09	.36	.86	.59	.66	.52	.53	.50	.85	7.71
1962	1.12	.64	.51	.58	1.08	.11	.77	.62	.22	.00	.75	1.06	7.45
1963	.73	.73	1.23	.25	.87	.66	.66	.68	.22	.51	.68	.53	7.76
1964	.25	.78	.84	.33	.61	1.11	.79	.65	.04	.40	.57	.75	7.10
1965	.82	.87	1.15	.03	.83	1.18	.56	.50	.49	.53	.51	.89	8.36
1966	.97	.82	.71	.03	.49	.02	.43	.64	.52	.50	.75	.97	6.84
1967	.98	.61	.96	1.25	.97	.57	.94	.64	.52	.53	.38	1.01	9.35
1968	1.15	.82	.85	.79	.35	.00	.51	.51	.49	.41	.75	.96	7.57
1969	.36	1.22	.80	.64	.24	1.00	.79	.52	.45	.46	.15	.67	7.29
1970	.65	.81	1.34	.22	.88	.51	.59	.15	.51	.29	.44	.95	7.36
1971	.59	.96	.46	.12	.29	.14	.96	.50	.44	.52	.62	.99	6.59
1972	.82	.71	1.27	.77	.00	.89	.33	.67	.52	.53	.12	.52	7.16
1973	1.08	.16	1.09	.00	.38	.69	.45	.66	.31	.48	.65	1.05	7.00
1974	1.12	.46	.54	.46	.06	.77	.49	.60	.52	.53	.70	.00	6.27
1975	1.10	.49	.58	.08	.11	.04	.57	.34	.52	.53	.67	.85	5.87
1976	.31	.93	.72	.29	.92	.12	.65	.60	.52	.53	.72	.51	6.80
1977	.36	.91	.89	.00	.51	.42	.61	.68	.50	.53	.48	.47	6.37
1978	.11	.85	1.04	.73	.04	.95	.88	.55	.51	.09	.26	.42	6.44
1979	1.05	.90	.91	.48	.43	.58	.86	.65	.52	.53	.74	.36	8.02
1980	.83	.60	.46	.19	.16	1.00	.75	.63	.17	.52	.43	.55	6.30
1981	1.02	.80	1.23	.67	1.09	.35	.96	.66	.50	.45	.75	.65	9.13
1982	.07	1.04	1.17	.64	1.05	.64	.84	.46	.46	.42	.54	1.00	8.33
1983	.67	.18	.46	.03	.86	.29	.53	.68	.37	.43	.27	.85	5.62
1984	.47	1.11	.90	.05	.00	1.06	1.05	.67	.52	.52	.75	.86	7.95
1985	.06	.47	.59	.15	.30	.50	.67	.69	.26	.53	.68	.97	5.89
1986	.86	1.06	.44	.70	.21	.03	.85	.67	.47	.53	.22	.00	6.03
1987	.65	.62	.89	.49	.11	.49	.74	.68	.27	.14	.74	.70	6.52
1988	.47	.90	.38	.65	.01	.74	.88	.62	.40	.53	.73	1.05	7.37
1989	.85	.00	.65	1.00	.75	.71	.43	.65	.52	.53	.41	1.06	7.55
1990	.87	1.19	.37	.39	.06	.75	1.00	.58	.34	.51	.74	.82	7.63
1991	.22	.95	.30	.94	.29	.77	.58	.69	.52	.53	.61	1.01	7.41
1992	1.13	.83	1.03	.92	.35	.46	.83	.69	.52	.53	.61	.84	8.73
1993	.01	.63	.47	.51	.42	.27	.78	.68	.52	.45	.44	.99	6.18
1994	1.02	1.20	.86	.61	1.03	.53	.83	.43	.50	.53	.72	.98	9.25

First and second phase irrigation water use for 2030 – NON.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.18	.59	.53	1.11	.66	.18	.53	.26	.40	.55	.89	.29	6.17
1921	.67	.01	.06	.89	.74	.71	.61	.25	.09	.52	.35	.92	5.83
1922	.32	.21	.25	.69	.32	.99	.62	.36	.35	.39	.86	1.09	6.45
1923	.72	.61	.58	.62	.44	.80	.56	.29	.40	.55	.78	.72	7.05
1924	.34	.02	.00	.28	.59	.00	.16	.32	.37	.45	.89	.47	3.89
1925	.29	.52	.72	.23	.93	.65	.59	.27	.22	.55	.89	.21	6.07
1926	.21	.29	.25	.89	.35	.43	.62	.40	.40	.45	.66	1.09	6.03
1927	.27	.61	.18	.77	.86	.49	.56	.34	.40	.55	.82	.73	6.59
1928	.46	.66	.31	.65	.69	.15	.38	.34	.03	.21	.81	.19	4.90
1929	.62	.10	.36	.28	.61	.35	.39	.39	.37	.49	.73	.77	5.45
1930	.61	.64	.15	.21	.71	.70	.48	.39	.40	.43	.89	1.13	6.73
1931	.50	.68	.26	.77	.00	.49	.52	.10	.35	.54	.89	.83	5.92
1932	.82	.43	.35	1.42	.68	.58	.37	.39	.40	.29	.89	1.11	7.72
1933	.82	.06	.11	.03	.65	.54	.32	.19	.34	.32	.44	1.10	4.92
1934	.40	.24	.01	1.27	.64	.45	.23	.35	.33	.55	.87	1.04	6.38
1935	.85	.66	.75	.46	.15	.56	.58	.00	.40	.55	.89	1.03	6.88
1936	.52	.04	.47	.64	.34	.69	.52	.40	.39	.54	.89	1.01	6.46
1937	.77	.64	.09	.77	.48	.81	.22	.40	.03	.24	.78	.92	6.14
1938	.24	.57	.25	.89	.32	.75	.58	.16	.40	.33	.78	.81	6.09
1939	.60	.03	.34	1.02	1.00	.71	.47	.04	.08	.55	.88	.62	6.35
1940	.64	.41	.11	.88	.50	.41	.06	.40	.40	.49	.89	1.03	6.22
1941	.67	.69	.35	.57	.15	.12	.31	.36	.35	.54	.66	.88	5.64
1942	.50	.05	.09	.22	.54	.56	.00	.03	.39	.05	.00	1.06	3.49
1943	.00	.06	.10	.92	.18	.88	.68	.36	.08	.55	.89	.20	4.90
1944	.71	.48	.69	1.15	.79	.04	.55	.35	.39	.55	.89	1.10	7.69
1945	.93	.68	.72	.77	.75	.57	.55	.35	.40	.55	.89	1.06	8.21
1946	.08	.13	.61	1.31	.26	.29	.38	.39	.03	.55	.88	.79	5.70
1947	.49	.08	.18	.37	.86	.41	.24	.37	.40	.55	.89	.98	5.82
1948	.42	.44	.36	.39	.50	.39	.08	.36	.38	.53	.89	.89	5.62
1949	.54	.38	.26	1.36	.89	.62	.15	.26	.39	.53	.70	1.05	7.13
1950	.53	.36	.06	1.13	.78	.56	.29	.36	.34	.55	.16	.86	5.97
1951	.51	.78	.18	.03	.93	.34	.36	.29	.39	.22	.82	1.05	5.90
1952	.52	.38	.35	.82	.18	.72	.29	.38	.38	.55	.51	1.08	6.16
1953	.70	.30	.45	1.05	.14	.52	.35	.11	.37	.55	.89	.65	6.08
1954	.07	.02	.40	.08	.21	.80	.45	.35	.40	.55	.89	1.07	5.30
1955	.51	.47	.27	1.47	.28	.22	.63	.30	.40	.54	.88	.83	6.79
1956	.72	.18	.00	.23	.88	.49	.16	.40	.35	.08	.61	.00	4.10
1957	.02	.57	.69	.70	.66	.55	.00	.39	.40	.55	.89	.85	6.27
1958	.54	.28	.19	.94	.26	.99	.31	.04	.40	.45	.87	1.07	6.34
1959	.10	.38	.53	.85	.49	.48	.01	.39	.40	.54	.76	.98	5.92
1960	.37	.36	.10	1.27	.63	.33	.02	.28	.36	.54	.87	.77	5.90
1961	.77	.41	.47	.19	.31	.70	.20	.37	.40	.55	.69	.99	6.05
1962	.78	.28	.00	.59	.90	.04	.39	.36	.19	.15	.89	1.12	5.70
1963	.44	.26	.79	.53	1.05	.54	.22	.39	.16	.53	.81	.71	6.42
1964	.15	.43	.44	.59	.51	1.10	.42	.34	.01	.41	.59	.75	5.75
1965	.60	.42	.67	.10	.77	1.20	.30	.27	.35	.55	.67	1.00	6.91
1966	.64	.31	.21	.13	.64	.11	.06	.29	.40	.49	.88	1.10	5.23
1967	.67	.49	.44	1.14	.97	.73	.56	.38	.40	.54	.63	1.06	8.00
1968	.88	.53	.58	.82	.64	.01	.19	.19	.36	.49	.86	1.01	6.58
1969	.11	.74	.13	1.00	.52	1.05	.51	.32	.32	.51	.33	.64	6.17
1970	.45	.47	.69	.41	.91	.79	.33	.12	.39	.32	.68	1.01	6.58
1971	.27	.40	.12	.58	.69	.21	.50	.25	.37	.54	.76	1.12	5.82
1972	.51	.18	.73	.88	.28	.92	.04	.39	.40	.54	.21	.68	5.78
1973	.81	.22	.50	.54	.34	.22	.29	.38	.26	.49	.83	1.12	6.02
1974	.84	.31	.00	.40	.36	.87	.20	.38	.40	.55	.87	.15	5.34
1975	.86	.20	.26	.35	.26	.02	.27	.17	.40	.55	.86	.88	5.08
1976	.30	.41	.29	.46	.92	.42	.31	.38	.40	.54	.86	.63	5.91
1977	.15	.36	.49	.04	.95	.24	.22	.39	.40	.55	.68	.62	5.10
1978	.08	.44	.22	.98	.17	.81	.42	.28	.40	.30	.38	.78	5.27
1979	.63	.52	.42	.79	.75	.85	.40	.35	.40	.55	.87	.44	6.97
1980	.70	.25	.07	.29	.36	1.03	.42	.38	.23	.54	.58	.81	5.68
1981	.81	.40	.61	.54	1.12	.70	.61	.39	.35	.46	.89	.87	7.75
1982	.05	.58	.27	.58	1.21	.65	.46	.29	.37	.41	.74	1.08	6.70
1983	.47	.31	.01	.66	1.12	.47	.11	.40	.34	.49	.59	.98	5.92
1984	.30	.68	.69	.15	.20	1.04	.67	.35	.33	.55	.89	1.04	6.89
1985	.04	.45	.35	.36	.80	.34	.29	.40	.14	.55	.76	1.07	5.55
1986	.14	.51	.05	.54	.10	.11	.58	.40	.27	.55	.15	.00	3.40
1987	.57	.47	.21	.46	.37	.35	.31	.38	.14	.16	.88	.87	5.17
1988	.19	.59	.06	.99	.14	.85	.59	.29	.32	.54	.86	1.11	6.54
1989	.55	.02	.07	1.09	.81	.57	.16	.37	.40	.55	.51	1.13	6.23
1990	.61	.73	.03	.23	.40	.85	.63	.35	.25	.55	.89	.85	6.38
1991	.02	.48	.12	.87	.34	.74	.52	.40	.40	.55	.75	1.07	6.24
1992	.83	.40	.20	1.07	.43	.30	.43	.40	.40	.55	.85	.81	6.67
1993	.01	.36	.04	.45	.67	.18	.41	.35	.40	.48	.68	1.11	5.13
1994	.71	.65	.55	.16	.94	.30	.53	.35	.38	.55	.87	.87	6.85

First and second phase irrigation water use for 2030 – RORK.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.08	1.20	.13	3.12	.73	1.08	1.42	1.30	.90	1.20	1.99	.16	14.30
1921	2.45	.00	.00	1.95	2.32	2.19	1.92	.91	.33	1.06	.22	2.42	15.77
1922	.29	.35	.00	1.32	2.46	3.72	1.96	1.58	.64	.96	1.85	3.66	18.78
1923	2.47	2.16	1.18	.82	2.52	2.32	.56	1.30	.93	1.19	1.59	1.86	18.90
1924	1.91	.25	.03	1.99	1.24	.00	.14	1.39	.84	1.01	1.98	1.85	12.65
1925	2.19	1.54	1.27	3.31	3.56	2.40	1.77	1.26	.00	1.22	1.98	.71	21.22
1926	1.95	1.06	.95	2.55	.10	.84	1.87	1.55	.93	.31	1.74	3.52	17.37
1927	1.39	2.82	.00	2.45	3.76	2.31	1.67	1.54	.93	1.22	1.51	1.89	21.49
1928	2.25	2.55	.78	1.78	3.76	.00	1.40	1.57	.00	.58	1.92	.16	16.75
1929	2.23	.03	.95	1.45	3.31	3.12	.30	1.58	.91	.79	1.55	2.35	18.57
1930	2.60	2.84	.00	.00	2.35	3.37	1.35	1.60	.92	.91	1.99	3.68	21.61
1931	2.85	2.25	2.88	2.73	.00	.60	1.67	.20	.82	1.20	1.98	3.11	20.28
1932	3.26	1.82	.00	4.28	3.17	2.08	.99	1.59	.88	.23	1.93	3.55	23.79
1933	2.85	.00	.00	.04	2.88	1.64	1.20	.79	.92	.22	.74	3.46	14.74
1934	2.70	.23	.00	2.86	2.42	2.30	.18	1.34	.79	1.20	1.84	2.88	18.74
1935	3.25	2.58	.14	.00	.42	.10	1.82	.00	.93	1.20	1.98	3.21	15.62
1936	2.03	.00	2.43	.00	1.02	2.38	1.16	1.60	.89	1.21	1.98	2.77	17.46
1937	3.39	2.50	.00	1.43	1.65	2.63	.38	1.59	.00	.31	1.69	3.16	18.74
1938	.06	2.45	.00	1.61	.89	1.97	1.81	.55	.91	.46	1.76	2.44	14.93
1939	2.58	.00	.07	2.73	2.61	3.27	.11	.00	.00	1.19	1.92	1.91	16.41
1940	1.75	.73	.00	1.86	1.66	1.98	.00	1.60	.93	1.14	1.98	2.82	16.42
1941	2.77	1.90	.38	.00	1.11	1.93	1.82	1.22	.47	1.22	1.46	1.46	15.74
1942	1.71	.00	.00	.15	3.62	3.21	.00	.39	.81	.00	.00	3.28	13.17
1943	.00	.17	.00	1.99	.05	3.04	1.82	1.58	.00	1.22	1.98	.08	11.93
1944	1.84	2.85	1.29	3.39	2.91	.00	.65	1.48	.93	1.22	1.98	3.46	21.98
1945	3.82	3.02	2.89	1.58	3.88	1.23	1.58	1.57	.93	1.21	1.97	3.44	27.12
1946	.74	.36	1.25	3.75	.12	2.40	1.10	1.59	.06	1.16	1.86	2.83	17.21
1947	2.29	.00	.00	1.07	1.54	1.69	.99	1.35	.92	1.15	1.98	2.53	15.53
1948	.93	1.63	1.11	.05	1.81	1.58	.15	1.58	.88	1.17	1.98	2.55	15.41
1949	1.15	1.75	.00	3.04	3.14	2.51	.06	.61	.84	1.21	1.40	3.45	19.16
1950	2.21	1.41	.00	3.28	3.33	1.82	1.08	1.19	.91	1.07	.33	2.78	19.41
1951	2.08	3.18	.00	1.72	4.56	2.72	.50	1.35	.89	.36	1.95	3.47	22.77
1952	3.55	.47	.80	1.09	.00	2.69	.11	1.58	.78	1.22	.75	3.32	16.38
1953	3.54	.53	1.75	3.33	.03	2.04	1.15	.22	.78	1.21	1.97	1.54	18.10
1954	.78	.01	2.24	.00	.24	2.61	1.19	1.48	.91	1.22	1.93	3.49	16.09
1955	1.77	.99	1.10	3.81	.00	2.15	1.97	.30	.93	1.22	1.96	2.34	18.54
1956	1.62	.00	.00	1.16	2.52	1.12	.00	1.52	.53	.00	.98	.00	9.46
1957	.00	2.61	1.68	1.06	2.99	1.90	.00	1.58	.93	1.22	1.98	2.75	18.69
1958	1.91	1.01	.19	3.23	1.91	3.74	.91	.62	.93	.66	1.90	2.94	19.95
1959	1.65	.57	.61	2.99	1.91	2.68	.00	1.51	.93	1.21	1.59	2.27	17.92
1960	1.86	.30	.00	4.28	2.82	1.54	.00	.69	.72	1.22	1.98	2.25	17.67
1961	2.64	.69	1.79	1.04	2.16	3.01	.65	1.39	.93	1.22	1.52	2.91	19.93
1962	3.23	.65	.00	1.35	5.09	1.18	.91	1.31	.00	.00	1.98	3.67	19.38
1963	1.10	.05	2.39	.07	3.39	3.02	.56	1.53	.04	1.17	1.59	1.70	16.61
1964	.00	.92	.19	.26	2.64	4.40	1.08	1.54	.00	.85	1.36	2.64	15.87
1965	1.86	1.45	1.79	.04	2.66	4.54	.59	.99	.88	1.22	1.33	2.88	20.23
1966	2.84	1.46	.00	.23	1.29	2.24	.19	1.47	.92	1.16	1.97	3.36	17.15
1967	2.35	.70	.04	3.36	4.43	2.21	1.53	1.36	.93	1.19	.87	3.43	22.39
1968	3.77	1.15	.00	2.36	2.21	.05	.03	1.13	.80	1.01	1.97	3.03	17.49
1969	.45	2.40	.04	.52	1.31	3.58	.85	1.21	.79	.93	.06	1.95	14.10
1970	.53	1.36	1.96	.82	4.15	3.22	.00	.42	.93	.60	1.37	3.21	18.57
1971	.80	1.87	.00	2.03	1.30	.21	1.63	.82	.65	1.17	1.88	3.53	15.90
1972	1.80	.68	1.59	2.00	.84	3.06	.00	1.53	.92	1.21	.06	2.12	15.82
1973	3.66	.06	2.22	.03	1.90	3.17	.01	1.41	.31	.89	1.65	3.56	18.88
1974	3.49	.00	.00	1.10	.15	2.92	.00	1.38	.93	1.21	1.88	.03	13.08
1975	3.35	.63	.00	.77	1.49	1.38	.21	.33	.92	1.22	1.95	2.93	15.17
1976	.04	2.07	.00	.77	4.05	1.10	1.43	1.54	.93	1.22	1.92	1.19	16.26
1977	1.19	1.49	1.02	.03	1.21	2.79	.61	1.50	.89	1.21	1.13	1.94	15.00
1978	.21	1.05	1.25	1.66	1.65	3.82	1.04	1.34	.91	.41	.29	1.35	14.98
1979	3.50	2.06	.40	.14	2.71	3.41	1.36	1.55	.93	1.22	1.89	1.25	20.41
1980	2.92	1.22	.00	.24	2.04	3.66	.95	1.42	.16	1.21	1.05	1.55	16.43
1981	3.08	1.70	2.12	2.11	3.80	1.31	1.79	1.52	.91	1.06	1.98	2.31	23.71
1982	.05	2.64	.68	2.47	4.16	2.26	1.39	.94	.79	.89	1.24	3.54	21.05
1983	1.80	.00	.00	.00	2.90	.06	1.06	1.57	.60	.80	.58	2.74	12.10
1984	.79	2.03	2.09	1.08	.00	3.90	2.00	1.58	.93	1.01	1.97	2.62	19.99
1985	.16	.52	.49	.49	1.69	1.97	.77	1.60	.37	1.22	1.85	3.00	14.12
1986	2.48	2.11	.00	1.97	2.26	1.28	1.03	1.51	.67	1.21	.60	.00	15.12
1987	1.46	1.21	.94	.42	2.45	1.86	1.28	1.47	.41	.78	1.88	2.54	16.69
1988	.99	1.56	.00	2.56	.04	3.00	1.72	1.47	.56	1.22	1.94	3.63	18.70
1989	2.22	.00	.85	3.64	2.72	2.20	.00	1.49	.93	1.16	1.29	3.65	20.16
1990	2.52	2.73	.00	1.23	.00	2.61	1.72	.96	.16	1.14	1.94	2.77	17.79
1991	.27	1.82	.01	2.67	2.24	3.14	1.12	1.60	.93	1.21	1.57	3.52	20.09
1992	3.23	1.28	.12	3.56	.86	1.56	1.38	1.59	.93	1.22	1.43	3.13	20.30
1993	.00	1.09	.00	1.66	2.59	1.67	.84	1.56	.93	.94	1.57	3.08	15.91
1994	2.41	2.67	.11	2.11	4.16	1.46	1.36	1.19	.91	1.20	1.95	3.65	23.17

First and second phase irrigation water use for 2030 – THDRIEL.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.00	.07	.00	.15	.00	.00	.16	.13	.25	.34	.68	.24	2.02
1921	.30	.00	.00	.00	.20	.28	.31	.17	.03	.36	.32	.72	2.68
1922	.00	.00	.00	.00	.00	.12	.21	.20	.23	.17	.65	.68	2.26
1923	.36	.00	.00	.16	.00	.00	.08	.13	.26	.36	.60	.36	2.33
1924	.05	.00	.00	.11	.04	.00	.00	.12	.19	.30	.70	.48	1.98
1925	.21	.00	.00	.04	.17	.01	.20	.17	.10	.38	.69	.06	2.05
1926	.01	.00	.00	.00	.13	.00	.07	.20	.24	.27	.58	.72	2.21
1927	.00	.06	.00	.06	.18	.00	.20	.14	.26	.37	.63	.64	2.54
1928	.26	.00	.00	.08	.04	.00	.04	.12	.00	.09	.66	.00	1.28
1929	.24	.00	.00	.08	.19	.00	.18	.13	.13	.26	.52	.53	2.26
1930	.28	.10	.00	.00	.24	.00	.00	.21	.25	.12	.70	.74	2.65
1931	.27	.05	.00	.20	.00	.00	.18	.11	.21	.36	.68	.64	2.70
1932	.31	.00	.00	.19	.29	.19	.04	.20	.25	.18	.69	.73	3.08
1933	.34	.00	.00	.00	.14	.00	.00	.04	.26	.20	.34	.66	2.00
1934	.00	.00	.00	.31	.00	.00	.23	.19	.15	.36	.66	.65	2.54
1935	.41	.00	.00	.04	.10	.00	.20	.00	.24	.37	.70	.65	2.71
1936	.09	.00	.00	.00	.00	.14	.20	.21	.25	.37	.69	.66	2.62
1937	.26	.00	.00	.00	.24	.24	.00	.21	.10	.14	.50	.61	2.31
1938	.00	.00	.00	.00	.00	.00	.28	.08	.26	.15	.60	.54	1.92
1939	.00	.00	.00	.17	.15	.00	.13	.00	.03	.37	.67	.40	1.91
1940	.37	.00	.00	.00	.04	.19	.00	.21	.26	.34	.69	.66	2.76
1941	.16	.04	.00	.05	.08	.00	.00	.18	.18	.38	.45	.53	2.06
1942	.07	.00	.00	.00	.27	.00	.00	.02	.26	.00	.02	.72	1.36
1943	.00	.00	.00	.03	.00	.13	.27	.17	.00	.38	.69	.11	1.79
1944	.22	.00	.00	.19	.25	.00	.10	.20	.24	.38	.69	.74	3.01
1945	.41	.02	.00	.00	.05	.00	.17	.20	.26	.38	.69	.75	2.95
1946	.00	.00	.00	.28	.00	.00	.12	.20	.13	.37	.66	.56	2.33
1947	.00	.00	.00	.00	.17	.00	.00	.17	.26	.38	.69	.65	2.33
1948	.20	.00	.00	.06	.16	.00	.00	.17	.23	.38	.61	.55	2.36
1949	.26	.00	.00	.16	.14	.00	.14	.10	.23	.32	.48	.62	2.45
1950	.22	.00	.00	.28	.12	.09	.11	.20	.23	.37	.40	.50	2.51
1951	.18	.10	.00	.00	.01	.00	.14	.19	.25	.08	.63	.62	2.19
1952	.07	.00	.00	.10	.00	.21	.02	.20	.26	.38	.62	.71	2.57
1953	.22	.00	.00	.11	.00	.00	.20	.05	.22	.38	.69	.43	2.30
1954	.12	.00	.00	.00	.00	.00	.12	.15	.24	.38	.70	.71	2.40
1955	.31	.00	.00	.33	.00	.00	.25	.17	.26	.37	.69	.57	2.96
1956	.29	.00	.00	.00	.15	.00	.00	.19	.22	.16	.40	.00	1.41
1957	.00	.00	.00	.00	.15	.04	.00	.20	.26	.38	.70	.49	2.22
1958	.27	.00	.00	.13	.11	.20	.00	.00	.26	.29	.69	.74	2.68
1959	.00	.00	.00	.16	.03	.00	.00	.20	.26	.36	.62	.63	2.26
1960	.22	.00	.00	.23	.28	.00	.00	.14	.25	.38	.69	.51	2.70
1961	.39	.00	.00	.00	.12	.09	.00	.17	.26	.38	.62	.66	2.69
1962	.40	.00	.00	.00	.28	.00	.12	.21	.07	.26	.70	.75	2.77
1963	.04	.00	.02	.00	.31	.00	.06	.21	.09	.37	.62	.38	2.09
1964	.00	.00	.00	.16	.33	.39	.02	.18	.00	.32	.31	.48	2.19
1965	.32	.00	.00	.00	.18	.42	.20	.17	.22	.38	.61	.66	3.16
1966	.24	.00	.00	.00	.03	.00	.00	.18	.25	.35	.69	.72	2.46
1967	.27	.00	.00	.22	.31	.08	.17	.18	.25	.37	.52	.69	3.06
1968	.37	.00	.00	.22	.14	.00	.00	.10	.20	.35	.68	.59	2.65
1969	.00	.00	.00	.13	.14	.21	.20	.19	.21	.37	.36	.34	2.13
1970	.14	.00	.00	.00	.13	.04	.06	.10	.24	.18	.52	.72	2.12
1971	.06	.00	.00	.08	.08	.00	.14	.12	.24	.38	.61	.71	2.42
1972	.14	.00	.00	.22	.01	.06	.00	.20	.26	.35	.32	.38	1.94
1973	.34	.00	.00	.00	.00	.00	.00	.17	.11	.32	.63	.73	2.31
1974	.35	.00	.00	.00	.00	.00	.03	.20	.26	.38	.68	.03	1.94
1975	.31	.00	.00	.00	.00	.00	.00	.07	.26	.38	.67	.46	2.16
1976	.00	.00	.00	.07	.20	.00	.00	.21	.26	.38	.67	.36	2.14
1977	.00	.00	.00	.00	.04	.00	.00	.20	.25	.38	.52	.48	1.87
1978	.00	.00	.00	.20	.00	.00	.14	.12	.26	.24	.22	.63	1.81
1979	.15	.00	.00	.03	.00	.00	.15	.19	.26	.38	.63	.25	2.04
1980	.35	.00	.00	.00	.00	.33	.16	.18	.13	.38	.33	.56	2.42
1981	.36	.00	.00	.07	.28	.00	.00	.20	.25	.32	.69	.58	2.74
1982	.01	.00	.00	.10	.30	.21	.15	.16	.24	.10	.62	.68	2.59
1983	.00	.00	.00	.11	.19	.00	.00	.20	.20	.33	.42	.67	2.12
1984	.16	.04	.00	.00	.00	.33	.28	.21	.26	.38	.69	.66	3.00
1985	.00	.00	.00	.00	.22	.00	.00	.21	.19	.38	.48	.68	2.16
1986	.00	.00	.00	.18	.00	.00	.25	.21	.21	.37	.25	.00	1.47
1987	.23	.00	.00	.13	.00	.00	.12	.17	.05	.23	.64	.61	2.18
1988	.12	.00	.00	.05	.00	.00	.08	.15	.18	.37	.69	.75	2.39
1989	.21	.00	.00	.18	.20	.05	.02	.19	.24	.36	.51	.74	2.70
1990	.24	.09	.00	.00	.07	.00	.31	.21	.19	.38	.69	.64	2.81
1991	.00	.00	.00	.23	.00	.00	.17	.21	.26	.38	.58	.72	2.55
1992	.26	.00	.00	.15	.00	.00	.09	.20	.26	.38	.65	.63	2.62
1993	.00	.00	.00	.00	.00	.00	.02	.21	.26	.34	.61	.73	2.17
1994	.21	.11	.00	.05	.20	.00	.05	.18	.25	.37	.69	.56	2.69

First and second phase irrigation water use for 2030 – THLTUG.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.50	3.53	4.09	4.31	.00	1.66	3.54	1.91	2.89	3.34	3.75	1.39	31.90
1921	4.66	.00	1.56	1.29	2.90	2.72	4.11	2.38	1.47	3.41	1.13	4.87	30.52
1922	2.22	1.21	3.68	2.00	.77	3.05	3.74	2.95	2.74	2.29	3.50	4.70	32.85
1923	5.31	2.71	3.47	2.81	1.08	1.69	3.22	2.06	2.94	3.47	3.18	2.23	34.18
1924	2.50	.11	.44	2.91	1.58	.00	.96	2.19	2.59	3.04	3.82	2.09	22.24
1925	3.66	2.82	2.75	.73	2.85	2.15	3.73	2.39	1.83	3.53	3.79	.74	30.98
1926	2.55	1.28	2.05	2.41	1.65	.70	3.31	3.01	2.85	3.00	2.74	4.88	30.41
1927	2.11	3.82	1.54	3.11	2.73	1.46	3.70	2.35	2.94	3.45	3.39	3.55	34.13
1928	4.15	2.86	.34	2.08	1.94	.71	2.82	2.18	.61	1.32	3.48	.21	22.68
1929	3.78	.34	2.37	1.24	2.59	.00	3.05	2.64	2.56	3.18	3.15	3.05	27.96
1930	4.30	3.27	1.33	1.18	2.66	2.18	2.49	3.04	2.88	1.82	3.82	5.08	34.07
1931	4.09	3.72	2.15	2.87	.00	1.21	3.76	1.43	2.77	3.39	3.74	3.62	32.74
1932	4.41	2.23	2.13	4.79	2.68	2.30	2.45	2.99	2.88	1.74	3.81	4.99	37.40
1933	5.02	.00	.00	.37	2.51	.74	.02	1.20	2.91	2.69	1.16	4.59	21.22
1934	3.45	.00	.00	5.09	1.51	1.34	3.86	2.47	2.18	3.46	3.43	4.54	31.32
1935	5.70	2.02	3.39	3.03	1.14	1.83	3.78	.00	2.84	3.51	3.82	4.63	35.69
1936	3.43	.00	2.16	2.14	.05	2.70	3.13	3.08	2.79	3.46	3.80	4.55	31.30
1937	4.66	3.01	1.63	1.76	3.00	2.78	.27	3.07	1.62	1.87	2.59	4.38	30.63
1938	2.19	2.34	2.09	2.56	.00	.89	4.07	1.35	2.94	2.26	3.26	3.60	27.56
1939	3.05	.47	2.10	3.84	2.52	1.30	2.71	.50	.64	3.51	3.57	3.03	27.25
1940	4.89	2.49	2.61	1.90	2.05	1.95	1.70	3.08	2.94	3.42	3.79	4.39	35.21
1941	3.98	3.77	3.57	2.94	1.08	.56	1.42	2.84	2.64	3.42	2.48	3.35	32.04
1942	4.03	.00	.84	.80	3.50	1.01	.00	.12	2.89	.75	.12	4.87	18.92
1943	.00	.55	1.50	2.59	.85	1.62	4.27	2.43	1.19	3.55	3.80	.70	23.05
1944	4.23	1.94	4.44	3.77	2.64	.00	3.24	2.83	2.64	3.54	3.79	5.07	38.13
1945	5.69	3.46	3.76	2.97	1.04	1.32	2.99	2.88	2.94	3.53	3.76	5.14	39.47
1946	2.23	.84	3.38	4.36	.44	.51	2.84	2.99	1.63	3.52	3.65	3.96	30.33
1947	2.52	1.75	1.36	.15	2.50	.65	1.60	2.45	2.94	3.54	3.80	4.37	27.64
1948	3.96	2.83	1.90	2.68	1.58	1.10	1.95	2.81	2.87	3.54	3.11	3.98	32.29
1949	4.68	1.52	3.05	3.88	3.08	.00	2.94	1.24	2.82	3.22	2.39	3.55	32.37
1950	4.37	2.58	.00	4.10	2.74	2.00	2.71	2.86	2.69	3.52	1.49	3.73	32.79
1951	4.01	4.47	2.59	.12	2.05	1.31	3.01	2.78	2.81	1.75	3.22	4.12	32.23
1952	3.45	2.16	1.48	3.10	.00	3.26	2.22	2.99	2.89	3.55	2.91	4.82	32.83
1953	4.16	1.91	1.48	3.92	.00	2.43	3.35	1.24	2.75	3.55	3.81	2.81	31.40
1954	2.80	.06	2.47	.30	.62	2.30	2.87	2.00	2.73	3.52	3.82	4.86	28.36
1955	4.99	2.75	1.40	5.15	1.01	.37	3.59	2.81	2.94	3.51	3.68	3.79	35.99
1956	4.93	1.23	.00	1.68	3.42	.24	1.60	2.85	2.67	2.10	1.67	.00	22.39
1957	.73	2.86	3.14	1.79	1.63	2.71	.46	2.92	2.91	3.55	3.82	3.48	30.00
1958	4.47	.88	1.94	3.25	2.05	3.38	2.17	.05	2.90	2.98	3.68	5.04	32.80
1959	2.30	1.68	2.66	4.03	1.15	.00	.85	2.93	2.94	3.41	3.27	4.28	29.50
1960	4.08	1.82	1.48	4.55	2.95	1.34	1.33	2.36	2.81	3.52	3.67	3.39	33.29
1961	5.41	2.05	2.67	.71	2.29	2.21	1.56	2.41	2.94	3.54	3.16	4.55	33.52
1962	5.42	.65	1.77	.28	3.71	1.37	2.81	2.93	1.65	2.66	3.82	5.10	32.18
1963	2.60	1.33	4.41	1.43	3.71	.98	2.07	3.04	1.79	3.48	3.35	2.16	30.36
1964	.24	2.00	2.74	3.68	3.20	4.17	2.35	2.73	.20	3.02	1.12	2.96	28.41
1965	5.02	2.28	2.93	.22	2.44	4.36	3.46	2.35	2.46	3.55	3.14	4.56	36.77
1966	4.42	1.56	.89	.00	.95	.54	.07	2.18	2.88	3.30	3.73	4.89	25.43
1967	4.74	3.04	3.35	4.03	3.50	2.36	3.26	2.81	2.90	3.40	2.77	4.66	40.81
1968	5.24	2.91	2.81	3.74	3.13	.67	2.26	1.25	2.71	3.41	3.68	4.02	35.83
1969	1.50	3.03	1.94	2.99	1.91	3.40	3.64	2.59	2.52	3.47	.86	1.96	29.83
1970	3.49	2.71	3.81	.83	2.57	2.61	2.62	1.53	2.87	2.20	2.57	4.81	32.63
1971	3.08	2.46	1.82	2.32	2.18	.26	2.88	1.73	2.85	3.47	3.31	4.92	31.26
1972	3.64	1.55	3.88	3.72	1.40	2.39	.95	2.96	2.90	3.40	1.12	2.54	30.47
1973	5.18	.82	1.43	1.34	.18	.54	.98	2.69	1.95	3.20	3.32	5.01	26.65
1974	4.93	.97	.78	1.86	.34	1.40	2.27	2.95	2.93	3.54	3.68	.39	26.05
1975	5.01	.57	.48	.58	.85	.00	1.76	1.03	2.93	3.54	3.64	3.06	23.46
1976	1.81	1.73	2.56	1.88	3.68	1.71	1.92	3.02	2.91	3.54	3.57	2.14	30.47
1977	1.29	1.61	2.35	.07	2.14	.80	1.91	2.96	2.87	3.55	2.64	3.08	25.27
1978	.98	2.71	.00	4.22	.00	2.07	2.91	1.72	2.92	2.49	.83	4.19	25.03
1979	3.91	2.11	2.37	2.62	.93	2.10	2.60	2.68	2.94	3.54	3.38	1.44	30.63
1980	4.89	.55	.08	.75	.00	3.58	3.21	2.77	1.80	3.55	1.43	3.59	26.20
1981	5.03	1.48	2.89	1.88	3.81	1.80	2.73	2.96	2.77	3.17	3.68	3.71	35.91
1982	2.21	3.36	2.67	1.89	3.80	2.46	2.97	2.29	2.72	2.03	3.24	4.76	34.40
1983	1.92	.86	1.98	3.01	3.61	.86	2.16	2.99	2.50	3.23	1.68	4.65	29.45
1984	3.63	3.68	3.84	.88	.00	3.81	4.21	2.93	2.76	3.54	3.78	4.53	37.60
1985	.00	.78	1.76	1.81	2.80	1.51	1.75	3.07	2.09	3.55	2.19	4.74	26.03
1986	.67	1.78	.19	3.23	.00	.12	3.88	3.07	2.28	3.44	.63	.00	19.28
1987	4.10	1.70	2.32	3.06	.46	.40	2.70	2.56	1.20	2.15	3.59	4.13	28.38
1988	3.23	1.57	.65	2.98	.00	2.36	3.03	2.21	2.34	3.49	3.80	5.11	30.76
1989	3.93	.00	1.50	4.19	2.66	1.99	1.91	2.81	2.83	3.52	2.02	4.82	32.18
1990	4.25	4.18	.97	.38	1.31	2.10	4.31	3.00	2.32	3.54	3.76	4.26	34.38
1991	.10	1.93	1.03	4.12	.03	2.15	3.48	3.08	2.94	3.55	3.03	4.98	30.43
1992	4.57	2.64	2.33	3.79	1.58	1.09	2.65	2.95	2.94	3.54	3.63	4.29	36.00
1993	.69	1.83	.89	1.93	.48	1.37	2.71	3.00	2.90	3.13	3.09	5.02	27.04
1994	4.23	4.49	2.89	2.97	2.37	.95	2.91	2.55	2.88	3.52	3.81	3.80	37.37

First and second phase irrigation water use for 2030 – THSKOP.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	2.63	6.50	8.59	6.92	5.06	.96	5.23	3.70	3.90	3.89	3.93	3.71	55.02
1921	6.82	.00	3.38	7.05	6.65	3.66	6.01	3.24	3.16	3.84	.51	4.52	48.85
1922	.08	2.15	3.97	1.21	.00	7.39	6.27	2.25	2.22	2.74	3.74	3.61	35.63
1923	4.65	8.58	6.71	3.74	6.34	1.48	5.03	3.76	3.90	3.78	3.24	1.63	52.83
1924	2.70	1.62	1.69	4.22	1.79	.00	3.60	3.38	2.72	3.52	3.93	2.30	31.47
1925	3.56	4.13	7.74	.00	7.31	4.10	5.70	3.70	2.82	3.89	3.89	.63	47.47
1926	5.03	4.52	6.41	4.10	2.12	.14	4.87	4.24	3.90	2.39	2.89	5.21	45.82
1927	.00	8.50	3.97	5.48	6.64	.11	5.53	4.39	3.90	3.87	3.47	3.42	49.28
1928	5.42	8.09	4.84	4.72	.94	.00	1.55	3.19	1.35	1.75	3.59	.00	35.44
1929	3.78	1.36	.00	.66	6.70	5.30	2.50	3.37	3.82	3.26	3.31	3.93	37.99
1930	6.35	7.70	7.27	.00	6.01	4.38	3.71	4.39	3.90	2.33	3.93	5.23	55.21
1931	4.53	7.60	9.20	7.53	.21	1.63	5.20	1.55	3.17	3.22	3.91	4.46	52.20
1932	6.75	4.29	5.20	7.46	7.45	5.24	3.59	4.30	3.81	2.42	3.93	5.24	59.70
1933	6.80	.00	3.00	.00	5.65	4.10	2.10	1.03	3.90	1.63	.21	5.02	33.44
1934	2.05	3.35	.00	7.46	5.13	4.16	5.07	4.07	3.07	3.89	3.39	4.55	46.19
1935	6.20	8.06	6.44	6.19	2.57	2.02	5.59	.00	3.80	3.89	3.93	4.07	52.76
1936	3.65	.00	7.69	.00	1.87	6.38	4.92	4.39	3.90	3.79	3.93	4.35	44.87
1937	5.36	7.76	3.72	1.69	5.71	7.28	.46	4.37	1.31	1.43	2.60	3.58	45.27
1938	.91	6.15	3.78	1.87	.00	1.05	5.34	2.65	3.08	2.24	2.90	3.01	32.98
1939	2.36	.03	3.54	6.33	7.04	5.63	4.67	.00	1.45	3.89	3.60	1.81	40.35
1940	6.77	3.78	3.78	.06	3.01	6.07	2.18	4.39	3.76	3.23	3.93	4.86	45.82
1941	3.99	7.12	8.06	4.21	1.92	2.14	1.40	3.86	2.89	3.89	1.43	3.86	44.75
1942	2.36	.00	2.09	3.78	8.13	2.33	.00	1.93	2.65	.56	.00	4.48	28.32
1943	.00	.47	3.07	3.13	.00	5.84	6.05	3.33	.00	3.89	3.90	.00	29.68
1944	2.15	4.42	9.20	6.78	4.28	.00	5.14	4.11	3.75	3.89	3.89	5.04	52.66
1945	6.49	7.99	10.19	3.04	3.39	1.24	5.12	3.64	3.90	3.81	3.93	5.34	58.07
1946	.66	1.78	7.99	8.15	1.47	1.19	4.12	4.39	2.67	3.61	3.87	2.57	42.48
1947	2.34	1.68	4.25	1.67	5.43	.00	3.49	3.61	3.90	3.87	3.83	4.08	38.16
1948	3.66	6.50	7.23	4.37	4.89	2.60	2.98	3.38	3.57	3.88	3.93	1.86	48.84
1949	4.28	3.76	5.00	4.21	4.82	.00	4.38	2.16	3.51	3.39	2.18	4.62	42.29
1950	3.38	6.74	.10	6.73	5.54	3.90	3.46	3.73	3.29	3.73	.82	2.03	43.45
1951	3.76	8.86	5.14	.39	1.19	3.69	4.19	3.99	3.89	.96	3.48	4.03	43.57
1952	3.28	5.75	4.19	3.52	.00	4.93	2.81	3.63	3.90	3.88	2.68	4.98	43.55
1953	4.97	3.92	6.15	6.14	.14	3.65	5.18	2.34	3.12	3.81	3.92	1.70	45.03
1954	2.43	1.75	7.23	.09	1.04	4.58	5.33	3.40	3.90	3.88	3.91	5.08	42.62
1955	5.69	4.05	3.84	7.77	1.25	.01	5.61	2.69	3.90	3.89	3.93	3.63	46.25
1956	5.42	3.35	.00	1.46	4.06	1.88	3.67	4.08	3.45	.64	1.17	.00	29.17
1957	.00	7.20	5.55	.00	5.92	3.34	1.67	4.17	3.90	3.89	3.93	1.61	41.18
1958	4.97	2.50	2.23	4.55	2.94	5.15	3.43	.00	3.90	3.25	3.88	5.11	41.90
1959	.21	3.35	6.61	6.05	2.95	2.99	1.45	4.26	3.90	3.65	2.84	4.02	42.27
1960	3.39	5.31	1.26	7.29	7.51	.54	1.97	2.66	3.73	3.85	3.93	2.58	44.03
1961	6.51	3.57	5.66	.06	3.92	5.40	2.72	4.31	3.90	3.89	3.23	4.48	47.63
1962	6.53	3.97	4.29	.00	8.67	3.07	4.86	4.25	1.62	2.56	3.93	5.29	49.04
1963	4.55	5.48	8.35	.31	7.57	3.30	4.22	4.38	1.49	3.84	3.01	1.56	48.05
1964	.05	4.49	1.89	4.40	7.07	8.00	2.78	3.82	1.14	3.62	.04	2.62	39.92
1965	6.36	4.07	8.35	.19	4.78	8.02	5.64	3.82	3.49	3.89	2.96	4.38	55.95
1966	5.70	4.79	.00	.00	1.26	4.17	2.31	4.06	3.90	3.89	3.93	5.21	39.21
1967	5.41	7.13	5.05	7.32	7.76	5.70	5.84	3.97	3.90	3.89	1.81	4.90	62.67
1968	6.35	6.64	7.13	6.50	3.93	1.74	3.91	1.76	3.38	3.80	3.82	4.23	53.19
1969	.44	7.37	5.59	3.72	5.09	7.24	6.04	4.09	2.97	3.75	.67	1.46	48.42
1970	3.21	7.08	8.18	.26	4.00	4.17	3.35	1.65	3.55	2.25	2.99	5.12	45.80
1971	3.15	5.76	3.91	6.18	2.97	.12	5.22	3.39	3.67	3.89	3.20	5.36	46.81
1972	4.19	4.93	9.35	6.58	.00	6.79	1.83	4.39	3.90	3.80	.00	.86	46.63
1973	7.03	3.44	4.02	3.75	.00	1.52	2.46	4.39	2.12	3.72	3.48	5.33	41.25
1974	7.05	.74	5.26	2.24	.00	5.08	2.26	4.01	3.90	3.89	3.93	.02	38.38
1975	6.26	4.51	1.68	.19	3.96	.00	4.50	2.16	3.90	3.89	3.76	3.53	38.34
1976	.11	3.78	5.56	5.20	7.26	3.73	4.80	4.39	3.90	3.87	3.75	2.00	48.35
1977	.09	5.24	6.60	.00	4.20	3.19	4.07	4.37	3.89	3.79	2.52	2.50	40.46
1978	.09	6.23	2.53	5.68	3.96	4.03	4.56	3.18	3.90	1.94	.00	4.26	40.35
1979	1.88	3.12	6.81	4.07	.37	1.04	5.89	3.92	3.90	3.89	3.82	.59	39.30
1980	6.78	3.52	2.35	.00	.00	5.92	4.99	4.15	3.10	3.80	.79	3.40	38.80
1981	6.62	4.53	4.84	2.93	9.87	3.90	2.81	4.21	3.78	3.56	3.89	4.96	55.90
1982	2.43	5.44	9.10	7.12	7.38	6.47	5.06	3.59	3.90	3.18	3.01	4.89	61.55
1983	1.66	.27	4.97	3.30	7.24	.08	1.95	4.38	3.29	3.56	1.12	4.05	35.86
1984	3.24	7.99	7.95	2.14	.00	7.06	6.26	4.39	3.90	3.89	3.93	4.73	55.48
1985	.10	2.07	3.57	1.17	7.18	4.06	3.81	4.39	3.27	3.89	1.90	4.49	39.90
1986	1.29	5.29	6.13	2.97	1.82	1.27	5.98	4.39	3.67	3.73	.22	.00	36.75
1987	5.45	3.76	2.86	5.14	3.27	2.01	5.85	4.39	1.92	2.55	3.71	4.03	44.95
1988	3.14	4.73	2.12	2.63	.00	2.98	5.27	3.72	3.53	3.73	3.88	5.31	41.05
1989	4.79	.21	6.46	6.46	4.83	3.01	2.56	4.15	3.82	3.43	1.18	5.36	46.26
1990	5.93	9.18	3.45	.00	4.12	5.93	6.31	4.34	3.25	3.89	3.93	4.37	54.70
1991	.00	3.04	6.18	6.70	5.49	2.92	5.36	4.39	3.90	3.89	2.59	5.36	49.82
1992	6.14	3.32	7.59	5.43	.00	1.71	5.17	4.39	3.90	3.89	3.42	4.63	49.59
1993	.00	4.84	4.20	1.82	.94	1.36	2.78	4.39	3.90	3.50	3.31	5.30	36.35
1994	4.87	9.52	8.19	1.46	6.53	1.77	3.78	4.16	3.78	3.89	3.78	4.41	56.14

First and second phase irrigation water use for 2030 – THSKOPDS.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.28	.64	.76	.65	.00	.39	.52	.28	.30	.25	.23	.00	4.30
1921	.53	.00	.38	.15	.62	.53	.54	.25	.21	.24	.00	.36	3.81
1922	.21	.37	.69	.30	.31	.62	.53	.33	.27	.12	.21	.36	4.32
1923	.56	.62	.64	.36	.37	.42	.50	.26	.30	.25	.19	.06	4.52
1924	.27	.15	.21	.40	.43	.00	.25	.26	.28	.22	.23	.08	2.78
1925	.37	.65	.52	.02	.62	.47	.52	.27	.22	.25	.23	.00	4.13
1926	.31	.42	.49	.38	.41	.24	.51	.33	.30	.21	.14	.36	4.10
1927	.29	.69	.41	.46	.60	.37	.49	.31	.30	.24	.20	.15	4.51
1928	.43	.63	.19	.26	.50	.24	.39	.31	.08	.06	.20	.00	3.28
1929	.36	.19	.51	.10	.57	.01	.36	.33	.27	.21	.20	.11	3.22
1930	.51	.57	.28	.17	.56	.51	.42	.33	.29	.14	.23	.38	4.40
1931	.42	.70	.38	.36	.00	.36	.49	.13	.29	.24	.23	.22	3.82
1932	.47	.56	.44	.72	.55	.45	.34	.33	.30	.06	.23	.37	4.83
1933	.57	.00	.09	.03	.57	.26	.04	.18	.30	.22	.00	.36	2.61
1934	.44	.00	.00	.73	.44	.34	.51	.29	.23	.25	.20	.34	3.78
1935	.62	.47	.67	.45	.33	.45	.53	.00	.30	.25	.23	.34	4.64
1936	.44	.18	.42	.34	.18	.55	.43	.33	.29	.24	.23	.33	3.96
1937	.52	.62	.38	.24	.62	.52	.17	.33	.16	.11	.14	.33	4.13
1938	.43	.55	.48	.39	.00	.28	.53	.17	.30	.16	.20	.25	3.73
1939	.41	.28	.48	.56	.56	.33	.40	.15	.04	.25	.22	.20	3.88
1940	.53	.60	.53	.27	.52	.35	.28	.33	.30	.25	.23	.30	4.49
1941	.42	.70	.66	.43	.32	.24	.27	.32	.27	.24	.13	.23	4.23
1942	.54	.00	.26	.07	.70	.30	.00	.00	.29	.04	.00	.35	2.54
1943	.00	.29	.33	.37	.32	.35	.54	.27	.20	.25	.23	.00	3.16
1944	.49	.47	.80	.53	.55	.02	.48	.32	.27	.25	.23	.38	4.80
1945	.64	.68	.68	.47	.33	.38	.42	.32	.30	.25	.23	.38	5.05
1946	.25	.32	.62	.61	.25	.22	.42	.33	.15	.25	.23	.27	3.92
1947	.31	.47	.34	.00	.55	.26	.26	.28	.30	.25	.23	.30	3.56
1948	.41	.62	.38	.37	.39	.32	.33	.33	.30	.25	.16	.31	4.16
1949	.52	.42	.60	.56	.67	.00	.42	.16	.30	.23	.13	.19	4.22
1950	.48	.56	.03	.56	.62	.43	.38	.31	.27	.25	.01	.26	4.17
1951	.46	.78	.51	.00	.53	.32	.42	.31	.29	.08	.18	.29	4.18
1952	.40	.51	.39	.44	.09	.65	.33	.33	.30	.25	.17	.36	4.22
1953	.52	.49	.31	.59	.13	.53	.45	.19	.27	.25	.23	.14	4.11
1954	.30	.19	.50	.02	.28	.51	.44	.26	.30	.25	.23	.37	3.64
1955	.56	.62	.35	.74	.36	.20	.49	.32	.30	.25	.23	.24	4.66
1956	.58	.40	.00	.22	.73	.16	.30	.33	.28	.10	.04	.00	3.16
1957	.09	.61	.60	.29	.40	.57	.14	.33	.30	.25	.23	.22	4.04
1958	.50	.33	.43	.46	.49	.67	.34	.00	.30	.22	.23	.37	4.35
1959	.26	.45	.53	.59	.35	.12	.19	.32	.30	.24	.19	.32	3.85
1960	.45	.47	.36	.66	.60	.37	.28	.25	.28	.25	.21	.21	4.38
1961	.59	.51	.54	.07	.54	.47	.30	.27	.30	.25	.18	.32	4.34
1962	.62	.29	.39	.01	.74	.36	.39	.32	.18	.16	.23	.38	4.07
1963	.35	.41	.79	.20	.73	.30	.32	.33	.19	.24	.19	.12	4.16
1964	.13	.51	.57	.53	.63	.68	.41	.31	.05	.20	.00	.14	4.16
1965	.58	.54	.55	.00	.54	.71	.48	.26	.23	.25	.18	.36	4.68
1966	.53	.43	.28	.00	.32	.22	.13	.22	.30	.22	.23	.36	3.23
1967	.55	.65	.64	.57	.69	.50	.47	.33	.30	.23	.14	.36	5.42
1968	.57	.65	.58	.51	.68	.26	.38	.15	.29	.25	.23	.33	4.88
1969	.20	.65	.45	.41	.46	.66	.51	.27	.25	.24	.00	.09	4.18
1970	.42	.61	.70	.08	.58	.56	.43	.20	.29	.13	.15	.36	4.52
1971	.37	.56	.39	.30	.53	.18	.44	.23	.28	.24	.18	.38	4.10
1972	.43	.41	.70	.51	.41	.51	.20	.33	.30	.25	.00	.17	4.21
1973	.60	.32	.35	.21	.20	.22	.28	.28	.23	.23	.18	.37	3.47
1974	.56	.37	.24	.27	.23	.38	.37	.32	.29	.25	.22	.00	3.50
1975	.58	.28	.21	.05	.33	.11	.32	.15	.30	.25	.21	.21	2.99
1976	.28	.45	.52	.22	.77	.42	.36	.33	.29	.25	.22	.08	4.20
1977	.20	.43	.49	.00	.54	.25	.36	.32	.30	.25	.13	.15	3.41
1978	.18	.59	.04	.61	.08	.47	.41	.25	.29	.15	.00	.30	3.37
1979	.48	.53	.50	.38	.33	.47	.41	.29	.30	.25	.21	.02	4.17
1980	.53	.23	.08	.10	.00	.65	.46	.31	.17	.25	.07	.22	3.07
1981	.55	.45	.58	.22	.76	.41	.51	.32	.29	.21	.22	.27	4.80
1982	.24	.68	.49	.21	.75	.49	.46	.25	.27	.19	.19	.37	4.59
1983	.29	.34	.43	.42	.76	.30	.33	.33	.26	.23	.03	.34	4.04
1984	.41	.74	.71	.10	.05	.67	.55	.31	.28	.25	.23	.33	4.62
1985	.09	.32	.41	.25	.59	.36	.33	.33	.19	.25	.12	.36	3.61
1986	.11	.47	.14	.43	.09	.06	.50	.33	.22	.24	.00	.00	2.61
1987	.49	.48	.46	.42	.25	.21	.43	.32	.14	.11	.23	.30	3.85
1988	.35	.45	.21	.43	.00	.52	.46	.25	.24	.25	.23	.38	3.79
1989	.44	.06	.32	.61	.57	.44	.30	.31	.29	.25	.05	.34	4.00
1990	.50	.78	.28	.03	.37	.48	.54	.33	.24	.25	.23	.31	4.33
1991	.10	.49	.26	.58	.11	.48	.49	.33	.30	.25	.15	.38	3.93
1992	.55	.59	.48	.55	.46	.30	.38	.32	.30	.25	.23	.29	4.71
1993	.10	.47	.24	.27	.24	.35	.38	.32	.30	.21	.17	.38	3.42
1994	.50	.78	.53	.43	.52	.30	.46	.28	.29	.25	.23	.27	4.85

First and second phase irrigation water use for 2030 – THWOOD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.46	.00	.39	.33	.00	.00	.60	.66	.66	.74	1.04	1.02	5.91
1921	1.23	.00	.10	.37	.18	.00	.81	.49	.50	.74	.44	1.16	6.03
1922	.05	.00	.03	.00	.00	.48	.81	.61	.22	.47	1.00	1.21	4.89
1923	.89	.24	.42	.09	.13	.00	.58	.65	.66	.74	1.00	.67	6.06
1924	.23	.00	.00	.14	.00	.00	.25	.55	.32	.66	1.04	.74	3.93
1925	.69	.00	.41	.00	.24	.00	.80	.64	.51	.74	1.04	.20	5.26
1926	.87	.00	.28	.04	.00	.00	.66	.73	.66	.42	.84	1.21	5.72
1927	.00	.29	.01	.19	.12	.00	.65	.64	.66	.74	.99	.96	5.25
1928	.64	.00	.22	.00	.23	.00	.40	.62	.00	.24	.95	.00	3.31
1929	.87	.00	.19	.00	.25	.00	.41	.69	.60	.72	.94	1.01	5.68
1930	.79	.09	.13	.00	.15	.00	.26	.74	.66	.24	1.04	1.21	5.31
1931	.86	.00	.52	.24	.00	.00	.80	.41	.55	.74	1.04	.96	6.11
1932	.91	.00	.28	.29	.10	.00	.57	.70	.58	.62	1.04	1.19	6.29
1933	1.06	.00	.00	.00	.00	.00	.46	.29	.66	.14	.43	1.21	4.25
1934	.35	.00	.00	.31	.00	.00	.48	.63	.59	.74	.99	1.04	5.12
1935	.98	.00	.40	.30	.00	.00	.71	.04	.66	.74	1.04	1.10	5.96
1936	.55	.00	.26	.00	.00	.08	.77	.74	.65	.74	1.03	1.06	5.87
1937	.85	.16	.09	.16	.02	.25	.00	.73	.14	.39	.57	1.02	4.36
1938	.18	.00	.00	.06	.00	.00	.73	.46	.66	.38	.75	.88	4.10
1939	.38	.00	.19	.41	.00	.03	.34	.09	.31	.73	1.02	.53	4.04
1940	1.06	.00	.06	.00	.00	.13	.41	.58	.66	.56	1.03	.99	5.48
1941	.72	.20	.35	.05	.11	.00	.30	.60	.55	.74	.65	.80	5.07
1942	.33	.00	.00	.18	.20	.00	.00	.38	.66	.00	.16	1.11	3.03
1943	.00	.00	.01	.02	.00	.17	.81	.50	.00	.74	1.03	.10	3.39
1944	.40	.00	.45	.29	.00	.00	.51	.65	.64	.74	1.02	1.13	5.82
1945	.90	.13	.57	.00	.00	.00	.62	.55	.66	.72	1.04	1.19	6.37
1946	.00	.00	.38	.42	.02	.00	.44	.71	.61	.73	.94	.69	4.92
1947	.39	.00	.15	.00	.07	.00	.23	.60	.66	.74	1.01	1.01	4.85
1948	.52	.00	.42	.16	.07	.00	.25	.62	.60	.74	1.03	.74	5.15
1949	.54	.00	.10	.01	.00	.00	.35	.45	.58	.61	.64	1.09	4.38
1950	.52	.13	.00	.35	.06	.00	.43	.62	.56	.71	.55	.74	4.68
1951	.52	.31	.29	.00	.00	.00	.50	.67	.62	.41	.93	.98	5.24
1952	.62	.00	.03	.19	.00	.00	.30	.54	.58	.74	.83	1.08	4.91
1953	.70	.00	.11	.21	.00	.00	.67	.39	.52	.73	1.04	.69	5.06
1954	.48	.00	.20	.00	.00	.00	.50	.49	.60	.74	1.04	1.12	5.18
1955	.85	.00	.20	.28	.00	.00	.60	.39	.65	.73	1.03	.90	5.64
1956	.62	.00	.00	.01	.00	.00	.37	.62	.53	.32	.53	.00	3.01
1957	.00	.00	.13	.00	.03	.00	.01	.66	.65	.74	1.04	.69	3.95
1958	.79	.00	.03	.22	.00	.19	.20	.00	.65	.52	1.03	1.14	4.76
1959	.06	.00	.16	.23	.01	.00	.12	.70	.66	.66	.78	.93	4.30
1960	.50	.00	.00	.17	.19	.00	.07	.46	.59	.70	1.02	.88	4.58
1961	1.01	.00	.18	.04	.00	.00	.32	.72	.66	.73	.96	1.02	5.64
1962	.85	.00	.24	.00	.25	.00	.49	.68	.28	.58	1.04	1.21	5.62
1963	.58	.00	.35	.00	.30	.00	.55	.75	.25	.74	.88	.78	5.19
1964	.00	.00	.17	.04	.31	.15	.18	.68	.18	.66	.34	.85	3.56
1965	.97	.00	.44	.00	.05	.39	.67	.64	.59	.74	.92	.98	6.40
1966	.73	.00	.02	.00	.00	.00	.06	.57	.63	.71	1.01	1.13	4.87
1967	.87	.00	.20	.34	.24	.00	.37	.56	.65	.74	.72	1.05	5.76
1968	1.00	.00	.11	.25	.04	.00	.39	.33	.44	.69	.99	.99	5.23
1969	.15	.00	.00	.17	.03	.06	.68	.64	.50	.64	.52	.68	4.07
1970	.50	.01	.43	.00	.00	.00	.27	.37	.59	.52	.82	1.14	4.66
1971	.78	.00	.24	.00	.00	.00	.57	.52	.65	.74	.91	1.18	5.60
1972	.71	.00	.51	.34	.00	.00	.41	.72	.66	.71	.29	.56	4.92
1973	.98	.00	.14	.00	.00	.00	.12	.75	.33	.72	.93	1.19	5.16
1974	.90	.00	.23	.00	.00	.00	.31	.75	.66	.72	1.01	.38	4.96
1975	.78	.00	.01	.00	.00	.00	.37	.34	.65	.74	1.02	.85	4.77
1976	.09	.00	.14	.00	.00	.00	.17	.69	.65	.74	.99	.43	3.91
1977	.22	.00	.05	.00	.00	.00	.35	.75	.63	.74	.73	.73	4.21
1978	.05	.00	.00	.32	.00	.00	.61	.49	.66	.43	.23	.85	3.63
1979	.33	.00	.14	.05	.00	.00	.70	.70	.66	.73	.96	.45	4.72
1980	.98	.00	.16	.00	.00	.09	.50	.71	.53	.70	.47	.93	5.08
1981	.98	.00	.14	.27	.28	.00	.24	.72	.65	.67	1.02	1.02	5.99
1982	.30	.03	.51	.36	.29	.12	.65	.53	.64	.30	.93	1.08	5.76
1983	.32	.00	.05	.25	.10	.00	.46	.71	.59	.70	.55	1.10	4.84
1984	.62	.00	.51	.00	.00	.25	.72	.75	.65	.74	1.02	1.07	6.35
1985	.00	.00	.00	.00	.18	.00	.15	.74	.54	.74	.64	1.03	4.03
1986	.25	.00	.15	.36	.00	.00	.59	.74	.60	.71	.30	.00	3.70
1987	.61	.00	.35	.09	.00	.00	.48	.59	.39	.55	.90	.81	4.77
1988	.41	.00	.03	.00	.00	.07	.32	.54	.48	.74	1.04	1.21	4.83
1989	.66	.00	.08	.20	.06	.00	.45	.64	.62	.73	.80	1.19	5.43
1990	.76	.29	.11	.00	.00	.00	.81	.73	.55	.74	1.02	.99	6.00
1991	.14	.00	.08	.42	.00	.00	.54	.75	.66	.74	.88	1.14	5.36
1992	.78	.04	.48	.20	.00	.00	.57	.74	.66	.74	.97	.93	6.11
1993	.20	.00	.16	.00	.00	.00	.38	.75	.64	.70	.88	1.14	4.86
1994	.81	.28	.43	.01	.17	.00	.31	.65	.47	.71	1.03	.88	5.74

First and second phase irrigation water use for 2030 – TM02.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.23	.00	.00	.00	.00	.00	.29	.32	.32	.36	.50	.49	2.50
1921	.59	.00	.00	.00	.00	.00	.39	.24	.24	.36	.22	.56	2.59
1922	.03	.00	.00	.00	.00	.23	.39	.29	.11	.23	.48	.58	2.35
1923	.43	.12	.00	.00	.00	.00	.28	.31	.32	.36	.48	.33	2.62
1924	.12	.00	.00	.00	.00	.00	.12	.27	.15	.32	.50	.36	1.85
1925	.33	.00	.00	.00	.00	.00	.39	.31	.25	.36	.50	.10	2.23
1926	.42	.00	.00	.00	.00	.00	.32	.35	.32	.20	.41	.58	2.60
1927	.00	.14	.00	.00	.00	.00	.31	.31	.32	.36	.47	.46	2.38
1928	.31	.00	.00	.00	.00	.00	.20	.30	.00	.12	.46	.00	1.39
1929	.42	.00	.00	.00	.00	.00	.20	.33	.29	.34	.45	.49	2.53
1930	.38	.05	.00	.00	.00	.00	.13	.35	.32	.12	.50	.58	2.43
1931	.42	.00	.00	.00	.00	.00	.38	.20	.27	.36	.50	.46	2.58
1932	.44	.00	.00	.00	.00	.00	.28	.33	.28	.30	.50	.57	2.70
1933	.51	.00	.00	.00	.00	.00	.23	.14	.32	.07	.21	.58	2.06
1934	.17	.00	.00	.00	.00	.00	.23	.30	.28	.35	.48	.50	2.33
1935	.47	.00	.00	.00	.00	.00	.34	.02	.32	.36	.50	.53	2.53
1936	.27	.00	.00	.00	.00	.04	.37	.36	.31	.35	.49	.51	2.71
1937	.41	.08	.00	.00	.00	.12	.00	.35	.07	.19	.28	.49	1.99
1938	.10	.00	.00	.00	.00	.00	.35	.22	.32	.18	.36	.43	1.96
1939	.19	.00	.00	.00	.00	.02	.17	.05	.15	.35	.49	.26	1.68
1940	.51	.00	.00	.00	.00	.07	.20	.28	.32	.27	.49	.48	2.62
1941	.35	.10	.00	.00	.00	.00	.15	.29	.26	.36	.31	.39	2.21
1942	.17	.00	.00	.00	.00	.00	.00	.19	.32	.00	.09	.54	1.29
1943	.00	.00	.00	.00	.00	.08	.39	.24	.00	.36	.49	.06	1.63
1944	.20	.00	.00	.00	.00	.00	.25	.31	.31	.35	.49	.54	2.45
1945	.43	.06	.00	.00	.00	.00	.30	.26	.32	.35	.50	.57	2.79
1946	.00	.00	.00	.00	.00	.00	.22	.34	.29	.35	.45	.34	1.99
1947	.19	.00	.00	.00	.00	.00	.12	.29	.32	.35	.49	.49	2.24
1948	.26	.00	.00	.00	.00	.00	.13	.30	.29	.36	.49	.36	2.18
1949	.27	.00	.00	.00	.00	.00	.17	.22	.28	.29	.31	.53	2.07
1950	.26	.07	.00	.00	.00	.00	.21	.30	.27	.34	.27	.36	2.08
1951	.26	.15	.00	.00	.00	.00	.24	.32	.30	.20	.45	.47	2.40
1952	.30	.00	.00	.00	.00	.00	.15	.26	.28	.36	.40	.52	2.27
1953	.34	.00	.00	.00	.00	.00	.32	.19	.25	.35	.50	.34	2.29
1954	.24	.00	.00	.00	.00	.00	.24	.24	.29	.36	.50	.54	2.40
1955	.41	.00	.00	.00	.00	.00	.29	.19	.31	.35	.50	.44	2.49
1956	.30	.00	.00	.00	.00	.00	.18	.30	.26	.16	.26	.00	1.46
1957	.00	.00	.00	.00	.00	.00	.01	.32	.31	.36	.50	.34	1.83
1958	.38	.00	.00	.00	.00	.09	.10	.00	.31	.25	.49	.55	2.18
1959	.04	.00	.00	.00	.00	.00	.06	.34	.32	.32	.37	.45	1.89
1960	.25	.00	.00	.00	.00	.00	.04	.22	.28	.34	.49	.42	2.05
1961	.49	.00	.00	.00	.00	.00	.16	.34	.32	.35	.46	.49	2.61
1962	.41	.00	.00	.00	.00	.00	.24	.33	.14	.28	.50	.58	2.47
1963	.28	.00	.00	.00	.00	.00	.27	.36	.12	.35	.43	.38	2.19
1964	.00	.00	.00	.00	.00	.07	.09	.33	.09	.32	.17	.41	1.48
1965	.47	.00	.00	.00	.00	.19	.32	.31	.29	.36	.44	.47	2.84
1966	.36	.00	.00	.00	.00	.00	.03	.28	.31	.34	.48	.54	2.34
1967	.42	.00	.00	.00	.00	.00	.18	.27	.31	.35	.35	.51	2.40
1968	.48	.00	.00	.00	.00	.00	.19	.16	.21	.33	.48	.48	2.34
1969	.08	.00	.00	.00	.00	.03	.33	.31	.24	.31	.26	.33	1.89
1970	.25	.01	.00	.00	.00	.00	.14	.18	.28	.25	.39	.55	2.05
1971	.38	.00	.00	.00	.00	.00	.28	.25	.31	.36	.44	.57	2.58
1972	.35	.00	.00	.00	.00	.00	.20	.35	.32	.34	.15	.28	1.97
1973	.47	.00	.00	.00	.00	.00	.06	.36	.16	.35	.45	.57	2.42
1974	.43	.00	.00	.00	.00	.00	.16	.36	.32	.35	.48	.19	2.29
1975	.38	.00	.00	.00	.00	.00	.18	.17	.31	.36	.49	.41	2.30
1976	.05	.00	.00	.00	.00	.00	.09	.33	.31	.36	.47	.21	1.83
1977	.12	.00	.00	.00	.00	.00	.17	.36	.31	.35	.35	.36	2.02
1978	.03	.00	.00	.00	.00	.00	.29	.24	.32	.21	.12	.41	1.61
1979	.17	.00	.00	.00	.00	.00	.34	.33	.32	.35	.46	.22	2.19
1980	.47	.00	.00	.00	.00	.05	.24	.34	.25	.34	.23	.45	2.38
1981	.47	.00	.00	.00	.00	.00	.12	.35	.31	.32	.49	.49	2.55
1982	.15	.02	.00	.00	.00	.06	.32	.26	.31	.15	.45	.52	2.24
1983	.16	.00	.00	.00	.00	.00	.23	.34	.28	.34	.27	.53	2.15
1984	.30	.00	.00	.00	.00	.12	.35	.36	.31	.35	.49	.52	2.81
1985	.00	.00	.00	.00	.00	.00	.08	.36	.26	.36	.31	.50	1.86
1986	.13	.00	.00	.00	.00	.00	.29	.35	.29	.34	.15	.00	1.55
1987	.30	.00	.00	.00	.00	.00	.23	.29	.19	.26	.43	.39	2.10
1988	.20	.00	.00	.00	.00	.04	.16	.26	.23	.35	.50	.58	2.32
1989	.32	.00	.00	.00	.00	.00	.22	.31	.30	.35	.39	.57	2.46
1990	.37	.14	.00	.00	.00	.00	.39	.35	.27	.36	.49	.48	2.84
1991	.08	.00	.00	.00	.00	.00	.26	.36	.32	.36	.42	.55	2.34
1992	.38	.03	.00	.00	.00	.00	.27	.36	.32	.36	.47	.45	2.62
1993	.11	.00	.00	.00	.00	.00	.19	.36	.31	.34	.42	.55	2.27
1994	.39	.14	.00	.00	.00	.00	.16	.31	.23	.34	.49	.43	2.49

First and second phase irrigation water use for 2030 – TM06.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.69	1.59	2.08	1.70	1.28	.34	1.25	.89	.92	.92	.93	.90	13.49
1921	1.63	.00	.91	1.73	1.64	.94	1.43	.78	.76	.91	.17	1.08	11.98
1922	.08	.62	1.04	.43	.00	1.78	1.48	.56	.55	.66	.89	.88	8.98
1923	1.14	2.05	1.66	.99	1.57	.46	1.21	.90	.92	.90	.78	.44	13.01
1924	.71	.50	.54	1.10	.55	.00	.89	.81	.66	.84	.93	.59	8.12
1925	.90	1.06	1.89	.00	1.78	1.04	1.36	.89	.68	.92	.92	.21	11.65
1926	1.23	1.15	1.59	1.07	.63	.14	1.17	1.01	.92	.59	.70	1.24	11.43
1927	.00	2.03	1.05	1.38	1.63	.11	1.32	1.04	.92	.92	.83	.84	12.07
1928	1.31	1.94	1.24	1.21	.36	.00	.43	.77	.36	.44	.85	.00	8.93
1929	.95	.44	.00	.31	1.65	1.31	.64	.81	.90	.78	.79	.95	9.54
1930	1.52	1.86	1.78	.00	1.49	1.10	.92	1.04	.92	.57	.93	1.24	13.38
1931	1.12	1.83	2.21	1.84	.20	.49	1.25	.41	.76	.77	.93	1.07	12.87
1932	1.61	1.10	1.32	1.82	1.81	1.29	.89	1.02	.90	.59	.93	1.24	14.54
1933	1.62	.00	.83	.00	1.41	1.04	.56	.29	.92	.42	.10	1.19	8.38
1934	.56	.89	.00	1.82	1.30	1.05	1.22	.97	.74	.92	.81	1.09	11.37
1935	1.49	1.94	1.60	1.54	.73	.58	1.33	.00	.90	.92	.93	.98	12.93
1936	.92	.00	1.88	.00	.57	1.55	1.19	1.04	.92	.90	.93	1.04	10.93
1937	1.30	1.87	.99	.54	1.43	1.75	.19	1.03	.35	.37	.63	.87	11.32
1938	.31	1.51	1.00	.58	.00	.36	1.28	.65	.74	.55	.70	.74	8.43
1939	.63	.03	.95	1.57	1.72	1.38	1.13	.00	.38	.92	.86	.48	10.04
1940	1.62	.98	1.00	.06	.82	1.48	.57	1.04	.89	.77	.93	1.16	11.33
1941	1.00	1.73	1.96	1.10	.58	.60	.40	.92	.70	.92	.37	.94	11.21
1942	.63	.00	.63	1.00	1.97	.65	.00	.49	.65	.18	.00	1.07	7.26
1943	.00	.24	.84	.86	.00	1.43	1.44	.80	.00	.92	.92	.00	7.46
1944	.59	1.13	2.21	1.67	1.11	.00	1.23	.98	.89	.92	.92	1.20	12.84
1945	1.55	1.92	2.43	.84	.91	.40	1.23	.87	.92	.90	.93	1.27	14.17
1946	.25	.54	1.94	1.98	.48	.39	1.01	1.04	.65	.86	.92	.65	10.70
1947	.63	.51	1.11	.53	1.36	.00	.87	.86	.92	.92	.91	.98	9.61
1948	.92	1.59	1.77	1.13	1.24	.71	.75	.81	.85	.92	.93	.49	12.12
1949	1.06	.98	1.28	1.10	1.23	.00	1.06	.54	.84	.81	.54	1.10	10.53
1950	.86	1.64	.10	1.66	1.39	1.00	.86	.89	.79	.88	.24	.53	10.83
1951	.94	2.11	1.31	.25	.42	.95	1.02	.95	.92	.27	.83	.97	10.94
1952	.84	1.42	1.09	.94	.00	1.23	.71	.87	.92	.92	.65	1.18	10.79
1953	1.21	1.01	1.53	1.53	.14	.94	1.24	.58	.75	.90	.93	.45	11.23
1954	.65	.53	1.77	.09	.38	1.15	1.28	.82	.92	.92	.93	1.21	10.64
1955	1.38	1.04	1.02	1.89	.43	.01	1.34	.66	.92	.92	.93	.88	11.42
1956	1.31	.89	.00	.49	1.06	.55	.90	.97	.82	.20	.31	.00	7.50
1957	.00	1.74	1.40	.00	1.47	.87	.46	.99	.92	.92	.93	.43	10.14
1958	1.22	.70	.66	1.17	.81	1.27	.85	.00	.92	.78	.92	1.21	10.51
1959	.15	.89	1.63	1.51	.81	.79	.41	1.01	.92	.87	.69	.97	10.65
1960	.86	1.32	.44	1.78	1.83	.25	.53	.65	.88	.91	.93	.65	11.04
1961	1.56	.94	1.42	.06	1.03	1.33	.69	1.02	.92	.92	.77	1.07	11.73
1962	1.56	1.03	1.12	.00	2.09	.81	1.17	1.01	.42	.62	.93	1.25	12.00
1963	1.12	1.36	2.02	.23	1.84	.86	1.03	1.04	.39	.91	.73	.42	11.94
1964	.05	1.14	.58	1.14	1.73	1.91	.71	.91	.31	.86	.04	.66	10.04
1965	1.52	1.05	2.02	.19	1.22	1.92	1.35	.91	.83	.92	.72	1.05	13.69
1966	1.38	1.21	.00	.00	.43	1.06	.60	.96	.92	.92	.93	1.23	9.65
1967	1.31	1.73	1.29	1.79	1.88	1.40	1.39	.95	.92	.92	.46	1.17	15.20
1968	1.52	1.62	1.75	1.61	1.03	.52	.96	.45	.81	.90	.91	1.02	13.09
1969	.20	1.78	1.41	.99	1.29	1.74	1.43	.97	.72	.89	.20	.40	12.02
1970	.82	1.72	1.98	.22	1.05	1.06	.83	.43	.84	.55	.72	1.22	11.44
1971	.81	1.42	1.03	1.54	.81	.12	1.25	.82	.87	.92	.77	1.27	11.63
1972	1.04	1.24	2.25	1.63	.00	1.64	.49	1.04	.92	.90	.00	.27	11.42
1973	1.67	.91	1.06	.99	.00	.47	.63	1.04	.53	.88	.83	1.26	10.27
1974	1.68	.31	1.33	.66	.00	1.26	.59	.96	.92	.92	.93	.02	9.57
1975	1.50	1.15	.53	.19	1.04	.00	1.09	.54	.92	.92	.89	.86	9.63
1976	.11	.98	1.40	1.32	1.77	.96	1.16	1.04	.92	.92	.89	.52	11.99
1977	.09	1.31	1.63	.00	1.09	.84	.99	1.03	.92	.90	.62	.63	10.05
1978	.09	1.53	.72	1.42	1.04	1.02	1.10	.77	.92	.49	.00	1.02	10.14
1979	.53	.84	1.68	1.07	.24	.36	1.40	.93	.92	.92	.91	.21	9.99
1980	1.62	.92	.68	.00	.00	1.45	1.20	.99	.75	.90	.23	.83	9.57
1981	1.58	1.15	1.24	.81	2.35	1.00	.71	1.00	.90	.85	.92	1.18	13.69
1982	.65	1.35	2.19	1.75	1.80	1.57	1.21	.86	.92	.76	.73	1.16	14.95
1983	.48	.20	1.27	.89	1.77	.08	.52	1.04	.79	.85	.30	.98	9.15
1984	.83	1.92	1.93	.64	.00	1.70	1.48	1.04	.92	.92	.93	1.13	13.44
1985	.10	.60	.96	.42	1.75	1.03	.94	1.04	.78	.92	.48	1.08	10.10
1986	.39	1.32	1.53	.82	.56	.41	1.42	1.04	.87	.88	.10	.00	9.35
1987	1.32	.98	.80	1.31	.88	.57	1.39	1.04	.48	.62	.88	.97	11.25
1988	.81	1.19	.63	.74	.00	.79	1.26	.89	.84	.88	.92	1.26	10.23
1989	1.18	.19	1.60	1.60	1.23	.80	.66	.99	.91	.82	.32	1.27	11.54
1990	1.43	2.19	.93	.00	1.07	1.45	1.49	1.03	.78	.92	.93	1.05	13.27
1991	.00	.82	1.54	1.65	1.38	.78	1.28	1.04	.92	.92	.63	1.27	12.23
1992	1.48	.88	1.85	1.37	.00	.51	1.24	1.04	.92	.92	.82	1.11	12.13
1993	.00	1.22	1.10	.56	.36	.43	.71	1.04	.92	.83	.79	1.26	9.23
1994	1.19	2.26	1.99	.48	1.61	.52	.93	.99	.90	.92	.90	1.06	13.75

First and second phase irrigation water use for 2030 – TM08.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.50	.63	.00	.00	.00	.00	1.42	.76	1.72	2.04	2.86	2.06	11.99
1921	2.60	.00	.00	.00	.00	.00	1.91	1.59	.60	2.20	1.72	3.47	14.09
1922	1.92	.00	.00	.00	.00	.00	1.62	1.77	1.69	1.74	2.73	3.31	14.78
1923	3.26	.00	.00	.00	.00	.00	1.20	1.19	1.77	2.20	2.45	2.43	14.50
1924	1.76	.00	.00	.00	.00	.00	.12	1.38	1.49	1.92	2.95	1.90	11.52
1925	2.48	.00	.00	.00	.00	.00	1.71	1.47	.98	2.30	2.91	1.13	12.98
1926	1.66	.00	.00	.00	.00	.00	1.33	1.80	1.67	1.97	2.22	3.47	14.12
1927	1.23	.66	.00	.00	.00	.00	1.84	1.19	1.77	2.23	2.70	3.24	14.86
1928	2.68	.00	.00	.00	.00	.00	1.56	.98	.48	.93	2.78	.33	9.74
1929	2.76	.00	.00	.00	.00	.00	1.97	1.47	1.60	2.25	2.47	3.00	15.52
1930	2.22	.65	.00	.00	.00	.00	.95	1.82	1.72	.91	2.95	3.59	14.81
1931	2.66	.45	.00	.00	.00	.00	2.00	1.26	1.66	2.20	2.89	2.85	15.97
1932	2.65	.00	.00	.00	.00	.20	1.41	1.79	1.70	1.37	2.93	3.56	15.61
1933	2.77	.00	.00	.00	.00	.00	.00	.75	1.74	1.54	1.47	3.11	11.38
1934	1.99	.00	.00	.00	.00	.00	1.89	1.39	1.34	2.20	2.71	3.22	14.74
1935	3.31	.00	.00	.00	.00	.00	1.64	.00	1.65	2.25	2.95	3.34	15.14
1936	1.79	.00	.00	.00	.00	.06	1.46	1.88	1.64	2.29	2.93	3.28	15.33
1937	2.77	.20	.00	.00	.00	.22	.00	1.86	1.11	1.28	2.12	3.11	12.67
1938	.36	.00	.00	.00	.00	.00	2.01	.93	1.77	1.42	2.55	2.75	11.79
1939	1.67	.00	.00	.00	.00	.00	1.19	.00	.69	2.25	2.77	2.44	11.01
1940	2.86	.00	.00	.00	.00	.47	.98	1.88	1.77	2.18	2.91	3.29	16.34
1941	2.65	.61	.00	.00	.00	.00	.63	1.69	1.62	2.23	2.16	2.53	14.12
1942	1.94	.00	.00	.00	.00	.00	.00	.18	1.77	.40	.20	3.56	8.05
1943	.00	.00	.00	.00	.00	.06	2.18	1.54	.47	2.30	2.92	1.05	10.52
1944	2.40	.00	.00	.00	.00	.00	1.41	1.67	1.55	2.29	2.91	3.58	15.81
1945	3.14	.38	.00	.00	.00	.00	1.42	1.67	1.77	2.28	2.93	3.66	17.25
1946	1.69	.00	.00	.00	.00	.00	1.25	1.77	1.18	2.28	2.73	3.08	13.98
1947	1.55	.00	.00	.00	.00	.00	.90	1.46	1.77	2.30	2.93	3.28	14.19
1948	2.68	.00	.00	.00	.00	.00	.80	1.59	1.72	2.29	2.62	2.80	14.50
1949	2.78	.00	.00	.00	.00	.00	1.34	.80	1.64	2.03	1.91	3.00	13.50
1950	2.73	.00	.00	.00	.00	.00	1.36	1.74	1.62	2.27	1.71	2.88	14.31
1951	2.37	.83	.00	.00	.00	.00	1.48	1.66	1.69	1.39	2.55	3.03	15.00
1952	2.20	.00	.00	.00	.00	.00	1.16	1.79	1.70	2.30	2.17	3.38	14.70
1953	2.04	.00	.00	.00	.00	.00	1.67	.68	1.72	2.30	2.94	2.54	13.89
1954	1.94	.00	.00	.00	.00	.00	1.11	1.03	1.50	2.26	2.95	3.39	14.18
1955	2.85	.00	.00	.00	.00	.00	1.65	1.70	1.77	2.27	2.74	3.03	16.01
1956	2.62	.00	.00	.00	.00	.00	.53	1.59	1.57	1.62	1.71	.01	9.65
1957	.96	.09	.00	.00	.00	.00	.38	1.72	1.72	2.30	2.95	2.83	12.95
1958	2.62	.00	.00	.00	.00	.00	1.09	.09	1.72	1.79	2.75	3.59	13.65
1959	1.84	.00	.00	.00	.00	.00	.40	1.79	1.77	2.24	2.61	3.01	13.66
1960	2.48	.00	.00	.00	.00	.00	.42	1.62	1.72	2.27	2.91	2.76	14.18
1961	3.11	.00	.00	.00	.00	.00	.60	1.44	1.77	2.30	2.48	3.41	15.11
1962	2.90	.00	.00	.00	.00	.00	1.46	1.79	1.08	1.87	2.95	3.62	15.67
1963	1.33	.00	.00	.00	.00	.00	.99	1.82	1.16	2.28	2.76	1.82	12.16
1964	.00	.00	.00	.00	.00	.81	.71	1.60	.12	2.04	1.31	2.71	9.30
1965	2.75	.00	.00	.00	.00	.81	1.58	1.49	1.61	2.30	2.49	3.11	16.14
1966	2.37	.00	.00	.00	.00	.00	.00	1.55	1.71	2.18	2.88	3.48	14.17
1967	2.64	.00	.00	.00	.00	.00	1.36	1.61	1.72	2.25	2.40	3.20	15.18
1968	3.05	.00	.00	.00	.00	.00	.83	.93	1.60	2.18	2.80	2.59	13.98
1969	1.18	.00	.00	.00	.00	.13	1.61	1.74	1.62	2.25	1.23	1.78	11.54
1970	1.94	.00	.00	.00	.00	.00	.95	.90	1.72	1.54	2.02	3.41	12.48
1971	1.84	.00	.00	.00	.00	.00	1.11	.95	1.75	2.23	2.73	3.41	14.02
1972	2.15	.00	.00	.00	.00	.00	.50	1.77	1.72	2.17	1.70	1.97	11.98
1973	2.78	.00	.00	.00	.00	.00	.00	1.87	1.01	2.02	2.75	3.61	14.04
1974	2.68	.00	.00	.00	.00	.00	.98	1.82	1.77	2.30	2.86	.60	13.01
1975	2.70	.00	.00	.00	.00	.00	.73	.68	1.77	2.28	2.88	2.37	13.41
1976	.98	.00	.00	.00	.00	.00	.55	1.82	1.75	2.29	2.70	2.12	12.21
1977	.80	.00	.00	.00	.00	.00	.54	1.80	1.70	2.30	2.29	2.81	12.24
1978	.72	.00	.00	.00	.00	.00	1.39	.78	1.75	1.75	1.26	3.08	10.73
1979	2.06	.00	.00	.00	.00	.00	.93	1.69	1.77	2.30	2.58	1.70	13.03
1980	2.86	.00	.00	.00	.00	.30	1.38	1.65	1.29	2.30	1.25	2.90	13.93
1981	2.91	.00	.00	.00	.00	.00	.63	1.80	1.59	2.10	2.90	2.64	14.57
1982	1.64	.23	.00	.00	.00	.05	1.11	1.46	1.70	.88	2.58	3.28	12.93
1983	1.10	.00	.00	.00	.00	.00	1.16	1.79	1.47	2.07	1.81	3.41	12.81
1984	2.24	.15	.00	.00	.00	.43	2.05	1.82	1.66	2.30	2.90	3.29	16.84
1985	.00	.00	.00	.00	.00	.00	.57	1.87	1.42	2.30	1.72	3.31	11.19
1986	.65	.00	.00	.00	.00	.00	1.99	1.87	1.42	2.20	.95	.00	9.08
1987	2.19	.00	.00	.00	.00	.00	.93	1.29	.70	1.55	2.68	3.04	12.38
1988	2.15	.00	.00	.00	.00	.00	1.23	1.37	1.41	2.23	2.95	3.64	14.98
1989	2.34	.00	.00	.00	.00	.00	.93	1.69	1.65	2.30	2.00	3.51	14.42
1990	2.34	.42	.00	.00	.00	.00	2.19	1.82	1.41	2.30	2.87	3.08	16.43
1991	.00	.00	.00	.00	.00	.00	1.57	1.88	1.77	2.30	2.60	3.49	13.61
1992	2.37	.02	.00	.00	.00	.00	1.34	1.79	1.77	2.29	2.77	3.26	15.61
1993	.93	.00	.00	.00	.00	.00	1.51	1.87	1.72	2.06	2.47	3.54	14.10
1994	2.29	.86	.00	.00	.00	.00	1.13	1.59	1.72	2.27	2.93	2.82	15.61

First and second phase irrigation water use for 2030 – TM11.IRR   Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.07	2.23	2.49	1.84	0.00	0.47	1.77	1.27	1.17	0.99	0.75	0.45	14.50
1921	2.26	0.00	0.63	1.19	0.36	1.13	2.01	1.09	0.71	1.14	0.18	2.04	12.74
1922	0.60	0.54	1.86	0.03	0.00	1.80	2.04	1.20	1.01	0.79	1.68	1.36	12.91
1923	2.01	1.86	1.80	0.41	0.86	0.26	1.81	1.14	1.14	1.14	1.12	0.98	14.53
1924	1.45	0.44	0.57	0.87	0.38	0.00	1.23	1.16	1.06	1.08	1.17	1.35	10.76
1925	1.47	1.31	2.37	0.00	1.57	1.36	1.83	1.21	0.75	1.18	1.18	0.10	14.33
1926	1.31	1.14	1.39	1.09	0.13	0.09	1.73	1.46	1.09	0.74	1.45	1.39	13.01
1927	0.62	2.19	1.05	1.35	1.03	0.19	1.68	1.18	1.17	1.12	1.02	1.51	14.11
1928	1.89	2.42	0.45	1.37	0.44	0.00	0.89	1.25	0.22	0.34	1.62	0.00	10.89
1929	1.88	0.21	0.76	0.11	1.27	1.30	1.34	1.33	1.11	1.01	1.42	1.80	13.54
1930	1.94	1.62	1.80	0.03	0.02	1.41	1.78	1.46	0.87	0.79	1.34	0.79	13.85
1931	1.77	2.14	1.95	1.73	0.00	0.99	1.90	0.68	0.92	0.94	1.77	1.43	16.22
1932	1.48	1.70	1.63	2.03	1.13	1.36	1.36	1.45	1.15	0.66	1.77	0.96	16.68
1933	0.58	0.00	0.45	0.00	1.51	1.21	0.75	0.60	1.17	0.51	0.51	2.29	9.58
1934	1.80	0.95	0.03	2.17	1.12	0.61	1.40	1.38	0.96	1.18	1.05	1.12	13.77
1935	1.22	0.99	1.46	1.26	0.16	0.40	1.82	0.00	1.14	1.18	1.51	0.98	12.12
1936	1.47	0.08	1.80	0.00	1.07	1.72	1.39	1.46	1.13	0.80	0.68	0.86	12.46
1937	1.28	1.24	0.93	1.47	0.88	1.65	0.64	1.46	0.05	0.28	1.24	1.62	12.74
1938	1.03	1.53	0.29	0.94	0.08	0.44	1.99	0.70	1.17	0.43	1.52	1.61	11.73
1939	1.74	0.00	0.56	2.06	0.93	1.76	1.54	0.18	0.58	1.18	1.71	0.98	13.22
1940	2.02	1.16	0.26	0.23	0.09	1.48	0.68	1.46	1.17	1.02	1.06	0.80	11.43
1941	1.13	1.34	1.68	0.78	0.00	0.32	0.83	1.17	0.92	1.18	0.98	1.60	11.93
1942	1.07	0.00	0.39	0.00	1.66	0.42	0.00	0.93	1.16	0.00	0.00	2.21	7.84
1943	0.04	1.37	0.86	0.99	0.00	1.62	2.08	1.09	0.00	1.18	1.76	0.01	11.00
1944	1.18	2.14	2.59	1.69	0.90	0.00	1.72	1.42	1.08	0.99	0.80	0.70	15.21
1945	0.62	0.31	0.14	0.00	0.37	0.03	1.86	1.37	1.15	0.85	0.69	0.48	7.87
1946	0.72	0.41	1.95	1.93	0.00	0.66	1.28	1.46	0.29	1.08	1.76	1.59	13.13
1947	1.48	0.32	0.98	0.37	1.33	0.33	1.30	1.32	1.17	1.13	0.85	0.90	11.48
1948	1.50	1.88	2.38	0.42	0.43	0.42	0.91	1.27	1.15	1.11	1.00	1.53	14.00
1949	1.63	1.07	1.38	1.44	0.97	0.25	1.32	0.93	1.13	1.14	1.25	1.95	14.46
1950	1.59	2.42	1.23	1.64	0.81	1.17	1.27	1.32	0.97	1.08	0.59	1.69	15.78
1951	1.80	2.65	1.56	0.00	0.58	0.72	1.36	1.25	1.17	0.27	1.63	2.00	14.99
1952	1.69	1.56	2.44	0.52	0.00	1.19	1.04	1.40	1.17	1.07	1.15	1.61	14.84
1953	1.46	1.22	1.63	1.66	0.00	0.73	1.32	0.64	0.90	1.18	1.43	0.96	13.13
1954	0.75	0.02	1.27	0.00	0.00	1.56	1.69	1.29	1.17	0.90	0.73	0.64	10.02
1955	1.77	1.25	1.62	2.44	0.00	0.00	2.01	0.61	1.17	1.17	1.02	1.35	14.41
1956	1.85	0.53	0.00	0.56	0.74	0.33	1.22	1.43	0.99	0.00	1.19	0.00	8.84
1957	0.65	2.25	1.80	0.27	1.03	0.74	0.38	1.45	1.17	1.18	0.84	1.00	12.76
1958	1.83	1.16	0.80	1.03	0.00	1.90	1.49	0.00	1.17	1.08	1.64	0.90	13.00
1959	0.65	1.41	1.60	1.24	0.11	1.10	0.46	1.43	1.17	1.12	1.37	1.50	13.16
1960	1.50	1.44	0.03	2.47	1.73	0.03	0.78	0.97	1.13	1.18	1.06	1.43	13.75
1961	2.21	0.96	1.50	0.03	0.52	1.91	1.04	1.38	1.17	1.00	1.21	1.56	14.49
1962	1.21	1.09	1.33	0.00	1.90	1.21	1.71	1.38	0.46	0.59	1.77	1.36	14.01
1963	1.55	1.49	2.80	0.60	2.12	1.02	1.55	1.42	0.45	1.16	1.42	1.53	17.11
1964	0.25	1.79	1.08	0.73	0.87	2.24	1.09	1.32	0.22	1.01	0.97	1.38	12.95
1965	2.24	1.78	2.10	0.00	0.77	2.26	1.43	0.98	1.13	1.18	1.36	1.55	16.78
1966	1.79	1.58	0.44	0.00	0.72	0.02	0.46	1.30	1.17	1.12	1.01	0.68	10.29
1967	0.97	1.45	1.09	2.16	1.77	1.68	1.70	0.86	0.59	0.55	1.18	1.46	15.46
1968	1.03	1.12	1.65	1.30	1.07	0.00	0.87	0.59	1.11	1.04	1.59	1.01	12.38
1969	0.66	2.65	1.15	0.99	0.64	2.17	1.74	1.17	0.88	1.04	0.55	1.25	14.89
1970	1.29	1.91	2.30	0.00	1.32	1.60	1.43	0.47	1.15	0.52	1.39	2.04	15.42
1971	1.28	1.77	0.70	0.57	0.12	0.26	1.77	1.20	1.11	1.17	1.27	1.32	12.54
1972	1.68	1.16	2.27	1.59	0.16	2.09	0.00	1.46	1.17	1.18	0.04	0.84	13.64
1973	2.31	0.76	0.95	0.67	0.12	0.88	1.11	1.04	0.98	1.10	1.49	0.93	12.34
1974	0.67	0.77	1.61	0.08	0.00	0.77	1.28	1.38	1.16	1.04	0.85	0.00	9.61
1975	2.38	0.40	0.15	0.01	0.02	0.00	0.55	0.62	1.17	1.18	1.30	1.20	8.98
1976	0.62	1.19	1.29	0.54	1.39	0.28	0.42	1.46	1.17	1.18	0.86	0.73	11.13
1977	0.70	1.71	1.56	0.00	0.85	0.34	1.30	1.45	1.17	0.95	1.23	1.00	12.26
1978	0.31	1.38	0.68	2.00	0.00	1.63	1.64	0.71	0.83	0.46	0.04	1.31	10.99
1979	2.18	1.89	1.42	0.48	0.33	1.53	1.77	1.20	1.17	0.95	0.82	0.61	14.35
1980	2.02	1.13	0.47	0.35	0.00	2.32	1.70	1.09	0.77	1.18	1.04	1.25	13.32
1981	2.29	1.23	1.78	0.79	2.02	1.03	1.94	1.42	0.80	0.90	0.86	1.00	16.06
1982	0.54	2.29	2.31	1.31	1.96	1.38	1.72	1.23	1.04	1.04	1.34	0.93	17.09
1983	0.55	0.48	0.14	0.43	1.78	0.34	1.36	1.43	1.05	1.04	0.42	1.83	10.85
1984	1.39	2.47	2.12	0.00	0.00	2.11	2.06	0.64	0.49	0.56	0.55	0.69	13.08
1985	0.33	0.21	0.75	0.29	1.63	0.61	1.24	1.46	0.84	1.18	1.32	1.39	11.25
1986	1.12	1.61	0.82	1.34	0.00	0.00	1.68	1.46	1.01	1.13	0.16	0.00	10.33
1987	2.06	1.17	1.11	1.98	0.00	0.51	1.98	1.45	0.49	0.72	1.75	1.78	15.00
1988	1.54	1.15	0.99	0.65	0.00	1.02	1.52	1.18	0.88	1.18	1.14	0.67	11.92
1989	1.79	0.02	2.03	2.06	1.02	0.89	1.24	1.39	1.16	1.02	1.11	1.59	15.32
1990	1.52	0.88	1.24	0.00	0.01	1.07	2.09	1.46	0.73	1.18	1.04	0.76	11.98
1991	0.00	1.75	0.97	1.87	0.03	1.96	1.76	1.19	0.72	0.61	0.92	0.83	12.61
1992	0.70	1.77	1.75	1.23	0.33	0.64	1.48	1.44	1.17	0.89	0.77	1.44	13.61
1993	0.12	1.53	1.39	0.70	0.00	0.82	1.39	1.46	1.17	1.04	1.33	1.32	12.27
1994	1.91	1.25	1.20	1.40	1.34	0.98	1.46	1.18	1.08	1.17	1.13	1.39	15.49

First and second phase irrigation water use for 2030 – TM12.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.00	.27	.32	.40	.04	.00	.21	.12	.16	.21	.27	.00	1.99
1921	.30	.00	.05	.36	.11	.17	.25	.13	.02	.20	.06	.31	1.95
1922	.18	.06	.25	.21	.00	.25	.25	.15	.15	.15	.25	.33	2.23
1923	.30	.24	.33	.32	.00	.22	.25	.14	.16	.21	.22	.22	2.60
1924	.12	.00	.00	.19	.07	.00	.03	.16	.15	.18	.27	.08	1.25
1925	.17	.29	.30	.17	.13	.18	.26	.13	.09	.21	.27	.02	2.21
1926	.12	.14	.17	.27	.04	.04	.27	.20	.16	.18	.18	.34	2.13
1927	.10	.31	.16	.32	.21	.08	.24	.20	.16	.21	.24	.19	2.41
1928	.20	.29	.15	.06	.10	.00	.20	.19	.00	.05	.24	.00	1.47
1929	.22	.01	.31	.14	.13	.00	.15	.20	.14	.18	.23	.21	1.92
1930	.28	.26	.07	.15	.20	.17	.17	.21	.16	.14	.27	.35	2.44
1931	.23	.35	.23	.25	.00	.09	.19	.05	.15	.20	.27	.23	2.24
1932	.30	.15	.17	.52	.15	.08	.13	.20	.16	.07	.27	.35	2.53
1933	.35	.00	.12	.02	.15	.12	.00	.08	.16	.14	.08	.33	1.55
1934	.24	.00	.00	.51	.07	.02	.23	.17	.14	.21	.25	.32	2.16
1935	.36	.27	.45	.19	.02	.16	.19	.00	.16	.21	.27	.31	2.61
1936	.26	.00	.04	.32	.00	.23	.16	.21	.16	.20	.27	.33	2.16
1937	.31	.31	.10	.13	.18	.22	.02	.20	.04	.08	.20	.32	2.11
1938	.25	.30	.31	.29	.00	.13	.26	.11	.16	.14	.22	.25	2.41
1939	.27	.02	.34	.46	.24	.23	.16	.06	.00	.21	.26	.20	2.43
1940	.29	.26	.14	.25	.06	.00	.07	.21	.16	.20	.27	.31	2.23
1941	.21	.29	.41	.16	.00	.00	.07	.18	.15	.19	.20	.27	2.15
1942	.28	.00	.11	.21	.09	.11	.00	.01	.15	.06	.00	.31	1.34
1943	.00	.00	.08	.35	.00	.12	.28	.16	.11	.21	.27	.04	1.62
1944	.28	.22	.45	.47	.13	.00	.26	.17	.16	.21	.27	.35	2.97
1945	.38	.30	.27	.43	.00	.20	.16	.18	.16	.21	.27	.35	2.92
1946	.10	.07	.36	.43	.00	.00	.16	.21	.04	.21	.26	.21	2.04
1947	.18	.09	.01	.00	.07	.01	.05	.18	.16	.21	.27	.29	1.51
1948	.24	.23	.10	.36	.07	.02	.09	.19	.16	.20	.27	.24	2.16
1949	.29	.14	.34	.50	.25	.00	.12	.11	.16	.20	.18	.25	2.54
1950	.25	.00	.00	.32	.12	.04	.12	.18	.13	.21	.08	.20	1.66
1951	.26	.36	.22	.00	.18	.03	.22	.20	.15	.09	.24	.28	2.23
1952	.18	.16	.06	.26	.00	.21	.13	.20	.16	.21	.19	.33	2.07
1953	.25	.17	.15	.46	.00	.18	.14	.11	.15	.21	.27	.16	2.25
1954	.09	.00	.26	.09	.00	.20	.18	.15	.16	.21	.27	.34	1.95
1955	.32	.29	.04	.55	.00	.00	.23	.20	.16	.20	.27	.24	2.51
1956	.37	.12	.00	.21	.22	.00	.03	.21	.16	.10	.12	.00	1.55
1957	.02	.27	.24	.27	.00	.27	.00	.20	.16	.21	.27	.26	2.17
1958	.25	.11	.21	.36	.08	.31	.10	.02	.16	.17	.27	.35	2.39
1959	.05	.13	.28	.47	.00	.00	.00	.19	.16	.20	.25	.30	2.03
1960	.24	.15	.12	.47	.07	.09	.00	.19	.14	.20	.24	.23	2.13
1961	.34	.18	.28	.11	.00	.09	.08	.18	.16	.21	.24	.31	2.20
1962	.36	.04	.00	.17	.08	.04	.13	.18	.10	.16	.27	.34	1.86
1963	.21	.00	.37	.17	.31	.03	.10	.20	.08	.21	.26	.10	2.03
1964	.02	.03	.33	.39	.22	.29	.19	.18	.00	.14	.09	.19	2.06
1965	.32	.21	.28	.01	.12	.35	.23	.12	.09	.21	.20	.33	2.47
1966	.25	.03	.09	.10	.00	.07	.00	.09	.16	.18	.27	.33	1.56
1967	.31	.25	.44	.29	.18	.09	.19	.20	.16	.19	.21	.33	2.85
1968	.35	.23	.25	.31	.22	.00	.16	.06	.15	.21	.26	.32	2.51
1969	.07	.32	.15	.43	.01	.25	.24	.19	.12	.21	.03	.11	2.12
1970	.22	.22	.42	.07	.23	.20	.16	.09	.16	.12	.21	.33	2.44
1971	.21	.14	.15	.28	.17	.00	.20	.11	.15	.21	.24	.35	2.20
1972	.23	.03	.41	.38	.06	.22	.00	.20	.16	.20	.02	.17	2.08
1973	.36	.07	.24	.16	.00	.00	.06	.20	.11	.19	.23	.35	1.98
1974	.31	.13	.00	.11	.00	.14	.12	.20	.16	.21	.26	.00	1.63
1975	.36	.00	.11	.13	.00	.00	.18	.08	.16	.21	.27	.21	1.71
1976	.16	.17	.29	.09	.25	.11	.18	.20	.16	.21	.26	.17	2.23
1977	.02	.18	.20	.00	.16	.03	.11	.20	.16	.21	.19	.15	1.62
1978	.10	.24	.00	.36	.00	.15	.17	.14	.16	.15	.07	.30	1.83
1979	.24	.21	.22	.29	.11	.22	.14	.18	.16	.21	.26	.08	2.32
1980	.32	.02	.00	.06	.00	.28	.19	.19	.11	.21	.13	.26	1.77
1981	.35	.18	.31	.20	.32	.19	.24	.20	.12	.19	.27	.25	2.82
1982	.06	.29	.21	.22	.33	.17	.21	.11	.15	.15	.22	.34	2.46
1983	.17	.13	.01	.34	.29	.01	.05	.21	.14	.20	.14	.32	2.00
1984	.13	.34	.39	.00	.05	.26	.28	.18	.13	.21	.27	.31	2.56
1985	.03	.20	.12	.21	.16	.16	.22	.21	.07	.21	.20	.33	2.12
1986	.00	.22	.05	.18	.00	.00	.26	.21	.11	.21	.00	.00	1.24
1987	.24	.22	.12	.13	.00	.07	.15	.19	.06	.10	.25	.27	1.79
1988	.10	.28	.06	.37	.00	.21	.25	.14	.13	.21	.26	.35	2.36
1989	.24	.00	.08	.42	.17	.14	.11	.19	.16	.21	.12	.35	2.20
1990	.27	.36	.03	.05	.00	.23	.27	.19	.10	.21	.27	.27	2.24
1991	.00	.18	.13	.34	.05	.21	.23	.21	.16	.21	.21	.34	2.26
1992	.34	.14	.20	.40	.02	.06	.17	.21	.16	.21	.27	.25	2.44
1993	.01	.13	.03	.13	.14	.00	.18	.17	.16	.17	.20	.35	1.67
1994	.27	.33	.35	.03	.23	.00	.24	.19	.16	.21	.27	.23	2.51

First and second phase irrigation water use for 2030 – TM14.IRR Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	1.61	2.01	1.83	1.52	0.11	0.00	2.11	1.63	1.61	1.17	0.86	0.00	14.46
1921	3.39	0.00	0.17	0.77	0.45	0.07	2.47	1.18	0.81	1.61	1.24	1.72	13.88
1922	1.32	0.34	1.23	0.00	1.01	2.47	1.98	1.36	0.97	0.77	0.69	0.58	12.72
1923	0.49	0.48	0.47	0.03	0.27	0.60	1.41	1.64	1.33	1.01	0.78	0.79	9.30
1924	1.03	0.14	0.00	0.00	0.00	0.00	1.12	1.55	1.41	1.89	3.22	2.34	12.70
1925	1.42	1.09	2.13	0.00	1.62	0.68	2.10	1.36	0.79	1.24	0.98	0.59	14.00
1926	1.85	0.93	1.81	1.41	0.00	0.01	2.20	1.98	1.66	1.30	1.10	0.98	15.23
1927	1.26	1.49	0.33	0.68	1.36	0.04	1.85	1.43	1.35	1.04	0.79	0.69	12.31
1928	0.91	0.92	1.43	0.67	1.42	0.00	1.47	1.82	0.13	1.09	1.47	0.86	12.19
1929	2.73	0.00	1.14	0.00	0.26	1.03	1.56	1.95	1.50	1.30	1.01	0.89	13.37
1930	0.87	0.81	0.51	0.00	0.57	0.88	1.86	1.97	1.59	1.17	0.91	0.69	11.83
1931	0.58	0.79	1.51	0.55	0.00	0.57	2.28	0.11	1.27	1.80	1.38	1.04	11.88
1932	0.84	0.79	1.41	1.28	0.81	0.04	1.59	1.52	1.10	0.89	0.78	0.65	11.70
1933	0.50	0.00	0.47	0.00	1.11	0.54	1.70	0.79	1.14	0.95	1.76	1.88	10.84
1934	1.76	1.30	0.00	1.59	0.94	0.09	0.80	1.77	1.39	1.33	1.00	0.76	12.73
1935	0.61	0.49	0.42	0.16	0.00	0.00	2.23	0.00	1.66	2.12	1.61	1.18	10.48
1936	1.01	0.00	2.49	0.38	0.00	0.79	2.09	1.98	1.58	1.18	0.86	0.66	13.02
1937	0.55	0.48	0.25	0.78	0.38	1.56	1.12	1.54	0.00	1.02	1.57	1.40	10.65
1938	0.00	1.97	0.00	0.98	0.00	1.53	2.06	0.21	1.64	0.93	1.65	1.64	12.61
1939	1.56	0.00	0.72	0.88	1.18	0.93	1.73	0.00	0.88	2.12	1.56	1.27	12.83
1940	1.20	0.19	0.38	1.26	0.16	1.23	0.00	1.98	1.66	1.43	1.08	0.82	11.39
1941	0.73	0.72	0.38	0.15	0.00	0.00	1.01	1.43	1.40	1.65	1.29	1.12	9.88
1942	1.31	0.00	1.28	0.00	0.95	0.58	0.00	0.00	1.66	0.00	0.00	4.54	10.32
1943	0.00	0.00	0.69	1.49	0.00	2.09	2.42	1.95	0.00	1.75	1.40	0.43	12.22
1944	3.05	1.87	1.54	1.40	1.04	0.00	1.88	1.74	1.63	1.23	0.90	0.67	16.95
1945	0.49	0.37	0.27	0.81	0.99	0.07	1.76	1.14	0.86	0.67	0.53	0.42	8.38
1946	1.00	0.00	2.19	2.40	0.00	0.71	1.67	1.98	0.00	1.58	1.30	1.03	13.86
1947	0.97	0.00	1.26	0.48	2.00	0.56	1.49	1.60	1.24	0.94	0.72	0.58	11.84
1948	1.14	1.46	1.56	0.00	0.34	1.18	0.34	1.80	1.52	1.31	0.97	0.76	12.38
1949	1.15	1.33	0.34	1.78	0.76	1.02	1.01	0.89	1.58	1.31	1.05	0.87	13.09
1950	0.80	1.08	0.89	2.12	1.42	0.84	1.31	1.26	1.03	0.83	0.54	1.77	13.89
1951	1.41	1.15	0.26	0.00	1.85	0.66	0.91	1.15	1.64	0.35	1.55	1.24	12.17
1952	0.99	0.37	1.61	0.39	0.00	1.17	0.49	1.94	1.55	1.62	1.32	1.35	12.80
1953	1.12	0.00	2.13	2.06	0.00	0.55	1.90	0.54	1.47	1.84	1.36	1.17	14.14
1954	0.28	0.00	2.13	0.00	0.00	1.48	1.59	1.96	1.60	1.68	1.19	0.86	12.77
1955	1.03	1.25	1.70	1.43	0.53	0.06	2.47	0.84	1.15	0.94	0.74	0.63	12.77
1956	0.82	0.00	0.00	0.00	1.04	0.51	1.25	1.95	0.97	0.00	2.21	0.00	8.75
1957	0.01	2.46	2.30	0.88	0.07	0.13	0.00	1.98	1.66	1.99	1.42	1.08	13.98
1958	1.19	0.19	0.78	1.88	0.00	1.92	1.23	0.16	1.66	1.52	1.18	0.92	12.63
1959	1.16	0.54	2.20	0.60	0.89	0.75	0.10	1.87	1.56	1.13	0.91	0.84	12.55
1960	1.09	0.13	0.36	2.67	0.94	0.00	0.39	0.99	1.49	1.63	1.23	0.97	11.89
1961	0.86	0.65	1.71	0.00	0.04	2.04	0.90	1.97	1.66	1.25	0.96	0.84	12.88
1962	0.74	0.78	0.73	0.55	2.19	0.00	1.52	1.79	0.51	0.00	2.12	1.40	12.33
1963	1.07	1.26	1.14	0.00	1.56	0.84	1.27	1.64	0.43	1.15	0.97	0.97	12.30
1964	0.39	1.15	1.47	0.00	0.75	2.49	1.48	1.63	0.00	1.42	1.35	1.20	13.33
1965	1.14	1.19	1.16	0.00	1.53	2.87	0.52	1.42	1.48	1.16	0.93	0.81	14.21
1966	0.77	1.15	1.02	0.00	0.76	0.00	0.21	1.81	1.66	2.11	1.77	1.26	12.52
1967	0.93	0.78	1.64	1.23	0.91	0.72	1.01	0.82	0.64	0.51	0.49	0.55	10.23
1968	0.51	0.57	1.23	1.01	0.00	0.00	0.53	1.38	1.56	1.69	1.50	1.10	11.08
1969	0.56	1.78	1.52	0.99	0.00	2.45	1.43	1.37	1.18	0.97	1.23	1.30	14.78
1970	1.80	1.57	1.44	0.00	1.66	0.31	0.92	0.25	1.60	1.25	1.58	1.40	13.78
1971	1.23	1.12	0.63	0.00	0.00	0.00	2.18	1.58	1.45	1.84	1.36	1.03	12.42
1972	0.85	1.07	0.95	1.11	0.00	1.82	0.01	1.96	1.66	1.46	0.92	2.24	14.05
1973	2.07	0.00	1.80	0.00	0.03	1.05	0.07	1.91	0.91	1.98	1.51	1.13	12.46
1974	0.83	0.13	0.92	0.43	0.00	1.32	0.67	1.66	1.66	2.14	1.53	0.00	11.29
1975	3.46	0.13	0.67	0.00	0.00	0.00	0.65	0.99	1.66	2.10	2.23	1.63	13.52
1976	0.89	1.62	1.39	0.00	1.78	0.00	0.71	1.65	1.66	1.60	1.17	1.04	13.51
1977	0.51	1.87	1.39	0.00	0.64	0.00	0.93	1.98	1.61	1.68	1.27	1.62	13.50
1978	0.00	1.43	1.76	1.08	0.00	2.04	1.91	1.47	1.62	0.29	1.71	2.09	15.40
1979	2.35	1.54	1.86	0.52	0.07	0.43	1.94	1.79	1.32	0.98	0.73	0.99	14.52
1980	1.59	0.20	0.17	0.00	0.00	2.06	1.38	1.81	0.33	2.15	1.78	2.06	13.53
1981	1.85	1.25	1.62	1.04	1.63	0.05	1.74	1.19	0.88	0.69	0.55	0.52	13.01
1982	0.00	2.32	1.97	0.43	2.13	1.01	1.40	1.12	1.06	0.92	0.81	0.73	13.90
1983	1.22	0.00	0.77	0.00	1.68	0.00	0.68	1.98	1.01	1.71	1.29	1.66	12.00
1984	1.36	2.01	1.38	0.00	0.00	2.41	2.47	1.89	1.66	1.70	1.19	0.86	16.93
1985	0.00	0.14	0.42	0.00	0.00	0.69	1.38	1.98	0.58	1.81	1.39	1.04	9.43
1986	0.87	0.85	0.58	1.23	0.00	0.00	1.85	1.94	1.50	1.83	1.18	0.00	11.83
1987	2.24	0.63	1.47	0.76	0.00	0.79	1.06	1.93	0.51	0.27	1.99	1.57	13.22
1988	1.20	1.69	0.10	0.51	0.00	0.95	1.71	1.81	1.20	1.99	1.44	1.03	13.63
1989	0.84	0.00	1.24	1.95	1.30	1.32	0.60	1.88	1.50	1.11	0.91	0.81	13.46
1990	0.73	0.70	0.00	0.12	0.00	1.36	2.43	1.84	0.78	1.67	1.25	0.94	11.82
1991	0.00	1.40	0.00	2.19	0.00	1.60	0.27	1.98	1.66	1.29	0.98	0.77	12.14
1992	0.60	0.71	0.75	1.06	0.03	0.77	1.73	1.40	1.06	0.78	0.61	0.52	10.02
1993	0.00	0.48	0.40	0.28	0.09	0.00	1.60	1.98	1.66	1.42	1.16	1.03	10.10
1994	0.89	0.75	1.12	0.85	1.77	0.61	1.34	0.95	1.10	0.91	0.72	0.56	11.57

First and second phase irrigation water use for 2030 – TM20.IRR Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.37	0.00	0.00	0.00	0.00	0.00	0.79	0.04	0.64	0.62	1.09	0.80	4.35
1921	0.82	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.26	0.80	0.53	1.41	4.82
1922	0.43	0.00	0.00	0.00	0.00	0.00	0.72	0.76	0.64	0.81	1.01	0.76	5.13
1923	0.59	0.00	0.00	0.00	0.00	0.00	0.79	0.58	0.66	0.79	0.72	0.78	4.91
1924	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.61	0.65	1.11	0.10	3.95
1925	0.56	0.00	0.00	0.00	0.00	0.00	0.73	0.42	0.33	0.82	1.11	0.34	4.31
1926	0.97	0.00	0.00	0.00	0.00	0.00	0.67	0.73	0.66	0.69	0.59	1.07	5.38
1927	0.37	0.10	0.00	0.00	0.00	0.00	0.72	0.54	0.66	0.79	0.97	1.04	5.19
1928	0.64	0.00	0.00	0.00	0.00	0.00	0.21	0.42	0.02	0.19	1.07	0.16	2.71
1929	0.77	0.00	0.00	0.00	0.00	0.00	0.64	0.69	0.63	0.77	0.90	1.07	5.47
1930	1.03	0.00	0.00	0.00	0.00	0.00	0.33	0.74	0.65	0.31	1.11	0.96	5.13
1931	1.03	0.06	0.00	0.00	0.00	0.00	0.81	0.29	0.60	0.80	1.11	0.81	5.51
1932	1.27	0.00	0.00	0.00	0.00	0.00	0.59	0.76	0.59	0.28	1.10	1.04	5.63
1933	0.83	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.66	0.22	0.41	1.15	3.41
1934	0.84	0.00	0.00	0.00	0.00	0.00	0.37	0.54	0.24	0.81	0.93	1.12	4.85
1935	0.86	0.02	0.00	0.00	0.00	0.00	0.89	0.02	0.63	0.81	1.11	0.86	5.20
1936	0.84	0.00	0.00	0.00	0.00	0.00	0.92	0.72	0.47	0.79	0.90	0.66	5.30
1937	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.40	0.24	0.91	1.27	4.18
1938	0.16	0.00	0.00	0.00	0.00	0.00	0.47	0.33	0.66	0.60	0.95	0.83	4.00
1939	0.83	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.06	0.79	1.04	0.76	3.81
1940	1.06	0.00	0.00	0.00	0.00	0.00	0.35	0.76	0.64	0.65	1.10	1.12	5.68
1941	0.90	0.00	0.00	0.00	0.00	0.00	0.29	0.57	0.61	0.58	0.75	1.19	4.89
1942	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	1.45	3.04
1943	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.63	0.22	0.82	1.09	0.00	3.65
1944	1.16	0.00	0.00	0.00	0.00	0.00	0.59	0.62	0.63	0.81	1.08	0.79	5.68
1945	0.60	0.49	0.00	0.00	0.00	0.00	0.68	0.68	0.66	0.80	0.79	0.58	5.28
1946	0.97	0.00	0.00	0.00	0.00	0.00	0.50	0.68	0.17	0.60	1.11	1.19	5.22
1947	0.86	0.00	0.00	0.00	0.00	0.00	0.17	0.59	0.66	0.81	1.11	0.90	5.10
1948	1.05	0.00	0.00	0.00	0.00	0.00	0.51	0.42	0.65	0.78	1.06	0.96	5.43
1949	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.64	0.48	0.45	1.34	4.23
1950	1.33	0.00	0.00	0.00	0.00	0.00	0.28	0.71	0.62	0.82	0.16	0.98	4.90
1951	0.92	0.35	0.00	0.00	0.00	0.00	0.42	0.51	0.55	0.50	0.68	1.29	5.22
1952	0.84	0.00	0.00	0.00	0.00	0.07	0.46	0.72	0.58	0.81	0.56	1.19	5.23
1953	0.93	0.00	0.00	0.00	0.00	0.00	0.44	0.15	0.61	0.81	1.10	0.82	4.86
1954	0.39	0.00	0.00	0.00	0.00	0.00	0.36	0.51	0.59	0.80	1.04	0.93	4.62
1955	0.95	0.02	0.00	0.00	0.00	0.00	0.69	0.64	0.66	0.82	0.93	0.96	5.67
1956	1.04	0.00	0.00	0.00	0.00	0.00	0.22	0.59	0.56	0.55	0.50	0.00	3.46
1957	0.31	0.00	0.00	0.00	0.00	0.02	0.00	0.63	0.59	0.80	1.11	0.95	4.41
1958	1.09	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.63	0.67	0.90	1.38	4.95
1959	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.65	0.78	0.94	1.07	4.99
1960	0.98	0.00	0.00	0.00	0.00	0.00	0.14	0.73	0.57	0.69	0.97	0.99	5.07
1961	1.11	0.00	0.00	0.00	0.00	0.00	0.01	0.57	0.65	0.82	0.77	1.15	5.08
1962	0.94	0.00	0.00	0.00	0.00	0.00	0.61	0.64	0.41	0.22	1.09	1.47	5.38
1963	0.33	0.00	0.00	0.00	0.00	0.00	0.17	0.67	0.18	0.68	1.03	0.45	3.51
1964	0.05	0.00	0.00	0.00	0.00	0.46	0.39	0.56	0.00	0.57	0.40	0.91	3.34
1965	1.22	0.00	0.00	0.00	0.00	0.50	0.35	0.31	0.54	0.81	0.65	1.18	5.56
1966	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.60	0.72	1.06	1.47	5.60
1967	0.94	0.00	0.00	0.00	0.00	0.00	0.51	0.68	0.64	0.80	0.78	0.79	5.14
1968	0.84	0.00	0.00	0.00	0.00	0.00	0.23	0.16	0.57	0.66	0.94	1.04	4.44
1969	0.35	0.00	0.00	0.00	0.00	0.17	0.74	0.59	0.52	0.78	0.00	0.66	3.81
1970	0.65	0.00	0.00	0.00	0.00	0.00	0.41	0.16	0.59	0.39	0.43	1.37	4.00
1971	0.59	0.00	0.00	0.00	0.00	0.00	0.67	0.27	0.63	0.73	1.00	1.11	5.00
1972	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.64	0.67	0.41	0.64	4.03
1973	1.18	0.00	0.00	0.00	0.00	0.00	0.12	0.57	0.40	0.60	1.03	1.37	5.27
1974	1.16	0.00	0.00	0.00	0.00	0.00	0.29	0.75	0.66	0.79	1.09	0.12	4.86
1975	1.29	0.00	0.00	0.00	0.00	0.00	0.52	0.31	0.66	0.74	0.94	0.89	5.35
1976	0.35	0.00	0.00	0.00	0.00	0.00	0.25	0.73	0.58	0.81	0.96	0.66	4.34
1977	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.61	0.78	0.91	0.75	4.52
1978	0.56	0.00	0.00	0.00	0.00	0.00	0.53	0.08	0.61	0.43	0.49	1.16	3.86
1979	1.15	0.04	0.00	0.00	0.00	0.00	0.59	0.69	0.66	0.82	0.77	0.50	5.22
1980	1.27	0.00	0.00	0.00	0.00	0.07	0.45	0.62	0.49	0.81	0.38	1.21	5.30
1981	1.38	0.00	0.00	0.00	0.00	0.00	0.46	0.68	0.59	0.78	1.07	0.91	5.87
1982	0.93	0.02	0.00	0.00	0.00	0.00	0.46	0.64	0.61	0.47	0.91	0.86	4.90
1983	0.78	0.00	0.00	0.00	0.00	0.00	0.46	0.68	0.51	0.73	0.82	1.02	5.00
1984	0.79	0.21	0.00	0.00	0.00	0.00	0.90	0.70	0.45	0.79	1.09	0.95	5.88
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.76	0.51	0.81	0.54	1.32	4.06
1986	0.50	0.00	0.00	0.00	0.00	0.00	0.59	0.72	0.50	0.69	0.27	0.00	3.27
1987	0.85	0.00	0.00	0.00	0.00	0.00	0.38	0.39	0.06	0.77	0.92	1.19	4.56
1988	0.67	0.00	0.00	0.00	0.00	0.00	0.74	0.58	0.58	0.81	1.11	0.98	5.47
1989	0.99	0.00	0.00	0.00	0.00	0.00	0.75	0.74	0.61	0.82	0.67	1.18	5.76
1990	1.05	0.19	0.00	0.00	0.00	0.00	0.87	0.72	0.55	0.82	1.05	1.03	6.28
1991	0.00	0.00	0.00	0.00	0.00	0.20	0.66	0.76	0.66	0.82	0.73	0.56	4.39
1992	0.53	0.01	0.00	0.00	0.00	0.00	0.48	0.73	0.66	0.82	0.98	0.71	4.92
1993	0.58	0.00	0.00	0.00	0.00	0.00	0.51	0.74	0.61	0.58	1.00	0.87	4.89
1994	0.87	0.42	0.00	0.00	0.00	0.00	0.12	0.66	0.45	0.79	1.05	0.90	5.26

First and second phase irrigation water use for 2030 – TM21.IRR Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.03	.00	.00	.00	.00	.00	.10	.00	.08	.08	.14	.09	.52
1921	.09	.00	.00	.00	.00	.00	.06	.06	.03	.10	.06	.18	.59
1922	.04	.00	.00	.00	.00	.00	.09	.10	.08	.10	.13	.19	.73
1923	.18	.00	.00	.00	.00	.00	.10	.07	.08	.10	.11	.09	.74
1924	.10	.00	.00	.00	.00	.00	.00	.08	.08	.08	.14	.00	.48
1925	.06	.00	.00	.00	.00	.00	.09	.05	.04	.11	.14	.03	.51
1926	.12	.00	.00	.00	.00	.00	.08	.09	.08	.09	.07	.18	.71
1927	.03	.01	.00	.00	.00	.00	.09	.07	.08	.10	.12	.13	.63
1928	.07	.00	.00	.00	.00	.00	.02	.05	.00	.02	.14	.00	.29
1929	.09	.00	.00	.00	.00	.00	.08	.09	.08	.10	.11	.16	.70
1930	.15	.00	.00	.00	.00	.00	.03	.10	.08	.03	.14	.20	.73
1931	.12	.00	.00	.00	.00	.00	.10	.03	.08	.10	.14	.10	.68
1932	.16	.00	.00	.00	.00	.00	.07	.10	.07	.03	.14	.19	.77
1933	.15	.00	.00	.00	.00	.00	.00	.01	.08	.02	.04	.14	.45
1934	.10	.00	.00	.00	.00	.00	.04	.07	.03	.10	.12	.18	.63
1935	.19	.00	.00	.00	.00	.00	.11	.00	.08	.10	.14	.16	.79
1936	.10	.00	.00	.00	.00	.00	.12	.09	.06	.10	.14	.18	.79
1937	.15	.00	.00	.00	.00	.00	.00	.10	.05	.02	.11	.16	.60
1938	.00	.00	.00	.00	.00	.00	.05	.04	.08	.07	.12	.10	.47
1939	.10	.00	.00	.00	.00	.00	.03	.00	.00	.10	.13	.09	.45
1940	.13	.00	.00	.00	.00	.00	.04	.10	.08	.08	.14	.18	.75
1941	.11	.00	.00	.00	.00	.00	.03	.07	.08	.07	.09	.15	.60
1942	.12	.00	.00	.00	.00	.00	.00	.00	.08	.00	.00	.19	.38
1943	.00	.00	.00	.00	.00	.00	.11	.08	.02	.11	.14	.00	.46
1944	.14	.00	.00	.00	.00	.00	.07	.08	.08	.10	.14	.19	.81
1945	.17	.07	.00	.00	.00	.00	.08	.09	.08	.10	.14	.19	.93
1946	.12	.00	.00	.00	.00	.00	.06	.09	.02	.07	.14	.15	.64
1947	.10	.00	.00	.00	.00	.00	.01	.07	.08	.10	.14	.16	.68
1948	.13	.00	.00	.00	.00	.00	.06	.05	.08	.10	.14	.12	.68
1949	.16	.00	.00	.00	.00	.00	.00	.02	.08	.06	.05	.17	.54
1950	.17	.00	.00	.00	.00	.00	.03	.09	.08	.10	.01	.12	.60
1951	.11	.04	.00	.00	.00	.00	.05	.06	.07	.06	.08	.16	.63
1952	.10	.00	.00	.00	.00	.00	.05	.09	.07	.10	.06	.15	.63
1953	.11	.00	.00	.00	.00	.00	.05	.01	.08	.10	.14	.10	.59
1954	.03	.00	.00	.00	.00	.00	.04	.06	.07	.10	.13	.15	.60
1955	.15	.00	.00	.00	.00	.00	.08	.08	.08	.11	.12	.15	.77
1956	.13	.00	.00	.00	.00	.00	.02	.07	.07	.07	.06	.00	.41
1957	.02	.00	.00	.00	.00	.00	.00	.08	.08	.10	.14	.14	.57
1958	.14	.00	.00	.00	.00	.00	.03	.00	.08	.08	.11	.18	.62
1959	.11	.00	.00	.00	.00	.00	.00	.08	.08	.10	.12	.13	.62
1960	.12	.00	.00	.00	.00	.00	.01	.09	.07	.09	.12	.12	.62
1961	.18	.00	.00	.00	.00	.00	.00	.07	.08	.10	.09	.19	.72
1962	.15	.00	.00	.00	.00	.00	.07	.08	.05	.02	.14	.19	.71
1963	.03	.00	.00	.00	.00	.00	.01	.09	.02	.09	.13	.04	.40
1964	.00	.00	.00	.00	.00	.06	.04	.07	.00	.07	.04	.11	.39
1965	.15	.00	.00	.00	.00	.06	.04	.03	.07	.10	.08	.17	.70
1966	.13	.00	.00	.00	.00	.00	.00	.08	.08	.09	.14	.19	.71
1967	.11	.00	.00	.00	.00	.00	.06	.09	.08	.10	.10	.16	.69
1968	.15	.00	.00	.00	.00	.00	.02	.01	.07	.08	.12	.13	.59
1969	.03	.00	.00	.00	.00	.01	.09	.07	.07	.10	.00	.07	.45
1970	.07	.00	.00	.00	.00	.00	.05	.01	.07	.04	.05	.17	.47
1971	.06	.00	.00	.00	.00	.00	.08	.03	.08	.09	.13	.19	.66
1972	.12	.00	.00	.00	.00	.00	.00	.08	.08	.09	.04	.07	.49
1973	.15	.00	.00	.00	.00	.00	.01	.07	.05	.07	.13	.19	.67
1974	.14	.00	.00	.00	.00	.00	.03	.10	.08	.10	.14	.00	.60
1975	.16	.00	.00	.00	.00	.00	.06	.03	.08	.09	.12	.11	.66
1976	.03	.00	.00	.00	.00	.00	.02	.09	.07	.10	.12	.07	.52
1977	.09	.00	.00	.00	.00	.00	.00	.08	.08	.10	.11	.09	.56
1978	.06	.00	.00	.00	.00	.00	.06	.00	.08	.05	.06	.14	.45
1979	.14	.00	.00	.00	.00	.00	.07	.09	.08	.11	.13	.05	.67
1980	.16	.00	.00	.00	.00	.00	.05	.08	.06	.10	.04	.15	.65
1981	.18	.00	.00	.00	.00	.00	.05	.09	.08	.10	.14	.15	.79
1982	.11	.00	.00	.00	.00	.00	.05	.08	.08	.06	.11	.17	.66
1983	.09	.00	.00	.00	.00	.00	.05	.09	.06	.09	.10	.17	.66
1984	.09	.02	.00	.00	.00	.00	.12	.09	.06	.10	.14	.17	.78
1985	.00	.00	.00	.00	.00	.00	.00	.10	.06	.10	.06	.17	.50
1986	.05	.00	.00	.00	.00	.00	.07	.09	.06	.09	.02	.00	.39
1987	.10	.00	.00	.00	.00	.00	.04	.05	.00	.10	.12	.15	.55
1988	.07	.00	.00	.00	.00	.00	.09	.07	.07	.10	.14	.19	.75
1989	.13	.00	.00	.00	.00	.00	.09	.09	.08	.10	.08	.17	.76
1990	.13	.02	.00	.00	.00	.00	.11	.09	.07	.11	.13	.13	.79
1991	.00	.00	.00	.00	.00	.02	.08	.10	.08	.11	.13	.18	.70
1992	.16	.00	.00	.00	.00	.00	.06	.09	.08	.11	.14	.17	.81
1993	.06	.00	.00	.00	.00	.00	.06	.10	.08	.07	.13	.19	.68
1994	.10	.05	.00	.00	.00	.00	.00	.08	.06	.10	.13	.17	.70

First and second phase irrigation water use for 2030 – TM23.IRR Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.05	0.06	0.09	0.05	0.36
1921	0.07	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.01	0.07	0.03	0.11	0.39
1922	0.04	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.05	0.05	0.09	0.09	0.44
1923	0.08	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.06	0.07	0.07	0.06	0.44
1924	0.07	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.05	0.05	0.10	0.06	0.39
1925	0.06	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.02	0.07	0.09	0.02	0.37
1926	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.06	0.06	0.04	0.12	0.44
1927	0.05	0.01	0.00	0.00	0.00	0.00	0.06	0.04	0.06	0.07	0.07	0.08	0.44
1928	0.07	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.00	0.02	0.09	0.04	0.32
1929	0.06	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.05	0.06	0.07	0.09	0.43
1930	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.06	0.03	0.09	0.10	0.45
1931	0.08	0.02	0.00	0.00	0.00	0.00	0.07	0.00	0.05	0.07	0.09	0.08	0.46
1932	0.10	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.05	0.02	0.09	0.11	0.48
1933	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.03	0.05	0.11	0.38
1934	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.07	0.08	0.10	0.38
1935	0.10	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.05	0.07	0.09	0.10	0.48
1936	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.06	0.04	0.07	0.08	0.08	0.47
1937	0.10	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.03	0.01	0.08	0.11	0.40
1938	0.04	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.06	0.05	0.07	0.06	0.35
1939	0.06	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.07	0.09	0.06	0.33
1940	0.09	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.05	0.06	0.08	0.08	0.44
1941	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.05	0.06	0.06	0.09	0.40
1942	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.12	0.23
1943	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.02	0.07	0.09	0.02	0.32
1944	0.09	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.07	0.07	0.05	0.43
1945	0.05	0.03	0.00	0.00	0.00	0.00	0.06	0.06	0.05	0.07	0.06	0.05	0.43
1946	0.07	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.06	0.09	0.08	0.38
1947	0.07	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.06	0.07	0.07	0.06	0.39
1948	0.08	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.05	0.07	0.08	0.09	0.44
1949	0.11	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.05	0.05	0.04	0.12	0.43
1950	0.11	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.05	0.07	0.00	0.08	0.40
1951	0.07	0.03	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.07	0.11	0.48
1952	0.07	0.00	0.00	0.00	0.00	0.01	0.04	0.06	0.05	0.07	0.04	0.11	0.45
1953	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.05	0.07	0.09	0.06	0.38
1954	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.05	0.07	0.07	0.09	0.36
1955	0.09	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.07	0.08	0.08	0.47
1956	0.09	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.05	0.05	0.05	0.00	0.33
1957	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.05	0.07	0.07	0.09	0.36
1958	0.11	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.06	0.06	0.08	0.11	0.44
1959	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.07	0.08	0.40
1960	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.06	0.08	0.07	0.39
1961	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.06	0.07	0.06	0.12	0.48
1962	0.10	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.04	0.00	0.09	0.12	0.45
1963	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.02	0.06	0.09	0.06	0.36
1964	0.04	0.00	0.00	0.00	0.00	0.04	0.05	0.04	0.00	0.05	0.04	0.08	0.34
1965	0.08	0.00	0.00	0.00	0.00	0.05	0.04	0.02	0.05	0.07	0.05	0.11	0.47
1966	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.09	0.07	0.40
1967	0.07	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.06	0.07	0.05	0.10	0.45
1968	0.10	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.05	0.08	0.09	0.41
1969	0.02	0.00	0.00	0.00	0.00	0.02	0.06	0.04	0.04	0.07	0.01	0.04	0.30
1970	0.06	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.05	0.03	0.04	0.11	0.33
1971	0.06	0.00	0.00	0.00	0.00	0.00	0.06	0.03	0.05	0.06	0.09	0.06	0.41
1972	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.06	0.03	0.06	0.33
1973	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.04	0.05	0.09	0.08	0.42
1974	0.07	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.06	0.06	0.06	0.00	0.34
1975	0.12	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0.06	0.06	0.09	0.08	0.49
1976	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.05	0.07	0.07	0.06	0.36
1977	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.07	0.07	0.05	0.35
1978	0.03	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.06	0.04	0.05	0.11	0.35
1979	0.10	0.01	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.07	0.07	0.03	0.46
1980	0.11	0.00	0.00	0.00	0.00	0.01	0.05	0.05	0.04	0.07	0.04	0.08	0.45
1981	0.13	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.05	0.07	0.07	0.06	0.49
1982	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.05	0.04	0.06	0.11	0.38
1983	0.08	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.04	0.06	0.06	0.11	0.43
1984	0.05	0.00	0.00	0.00	0.00	0.00	0.08	0.06	0.05	0.07	0.06	0.08	0.45
1985	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.03	0.07	0.07	0.12	0.42
1986	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.02	0.06	0.00	0.00	0.24
1987	0.08	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.01	0.05	0.08	0.11	0.42
1988	0.08	0.00	0.00	0.00	0.00	0.02	0.07	0.05	0.05	0.07	0.08	0.05	0.47
1989	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.05	0.07	0.04	0.11	0.43
1990	0.07	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.05	0.07	0.08	0.09	0.46
1991	0.02	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.06	0.05	0.07	0.10	0.43
1992	0.08	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.06	0.07	0.07	0.10	0.47
1993	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.05	0.06	0.06	0.13	0.41
1994	0.07	0.04	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.07	0.08	0.11	0.45

First and second phase irrigation water use for 2030 – TM24.IRR Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.20	0.94	0.81	1.56	0.57	0.00	0.55	0.46	0.49	0.49	0.39	0.22	6.68
1921	1.39	0.00	0.00	0.89	0.91	0.00	0.79	0.35	0.18	0.61	0.30	0.79	6.21
1922	0.17	0.00	0.00	0.29	1.26	2.09	0.99	0.29	0.26	0.43	0.55	0.34	6.67
1923	0.47	0.56	0.51	0.00	0.81	0.88	0.52	0.56	0.49	0.39	0.40	0.73	6.32
1924	1.40	0.06	0.00	1.15	0.54	0.00	0.00	0.52	0.45	0.58	0.44	0.70	5.84
1925	1.03	0.47	0.91	1.33	1.54	1.19	0.83	0.52	0.00	0.64	0.68	0.06	9.20
1926	1.34	0.58	0.33	1.06	0.26	0.38	0.93	0.61	0.40	0.25	0.85	0.60	7.59
1927	0.66	1.28	0.00	1.08	1.40	0.82	0.66	0.56	0.49	0.34	0.43	0.99	8.71
1928	1.34	1.28	0.27	1.09	2.03	0.00	0.95	0.56	0.00	0.13	0.98	0.00	8.63
1929	1.17	0.00	0.07	0.00	1.77	1.80	0.16	0.59	0.47	0.40	0.74	0.91	8.08
1930	1.00	0.69	0.00	0.00	1.03	1.56	0.64	0.62	0.38	0.38	0.40	0.27	6.97
1931	0.37	0.92	0.87	1.05	0.34	0.60	0.79	0.04	0.43	0.62	0.57	0.42	7.02
1932	0.55	0.77	0.00	2.19	1.61	0.80	0.31	0.61	0.48	0.33	0.65	0.38	8.68
1933	0.29	0.00	0.00	0.00	1.78	0.81	0.44	0.30	0.49	0.17	0.46	1.58	6.32
1934	1.21	0.09	0.00	1.16	0.42	0.56	0.32	0.51	0.40	0.55	0.42	0.48	6.12
1935	0.68	0.58	0.73	0.00	0.67	0.00	0.83	0.00	0.49	0.63	0.67	0.36	5.64
1936	0.93	0.00	1.29	0.00	0.42	1.65	0.34	0.62	0.48	0.33	0.26	0.41	6.73
1937	0.54	0.50	0.00	1.17	1.40	1.76	0.06	0.55	0.00	0.33	0.74	1.24	8.29
1938	0.00	1.16	0.00	0.91	0.00	0.92	1.01	0.17	0.48	0.21	0.86	1.03	6.75
1939	1.10	0.00	0.00	1.01	0.80	2.13	0.45	0.00	0.00	0.63	1.03	0.84	7.99
1940	1.58	0.23	0.00	1.08	0.61	0.69	0.00	0.62	0.49	0.55	0.36	0.37	6.58
1941	0.69	1.01	0.18	0.00	0.15	1.11	0.34	0.36	0.22	0.64	0.73	0.70	6.13
1942	0.95	0.00	0.00	0.00	1.81	0.35	0.00	0.36	0.46	0.00	0.00	1.74	5.67
1943	0.00	0.12	0.00	0.89	0.00	1.61	1.04	0.55	0.00	0.64	0.88	0.00	5.73
1944	0.40	1.28	1.14	0.97	1.51	0.00	0.29	0.57	0.46	0.45	0.33	0.23	7.63
1945	0.17	0.12	0.08	0.23	1.20	0.04	0.92	0.58	0.44	0.29	0.25	0.21	4.53
1946	0.69	0.25	0.68	1.78	0.00	1.07	0.36	0.62	0.01	0.57	0.76	0.50	7.29
1947	0.71	0.00	0.00	0.06	1.33	0.90	0.75	0.48	0.49	0.40	0.31	0.62	6.05
1948	0.59	0.85	0.77	0.00	0.37	0.92	0.00	0.60	0.47	0.53	0.34	0.46	5.90
1949	0.63	0.46	0.00	1.19	1.33	1.43	0.00	0.30	0.45	0.61	0.71	0.67	7.78
1950	1.07	0.99	0.00	1.56	0.91	1.32	0.18	0.50	0.43	0.31	0.19	1.71	9.17
1951	0.84	1.54	0.00	0.30	2.29	1.55	0.37	0.52	0.49	0.00	1.02	0.91	9.83
1952	0.54	0.00	0.48	0.00	0.00	1.40	0.11	0.62	0.38	0.47	0.04	1.64	5.68
1953	1.47	0.31	0.72	1.60	0.00	0.57	0.79	0.15	0.34	0.64	0.56	0.93	8.08
1954	0.47	0.00	1.03	0.03	0.11	1.16	0.48	0.60	0.45	0.38	0.32	0.26	5.29
1955	0.69	0.92	0.46	1.57	0.47	0.30	0.96	0.14	0.46	0.64	0.46	0.61	7.68
1956	1.00	0.00	0.00	0.91	0.82	0.21	0.00	0.58	0.21	0.00	0.57	0.13	4.43
1957	0.02	1.35	0.82	0.15	0.63	0.38	0.00	0.60	0.48	0.55	0.34	0.76	6.08
1958	0.83	0.54	0.00	1.48	0.34	1.46	0.40	0.20	0.49	0.47	0.64	0.54	7.39
1959	0.57	0.00	0.27	1.60	0.76	1.55	0.00	0.54	0.49	0.57	0.61	0.79	7.75
1960	0.90	0.50	0.00	2.27	1.81	0.28	0.00	0.41	0.43	0.64	0.42	0.67	8.33
1961	1.08	0.37	0.54	0.40	0.52	1.59	0.55	0.62	0.42	0.29	0.49	0.77	7.64
1962	0.75	0.69	0.59	0.06	2.61	0.98	0.66	0.50	0.00	0.00	1.04	1.32	9.20
1963	0.86	0.24	1.02	0.42	1.66	1.44	0.04	0.61	0.00	0.62	0.80	1.10	8.81
1964	0.00	0.48	0.00	0.45	0.84	2.31	0.40	0.59	0.00	0.46	0.73	1.09	7.35
1965	0.76	0.76	0.82	0.00	1.56	2.36	0.22	0.43	0.47	0.49	0.61	1.05	9.53
1966	1.22	0.49	0.00	0.00	0.94	1.28	0.01	0.57	0.49	0.45	0.32	0.27	6.04
1967	0.53	0.31	0.08	1.77	1.59	0.97	0.57	0.52	0.49	0.39	0.44	0.98	8.64
1968	0.54	0.53	0.05	0.65	1.30	0.00	0.00	0.43	0.42	0.46	0.67	0.50	5.55
1969	0.03	1.21	0.18	1.16	0.64	2.04	0.37	0.41	0.42	0.48	0.31	1.26	8.51
1970	0.40	0.92	1.01	0.00	1.60	1.36	0.00	0.02	0.47	0.41	0.65	1.25	8.09
1971	1.00	0.98	0.00	1.08	0.35	0.00	0.72	0.42	0.44	0.57	0.41	0.27	6.24
1972	0.90	0.52	1.03	1.39	0.83	1.59	0.00	0.61	0.49	0.51	0.00	0.87	8.74
1973	1.66	0.00	0.51	0.39	0.18	1.38	0.00	0.56	0.20	0.45	0.89	0.61	6.83
1974	0.50	0.00	0.00	0.48	0.00	1.77	0.02	0.56	0.49	0.43	0.32	0.00	4.57
1975	1.68	0.26	0.00	0.00	0.68	0.00	0.05	0.09	0.49	0.63	0.56	0.42	4.86
1976	0.15	1.05	0.00	0.07	2.05	0.76	0.68	0.58	0.49	0.33	0.28	0.51	6.95
1977	0.99	1.39	0.00	0.00	0.84	0.84	0.13	0.61	0.49	0.40	0.50	0.95	7.14
1978	0.64	0.84	0.00	1.20	0.84	2.07	0.63	0.53	0.44	0.20	0.24	0.87	8.50
1979	1.75	0.88	0.08	0.00	0.24	1.68	0.73	0.60	0.33	0.27	0.25	0.65	7.46
1980	1.43	0.83	0.01	0.96	0.70	2.16	0.64	0.50	0.24	0.54	0.57	0.85	9.43
1981	1.35	1.12	1.05	0.65	2.28	1.12	0.90	0.55	0.38	0.37	0.34	0.37	10.48
1982	0.01	1.52	0.80	1.27	1.82	1.31	0.57	0.31	0.40	0.53	0.73	0.65	9.92
1983	0.48	0.00	0.00	0.00	1.69	0.04	0.47	0.61	0.30	0.43	0.23	1.60	5.85
1984	0.00	1.03	0.61	0.00	0.00	2.10	1.07	0.37	0.20	0.24	0.24	0.35	6.21
1985	0.03	0.23	0.00	0.00	0.33	1.14	0.21	0.62	0.30	0.58	0.44	0.35	4.23
1986	0.96	0.77	0.00	0.64	0.33	1.53	0.41	0.60	0.39	0.43	0.31	0.00	6.37
1987	0.23	0.09	0.00	0.98	0.99	0.52	0.75	0.54	0.24	0.56	0.55	0.43	5.88
1988	0.39	1.09	0.00	0.89	0.00	1.55	0.98	0.57	0.29	0.45	0.37	0.24	6.82
1989	0.93	0.00	0.00	1.79	1.24	0.25	0.32	0.58	0.49	0.43	0.43	0.36	6.82
1990	0.33	0.24	0.00	0.28	0.00	1.25	1.06	0.54	0.01	0.64	0.64	0.57	5.56
1991	0.00	0.79	0.00	1.60	0.00	1.73	0.65	0.62	0.36	0.27	0.46	0.85	7.33
1992	0.73	0.82	0.61	1.50	0.00	1.68	0.68	0.62	0.35	0.26	0.35	0.47	8.07
1993	0.00	0.80	0.00	0.00	0.76	1.00	0.51	0.56	0.49	0.47	0.67	0.65	5.91
1994	0.94	1.33	0.00	0.30	1.67	0.47	0.40	0.52	0.49	0.44	0.32	0.21	7.09

First and second phase irrigation water use for 2030 – TM26.IRR Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	0.00	0.00	0.00	0.49	0.48	0.00	0.20	0.00	0.16	0.29	0.22	0.23	2.07
1921	0.00	0.00	0.00	0.69	0.34	0.45	0.19	0.00	0.00	0.36	0.40	1.11	3.54
1922	0.00	0.00	0.00	0.10	0.79	1.01	0.16	0.00	0.08	0.22	0.44	0.28	3.08
1923	0.20	0.00	0.00	0.00	0.23	0.07	0.00	0.00	0.16	0.36	0.31	0.47	1.80
1924	0.11	0.00	0.00	0.12	0.38	0.00	0.00	0.00	0.10	0.28	0.55	0.73	2.27
1925	0.00	0.00	0.00	0.34	0.05	0.33	0.25	0.00	0.00	0.35	0.64	0.45	2.41
1926	0.25	0.00	0.00	0.24	0.00	0.42	0.00	0.00	0.16	0.02	0.81	0.45	2.35
1927	0.00	0.00	0.00	0.39	0.00	0.11	0.00	0.00	0.16	0.35	0.32	0.70	2.03
1928	0.00	0.00	0.00	0.12	0.45	0.00	0.07	0.00	0.00	0.26	0.87	0.40	2.17
1929	0.00	0.00	0.00	0.00	0.56	0.58	0.00	0.00	0.10	0.23	0.57	0.43	2.47
1930	0.19	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.16	0.04	0.83	0.42	2.12
1931	0.26	0.00	0.00	0.38	0.00	0.00	0.09	0.00	0.00	0.33	0.50	0.29	1.85
1932	0.05	0.00	0.00	0.77	0.00	0.53	0.00	0.00	0.11	0.24	0.39	0.29	2.38
1933	0.06	0.00	0.00	0.00	0.61	0.18	0.00	0.00	0.11	0.02	0.58	1.24	2.80
1934	0.04	0.00	0.00	0.01	0.05	0.00	0.07	0.00	0.04	0.36	0.29	0.28	1.14
1935	0.03	0.00	0.00	0.00	0.51	0.00	0.13	0.00	0.12	0.36	0.53	0.38	2.06
1936	0.00	0.00	0.00	0.00	0.00	0.80	0.21	0.00	0.16	0.14	0.14	0.52	1.97
1937	0.00	0.00	0.00	0.32	0.92	0.46	0.00	0.00	0.00	0.21	0.81	0.74	3.46
1938	0.00	0.00	0.00	0.00	0.00	0.12	0.28	0.00	0.16	0.00	0.66	1.05	2.27
1939	0.10	0.00	0.00	0.12	0.43	0.35	0.04	0.00	0.00	0.36	1.00	0.59	2.99
1940	0.06	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.16	0.36	0.26	0.28	1.59
1941	0.17	0.00	0.00	0.00	0.45	0.05	0.00	0.00	0.00	0.36	0.80	0.52	2.35
1942	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.16	0.00	0.56	0.93	1.71
1943	0.00	0.00	0.00	0.34	0.00	0.46	0.23	0.00	0.00	0.36	1.00	0.35	2.74
1944	0.00	0.00	0.00	0.49	0.14	0.00	0.18	0.00	0.16	0.30	0.25	0.19	1.71
1945	0.14	0.00	0.17	0.00	0.19	0.00	0.24	0.00	0.16	0.25	0.23	0.19	1.57
1946	0.00	0.00	0.00	0.21	0.00	0.23	0.00	0.00	0.00	0.24	0.57	0.52	1.77
1947	0.25	0.00	0.00	0.00	0.79	0.00	0.06	0.00	0.16	0.22	0.18	0.67	2.33
1948	0.00	0.00	0.00	0.00	0.45	0.09	0.00	0.00	0.15	0.36	0.24	0.68	1.97
1949	0.00	0.00	0.00	0.07	0.42	0.61	0.00	0.00	0.05	0.36	0.54	0.98	3.03
1950	0.00	0.00	0.00	0.09	0.78	0.78	0.07	0.00	0.16	0.35	0.31	1.14	3.68
1951	0.00	0.00	0.00	0.00	0.66	0.44	0.00	0.00	0.16	0.00	1.00	1.00	3.26
1952	0.14	0.00	0.00	0.37	0.00	0.38	0.00	0.00	0.13	0.36	0.32	0.36	2.06
1953	0.18	0.00	0.00	0.29	0.13	0.10	0.00	0.00	0.04	0.31	0.56	0.51	2.12
1954	0.00	0.00	0.00	0.00	0.00	0.08	0.06	0.00	0.14	0.32	0.30	0.26	1.16
1955	0.00	0.00	0.00	0.39	0.00	0.00	0.09	0.00	0.16	0.28	0.46	0.60	1.98
1956	0.00	0.00	0.00	0.25	0.11	0.16	0.00	0.00	0.00	0.00	0.61	0.00	1.13
1957	0.00	0.00	0.00	0.00	0.68	0.74	0.00	0.00	0.16	0.36	0.24	0.62	2.80
1958	0.00	0.00	0.00	0.40	0.40	0.57	0.00	0.00	0.16	0.32	0.51	0.83	3.19
1959	0.00	0.00	0.00	0.22	0.21	0.43	0.00	0.00	0.16	0.34	0.44	0.86	2.66
1960	0.00	0.00	0.00	0.42	0.54	0.05	0.00	0.00	0.00	0.36	0.61	0.47	2.45
1961	0.02	0.00	0.00	0.31	0.56	0.64	0.01	0.00	0.16	0.21	0.27	0.58	2.76
1962	0.14	0.00	0.00	0.00	0.81	0.31	0.01	0.00	0.00	0.00	1.00	1.26	3.53
1963	0.00	0.00	0.10	0.00	0.81	0.59	0.00	0.00	0.08	0.36	0.37	0.47	2.78
1964	0.00	0.00	0.00	0.08	0.49	0.74	0.00	0.00	0.00	0.30	0.66	0.74	3.01
1965	0.00	0.00	0.00	0.11	0.19	0.99	0.15	0.00	0.12	0.24	0.35	0.68	2.83
1966	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.16	0.09	0.78	0.59	2.24
1967	0.00	0.00	0.00	0.39	0.87	0.00	0.18	0.00	0.15	0.25	0.48	1.10	3.42
1968	0.23	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.13	0.30	0.40	0.62	2.29
1969	0.00	0.00	0.00	0.28	0.34	0.76	0.08	0.00	0.02	0.26	0.65	0.99	3.38
1970	0.00	0.00	0.00	0.00	0.52	0.51	0.00	0.00	0.14	0.33	0.47	0.64	2.61
1971	0.00	0.00	0.00	0.00	0.12	0.06	0.04	0.00	0.13	0.36	0.30	0.19	1.20
1972	0.15	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.16	0.35	0.15	0.58	1.59
1973	0.00	0.00	0.00	0.00	0.15	0.32	0.00	0.00	0.00	0.14	0.93	0.52	2.06
1974	0.16	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.15	0.35	0.25	0.57	2.03
1975	0.00	0.00	0.00	0.09	0.20	0.01	0.00	0.00	0.16	0.36	0.38	0.30	1.50
1976	0.00	0.00	0.00	0.00	0.21	0.33	0.08	0.00	0.16	0.22	0.24	0.79	2.03
1977	0.00	0.00	0.00	0.00	0.01	0.63	0.00	0.00	0.16	0.27	0.63	0.67	2.37
1978	0.00	0.00	0.00	0.58	0.74	0.75	0.00	0.00	0.11	0.07	0.42	0.66	3.33
1979	0.08	0.00	0.00	0.00	0.00	0.83	0.14	0.00	0.15	0.19	0.19	0.74	2.32
1980	0.19	0.00	0.00	0.00	0.00	0.14	0.02	0.00	0.03	0.31	0.70	0.67	2.06
1981	0.01	0.00	0.00	0.00	1.00	0.64	0.15	0.00	0.14	0.27	0.27	0.23	2.71
1982	0.00	0.00	0.00	0.32	0.96	0.41	0.00	0.00	0.07	0.27	0.68	0.76	3.47
1983	0.00	0.00	0.00	0.00	0.49	0.05	0.01	0.00	0.00	0.00	0.43	1.07	2.05
1984	0.00	0.00	0.00	0.00	0.00	0.91	0.27	0.00	0.10	0.30	0.25	0.22	2.05
1985	0.00	0.00	0.00	0.00	0.09	0.28	0.00	0.00	0.00	0.36	0.34	0.31	1.38
1986	0.02	0.00	0.00	0.26	0.29	0.59	0.11	0.00	0.02	0.29	0.46	0.00	2.04
1987	0.00	0.00	0.00	0.00	0.65	0.43	0.10	0.00	0.02	0.17	0.75	0.72	2.84
1988	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.34	0.74	0.32	2.07
1989	0.00	0.00	0.00	0.09	0.37	0.00	0.00	0.00	0.16	0.36	0.37	0.32	1.67
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.36	0.43	0.33	1.41
1991	0.00	0.00	0.00	0.59	0.00	0.85	0.18	0.00	0.16	0.14	0.20	0.21	2.33
1992	0.06	0.00	0.00	0.42	0.00	0.20	0.00	0.00	0.16	0.36	0.26	0.33	1.79
1993	0.00	0.00	0.00	0.00	0.22	0.00	0.03	0.00	0.16	0.23	0.23	0.26	1.13
1994	0.00	0.00	0.00	0.01	0.59	0.27	0.00	0.00	0.14	0.36	0.29	0.20	1.86

First and second phase irrigation water use for 2030 – V3.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.71	2.41	1.07	4.10	5.20	1.01	1.37	1.35	1.22	1.12	2.40	2.71	24.67
1921	2.67	.00	.00	5.35	4.61	5.04	1.94	1.00	.59	1.53	.59	3.62	26.92
1922	.00	.00	.00	3.28	2.56	5.59	2.32	1.50	1.01	1.04	2.29	4.42	24.01
1923	3.27	2.68	.01	1.71	3.28	1.28	1.56	1.15	1.22	1.53	2.36	2.33	22.39
1924	2.35	.00	1.48	2.92	2.12	.00	.30	1.09	1.06	1.17	2.39	2.08	16.96
1925	3.43	2.04	1.61	2.84	4.66	1.02	2.25	.90	.00	1.53	2.40	.00	22.68
1926	4.07	2.09	1.31	5.32	2.04	1.40	2.53	1.47	1.22	.00	2.36	3.76	27.58
1927	1.92	3.83	.31	4.07	4.09	3.64	1.71	1.44	1.22	1.53	1.59	2.69	28.05
1928	3.08	3.36	.00	5.10	5.33	.00	1.98	1.49	.00	.89	2.36	.58	24.16
1929	.67	1.31	1.36	.66	4.40	4.47	2.13	1.48	1.21	.64	1.63	3.21	23.15
1930	4.25	3.35	.00	.39	4.59	5.78	.33	1.52	1.22	1.07	2.40	4.47	29.38
1931	4.25	2.67	2.98	5.25	.20	1.30	1.85	.00	.46	1.51	2.40	4.08	26.93
1932	4.77	4.07	.00	4.57	5.22	4.83	1.60	1.52	1.22	.60	2.40	4.07	34.88
1933	3.76	.00	.00	.24	4.82	2.81	1.58	1.05	1.21	.41	1.11	4.08	21.06
1934	2.71	1.07	.00	4.07	3.69	3.96	.51	1.31	1.18	1.53	2.22	4.01	26.25
1935	3.71	4.00	.16	.00	3.35	.82	1.98	.00	1.21	1.52	2.39	2.36	21.51
1936	2.72	.00	3.44	.86	1.30	4.56	2.42	1.52	1.22	1.53	2.40	3.06	25.03
1937	4.20	3.09	.53	3.53	3.94	3.05	.00	1.51	.15	.85	2.16	3.55	26.55
1938	1.46	2.72	.00	1.89	.00	1.63	2.33	.78	1.22	.02	1.98	3.72	17.75
1939	2.85	.19	2.49	5.31	3.24	5.29	1.52	.00	.00	1.53	2.37	2.98	27.77
1940	3.58	1.50	.75	4.54	2.50	4.66	.00	1.52	1.22	1.47	2.40	3.24	27.38
1941	4.02	3.02	1.37	.00	2.65	.09	2.58	.92	.11	1.53	1.95	2.37	20.60
1942	2.91	.00	.39	3.50	2.70	.90	.00	.90	1.18	.00	.00	3.76	16.24
1943	.30	.50	.00	1.35	1.19	3.97	2.75	1.48	.00	1.53	2.40	1.25	16.72
1944	1.47	3.47	3.82	3.93	2.21	.00	1.87	1.29	1.22	1.53	2.40	4.04	27.24
1945	4.97	3.23	4.01	2.82	3.82	2.51	2.10	1.45	1.22	1.51	2.37	3.31	33.33
1946	1.89	1.76	2.68	4.79	2.06	3.46	1.65	1.52	.06	1.07	2.34	4.20	27.47
1947	3.40	.00	.00	4.74	.67	2.68	2.39	1.27	1.22	1.53	2.40	2.51	22.82
1948	2.00	2.44	2.79	.69	2.05	3.99	.00	1.52	1.22	1.53	2.40	3.12	23.74
1949	1.24	2.50	.01	4.48	4.66	3.66	.84	.95	1.03	1.49	1.71	4.48	27.05
1950	3.08	2.00	1.28	5.18	5.47	3.24	.47	1.22	1.16	1.53	.00	3.56	28.20
1951	2.15	4.20	.00	.96	5.43	3.46	.58	1.37	1.19	.00	2.40	4.48	26.21
1952	4.75	.46	1.60	5.44	.00	4.60	.49	1.52	1.03	1.53	1.55	3.89	26.85
1953	4.03	.57	2.85	5.05	.11	4.62	1.81	.92	.92	1.53	2.40	2.35	27.17
1954	1.30	.02	2.62	.00	.04	3.89	1.87	1.49	1.11	1.51	2.36	4.20	20.41
1955	1.07	2.12	1.58	6.03	.18	1.88	2.36	.30	1.22	1.53	2.40	2.79	23.46
1956	1.31	.95	.00	3.39	4.20	2.19	.00	1.26	.52	.00	1.88	.00	15.70
1957	.00	3.83	3.02	3.36	4.24	4.23	.00	1.48	1.22	1.44	2.40	3.12	28.34
1958	2.13	1.23	.13	3.58	3.39	4.82	1.65	.52	1.22	1.47	2.21	3.17	25.53
1959	1.29	1.14	1.22	5.96	2.94	3.88	.10	.96	1.22	1.53	1.67	2.45	24.36
1960	1.96	.18	.00	5.71	1.80	3.64	.00	.97	.61	1.53	2.40	1.96	20.75
1961	3.31	1.30	2.19	1.15	3.01	4.67	1.94	1.41	1.22	1.53	1.45	3.06	26.24
1962	2.81	.02	.00	2.12	6.58	2.98	1.42	1.41	.00	.00	2.40	4.45	24.20
1963	1.36	.93	3.48	1.31	4.50	4.57	1.90	1.52	.57	1.53	1.94	3.91	27.51
1964	.00	2.33	.66	.88	4.15	5.48	1.87	1.45	.20	1.17	1.52	3.24	22.97
1965	2.06	1.52	2.94	1.51	3.24	5.82	1.38	1.22	.96	1.53	1.44	2.17	25.79
1966	3.14	2.97	.78	.00	2.44	2.90	2.00	1.41	1.22	1.29	2.35	4.18	24.69
1967	2.60	.22	.90	3.83	6.29	2.90	2.46	1.50	1.22	1.50	1.13	4.35	28.90
1968	4.45	1.41	.28	2.95	4.74	1.25	.58	1.25	1.19	1.18	2.40	3.23	24.91
1969	.17	2.83	.81	3.62	3.44	4.78	1.63	1.22	.92	1.21	1.27	2.74	24.64
1970	1.47	2.28	2.16	1.88	5.59	4.79	.00	.57	1.22	1.23	1.90	3.54	26.62
1971	1.84	2.64	.02	2.48	1.81	2.82	2.14	.83	.92	1.49	2.36	4.36	23.71
1972	3.53	1.85	2.51	4.05	.98	3.95	.00	1.47	1.22	1.52	.01	2.38	23.46
1973	3.93	1.72	1.63	2.26	3.66	2.99	.30	1.20	.64	.78	2.27	4.29	25.67
1974	3.64	.11	.00	1.22	1.20	3.93	.00	1.35	1.22	1.44	2.39	.49	16.99
1975	4.21	.84	.00	1.98	3.13	1.40	.31	.54	1.22	1.53	2.35	3.64	21.14
1976	.49	2.22	.00	.85	4.62	2.54	2.17	1.51	1.22	1.53	2.31	2.34	21.80
1977	2.27	1.53	.59	.00	2.36	4.97	.23	1.40	1.21	1.49	1.18	2.23	19.46
1978	.62	1.09	2.04	3.12	3.66	5.07	1.32	1.26	.96	.83	.26	1.61	21.85
1979	3.70	2.09	1.76	.34	2.85	5.11	2.36	1.44	1.22	1.53	2.34	2.34	27.09
1980	4.10	.70	.00	.01	2.79	2.90	1.45	1.19	.70	1.43	1.37	1.57	18.21
1981	3.86	3.11	2.38	1.85	5.23	3.01	2.30	1.47	1.15	1.38	2.40	3.52	31.66
1982	1.38	3.74	2.05	3.51	6.20	3.31	1.24	.46	1.11	1.28	1.43	4.38	30.08
1983	2.18	.00	.00	.00	4.19	2.30	1.16	1.46	.56	.50	.75	3.13	16.25
1984	2.50	2.97	2.71	3.06	.00	5.21	2.70	1.41	1.22	1.47	2.40	3.69	29.34
1985	.00	1.60	.44	.61	2.11	2.52	1.25	1.52	.57	1.53	2.27	3.81	18.21
1986	3.41	2.09	.00	1.56	4.35	2.70	1.38	1.51	.91	1.53	.53	.00	19.97
1987	1.22	.62	.72	1.42	5.38	4.13	1.58	1.41	.20	.72	2.04	3.69	23.14
1988	1.36	1.92	.00	3.46	.95	4.10	1.86	1.29	.41	1.53	2.26	4.39	23.52
1989	1.98	.00	.73	4.47	3.76	2.70	.00	1.47	1.21	1.46	1.87	4.48	24.13
1990	3.65	3.80	.93	.66	.38	3.31	2.73	1.07	.62	1.48	2.33	3.67	24.63
1991	.47	3.22	.00	3.82	3.07	5.23	1.97	1.52	1.22	1.52	1.99	4.20	28.23
1992	3.97	2.28	.51	4.61	1.93	4.01	2.00	1.52	1.22	1.53	1.99	3.75	29.30
1993	.00	2.29	1.58	2.27	2.37	2.75	1.59	1.51	1.22	1.37	1.90	4.26	23.09
1994	2.19	3.56	.61	2.72	5.78	3.01	1.43	1.25	1.22	1.53	2.40	4.48	30.17

First and second phase irrigation water use for 2030 – WAG.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.05	.31	.24	.19	.00	.00	.18	.03	.15	.12	.21	.08	1.57
1921	.23	.00	.05	.19	.11	.18	.23	.17	.01	.15	.06	.25	1.62
1922	.12	.12	.18	.04	.06	.18	.16	.20	.14	.04	.19	.23	1.67
1923	.30	.17	.30	.07	.14	.06	.19	.13	.15	.14	.15	.09	1.87
1924	.16	.03	.00	.01	.04	.00	.00	.16	.13	.11	.21	.08	.93
1925	.14	.25	.35	.14	.13	.24	.18	.16	.04	.15	.21	.00	1.98
1926	.08	.19	.00	.11	.14	.10	.19	.20	.14	.14	.10	.25	1.65
1927	.07	.36	.03	.00	.28	.07	.23	.14	.15	.15	.17	.17	1.82
1928	.10	.32	.11	.06	.10	.00	.17	.18	.00	.00	.18	.03	1.25
1929	.16	.06	.25	.00	.12	.00	.19	.20	.11	.13	.18	.22	1.62
1930	.19	.31	.26	.10	.24	.19	.08	.20	.15	.03	.21	.27	2.22
1931	.21	.33	.23	.04	.00	.12	.22	.08	.14	.15	.21	.15	1.87
1932	.27	.06	.11	.30	.03	.12	.18	.20	.14	.04	.21	.27	1.93
1933	.25	.00	.11	.00	.20	.11	.09	.07	.15	.04	.05	.22	1.29
1934	.17	.00	.00	.36	.00	.10	.18	.15	.09	.15	.18	.24	1.61
1935	.32	.31	.23	.00	.00	.12	.22	.00	.15	.15	.21	.21	1.92
1936	.19	.05	.24	.21	.07	.22	.23	.20	.11	.15	.21	.24	2.13
1937	.29	.24	.07	.10	.17	.20	.00	.19	.09	.03	.15	.22	1.76
1938	.04	.28	.09	.23	.00	.13	.21	.10	.15	.11	.17	.12	1.60
1939	.15	.09	.09	.17	.14	.11	.19	.00	.01	.15	.20	.12	1.42
1940	.28	.18	.00	.15	.00	.00	.10	.20	.15	.13	.21	.24	1.64
1941	.17	.33	.21	.00	.00	.00	.10	.13	.13	.12	.12	.20	1.50
1942	.19	.02	.05	.00	.18	.12	.00	.02	.13	.00	.00	.24	.95
1943	.00	.05	.21	.19	.00	.23	.25	.16	.06	.15	.21	.00	1.51
1944	.24	.21	.35	.24	.14	.00	.17	.15	.14	.15	.21	.27	2.27
1945	.30	.35	.28	.08	.08	.10	.18	.18	.15	.15	.21	.27	2.32
1946	.15	.12	.23	.27	.00	.04	.17	.20	.00	.15	.21	.17	1.70
1947	.13	.08	.06	.03	.10	.03	.09	.17	.15	.15	.20	.23	1.42
1948	.22	.27	.14	.06	.09	.01	.14	.16	.14	.15	.20	.15	1.74
1949	.27	.10	.10	.23	.18	.00	.14	.11	.14	.11	.07	.21	1.67
1950	.28	.28	.01	.11	.16	.04	.16	.18	.14	.15	.03	.15	1.70
1951	.21	.38	.11	.00	.13	.02	.22	.16	.15	.06	.16	.21	1.82
1952	.16	.19	.00	.22	.00	.21	.15	.20	.14	.15	.07	.24	1.72
1953	.17	.14	.11	.26	.00	.15	.14	.07	.14	.15	.20	.10	1.63
1954	.12	.06	.10	.00	.00	.05	.10	.13	.13	.15	.21	.23	1.28
1955	.27	.32	.04	.33	.00	.00	.22	.19	.15	.15	.18	.18	2.02
1956	.26	.13	.00	.00	.12	.02	.09	.16	.14	.06	.06	.00	1.03
1957	.00	.30	.19	.03	.06	.19	.06	.18	.14	.15	.21	.20	1.71
1958	.23	.16	.20	.14	.00	.22	.09	.00	.14	.10	.17	.25	1.70
1959	.13	.14	.11	.20	.02	.01	.05	.18	.15	.14	.16	.18	1.49
1960	.19	.14	.00	.32	.09	.03	.09	.18	.14	.15	.16	.15	1.62
1961	.30	.21	.16	.00	.00	.01	.04	.17	.15	.15	.14	.25	1.59
1962	.24	.05	.13	.10	.24	.00	.17	.18	.10	.09	.21	.26	1.78
1963	.16	.09	.26	.07	.24	.08	.16	.19	.07	.14	.20	.02	1.67
1964	.00	.16	.18	.20	.23	.29	.14	.15	.00	.09	.04	.16	1.64
1965	.28	.26	.21	.00	.19	.30	.16	.11	.12	.15	.12	.22	2.13
1966	.22	.05	.15	.00	.00	.00	.00	.16	.14	.13	.20	.26	1.30
1967	.21	.12	.19	.20	.21	.14	.18	.19	.15	.15	.15	.23	2.13
1968	.28	.22	.16	.18	.11	.00	.12	.06	.13	.15	.20	.15	1.77
1969	.10	.32	.11	.16	.03	.26	.24	.18	.12	.15	.00	.05	1.71
1970	.17	.28	.26	.06	.22	.22	.17	.06	.15	.06	.10	.25	1.99
1971	.15	.21	.20	.11	.11	.00	.17	.11	.14	.13	.18	.25	1.78
1972	.16	.07	.33	.11	.06	.10	.07	.18	.15	.13	.01	.06	1.44
1973	.30	.13	.13	.00	.05	.00	.06	.19	.08	.11	.18	.27	1.50
1974	.28	.15	.08	.00	.00	.18	.14	.18	.15	.15	.19	.00	1.50
1975	.27	.08	.00	.00	.00	.00	.17	.08	.15	.15	.20	.18	1.28
1976	.09	.27	.21	.03	.28	.07	.06	.20	.14	.15	.18	.12	1.80
1977	.07	.23	.14	.00	.19	.08	.05	.20	.14	.15	.15	.10	1.50
1978	.10	.20	.00	.13	.11	.13	.19	.03	.15	.08	.03	.21	1.36
1979	.25	.29	.19	.11	.18	.19	.20	.19	.15	.15	.18	.07	2.15
1980	.30	.14	.00	.00	.00	.22	.19	.19	.08	.15	.04	.20	1.50
1981	.30	.14	.26	.10	.28	.03	.17	.20	.13	.14	.19	.06	2.00
1982	.09	.35	.25	.13	.28	.10	.13	.14	.14	.07	.15	.24	2.08
1983	.15	.07	.12	.14	.24	.03	.11	.19	.11	.12	.08	.25	1.63
1984	.14	.27	.22	.01	.00	.21	.26	.18	.12	.15	.21	.23	2.00
1985	.01	.06	.20	.10	.14	.19	.17	.20	.09	.15	.08	.25	1.64
1986	.10	.22	.18	.14	.04	.03	.23	.20	.12	.15	.00	.00	1.41
1987	.22	.28	.27	.06	.00	.00	.17	.13	.00	.10	.19	.21	1.62
1988	.26	.23	.05	.15	.02	.19	.21	.17	.12	.14	.21	.27	2.02
1989	.21	.07	.21	.21	.20	.13	.14	.20	.13	.15	.06	.24	1.95
1990	.23	.30	.00	.00	.11	.24	.25	.19	.11	.15	.21	.20	2.00
1991	.00	.24	.00	.27	.05	.18	.16	.20	.15	.15	.18	.26	1.84
1992	.25	.23	.00	.12	.00	.11	.19	.17	.15	.15	.21	.17	1.75
1993	.00	.22	.10	.12	.06	.03	.15	.17	.15	.12	.15	.27	1.54
1994	.22	.40	.09	.11	.28	.07	.21	.18	.14	.15	.20	.25	2.29

First and second phase irrigation water use for 2030 – ZAAID.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1920	.00	.00	.00	1.21	1.59	.00	.21	.00	.47	1.09	2.72	3.14	10.42
1921	.28	.00	.00	1.38	1.04	.51	.30	.00	.00	1.09	1.79	2.30	8.69
1922	.00	.00	.00	.28	1.44	2.77	.68	.00	.25	.66	2.95	3.78	12.80
1923	.74	.00	.00	.00	.95	.44	.26	.00	.46	1.09	2.80	1.89	8.63
1924	.65	.00	.00	.97	1.45	.00	.00	.00	.42	.98	2.94	2.49	9.90
1925	.11	.00	.11	.42	1.41	.84	.76	.00	.00	1.08	2.99	1.85	9.57
1926	.62	.00	.00	.70	.00	1.08	.26	.00	.47	.11	2.97	3.68	9.89
1927	.00	.00	.00	1.52	1.47	.42	.00	.00	.47	1.08	2.65	2.40	10.02
1928	.23	.00	.00	.53	2.04	.00	.22	.00	.00	.67	2.70	.89	7.30
1929	.00	.00	.00	.00	2.35	2.10	.03	.00	.40	.69	2.64	3.45	11.66
1930	1.07	.00	.00	.00	.72	1.66	.00	.00	.47	.54	2.99	3.73	11.17
1931	.75	.00	.00	1.24	.00	.29	.32	.00	.19	1.06	2.99	3.35	10.19
1932	.39	.00	.00	2.33	.06	1.46	.00	.00	.31	.61	2.99	3.47	11.62
1933	.60	.00	.00	.00	1.82	1.18	.15	.00	.40	.19	1.99	3.65	9.96
1934	.10	.00	.00	.77	.79	.47	.30	.00	.29	1.09	2.96	3.26	10.02
1935	.50	.00	.00	.00	1.78	.34	.47	.00	.43	1.08	2.99	3.22	10.81
1936	.03	.00	.00	.00	.00	2.63	.67	.00	.47	1.09	2.99	2.94	10.82
1937	.43	.00	.00	1.31	2.49	1.90	.00	.00	.00	.79	2.50	3.36	12.78
1938	.00	.00	.00	.03	.00	1.14	.77	.00	.45	.00	2.22	3.22	7.84
1939	.54	.00	.00	.30	1.53	1.88	.07	.00	.00	1.07	2.98	3.00	11.38
1940	.63	.00	.00	.44	.84	.96	.00	.00	.47	1.03	2.96	3.37	10.70
1941	.62	.00	.00	.00	1.35	.72	.00	.00	.08	1.09	2.42	2.27	8.55
1942	.00	.00	.00	.04	.95	.17	.00	.00	.47	.00	1.00	3.24	5.86
1943	.00	.00	.00	1.46	.00	1.50	.81	.00	.00	1.09	2.99	1.32	9.17
1944	.00	.00	.00	1.76	.94	.00	.45	.00	.47	1.09	2.93	3.69	11.33
1945	1.43	.00	.27	.00	.88	.00	.67	.00	.47	1.08	2.96	3.70	11.46
1946	.00	.00	.00	1.20	.04	1.03	.00	.00	.00	.45	2.96	3.34	9.02
1947	.85	.00	.00	.00	1.92	.93	.20	.00	.47	1.09	2.99	2.35	10.80
1948	.19	.00	.14	.00	1.21	1.10	.00	.00	.45	1.09	2.99	2.82	9.99
1949	.00	.00	.00	.94	1.54	.81	.00	.00	.29	1.07	2.16	3.44	10.25
1950	.05	.00	.00	1.25	.94	2.52	.11	.00	.37	.91	1.56	3.42	11.13
1951	.00	.00	.00	.00	2.59	2.15	.00	.00	.47	.00	2.98	3.69	11.88
1952	.80	.00	.00	.63	.00	1.27	.00	.00	.41	1.09	2.61	3.35	10.15
1953	.97	.00	.00	1.25	.25	.41	.17	.00	.24	1.03	2.99	2.06	9.37
1954	.00	.00	.00	.00	.00	1.14	.31	.00	.42	1.05	2.92	3.56	9.40
1955	.00	.00	.00	1.80	.28	.00	.44	.00	.44	.99	2.99	2.64	9.57
1956	.00	.00	.00	.89	1.00	.35	.00	.00	.08	.00	1.94	.66	4.92
1957	.00	.00	.00	.00	1.97	1.57	.00	.00	.46	1.09	2.99	2.47	10.54
1958	.13	.00	.00	1.78	1.74	1.90	.00	.00	.47	.96	2.87	2.96	12.81
1959	.00	.00	.00	1.45	1.00	1.42	.00	.00	.47	1.04	2.43	2.89	10.70
1960	.00	.00	.00	1.90	1.76	.58	.00	.00	.00	1.09	2.99	1.90	10.22
1961	.37	.00	.00	.61	1.41	2.15	.26	.00	.47	1.09	2.50	2.85	11.71
1962	.69	.00	.00	.00	2.73	1.48	.11	.00	.00	.00	2.99	3.78	11.78
1963	.00	.00	.16	.00	1.83	1.77	.00	.00	.16	1.09	2.57	2.95	10.54
1964	.00	.00	.00	.19	1.69	2.64	.00	.00	.00	.90	2.44	3.29	11.15
1965	.05	.00	.02	.72	1.57	3.11	.46	.00	.37	1.09	2.40	2.21	12.01
1966	.05	.00	.00	.00	.57	2.34	.00	.00	.47	.66	2.77	3.44	10.29
1967	.00	.00	.00	1.17	2.99	.07	.44	.00	.45	1.08	1.90	3.65	11.75
1968	.93	.00	.00	.00	2.05	.00	.00	.00	.32	.84	2.99	2.91	10.04
1969	.00	.00	.00	.75	1.58	2.61	.28	.00	.20	.73	1.96	3.01	11.12
1970	.00	.00	.00	.36	2.11	1.55	.00	.00	.46	.95	2.66	2.85	10.93
1971	.00	.00	.00	.00	.69	.17	.28	.00	.41	1.09	2.88	3.74	9.26
1972	.44	.00	.00	.46	.00	1.05	.00	.00	.47	1.05	.77	2.19	6.44
1973	.00	.00	.00	.31	.71	1.35	.00	.00	.13	.64	2.78	3.17	9.10
1974	.72	.00	.00	.00	.08	2.09	.00	.00	.47	1.08	2.95	1.67	9.05
1975	.37	.00	.00	.76	.75	.40	.00	.00	.47	1.09	2.95	3.36	10.15
1976	.00	.00	.00	.00	1.25	1.11	.32	.00	.47	1.09	2.76	.84	7.84
1977	.00	.00	.00	.00	1.01	2.08	.00	.00	.47	1.07	1.89	2.40	8.92
1978	.00	.00	.00	2.14	2.37	2.23	.14	.00	.41	.35	1.35	2.24	11.23
1979	.59	.00	.00	.00	.49	2.88	.58	.00	.46	1.09	2.90	2.45	11.44
1980	.49	.00	.00	.00	.00	1.95	.05	.00	.11	1.01	2.13	2.15	7.89
1981	.40	.00	.00	.00	3.20	2.27	.63	.00	.44	.90	2.99	3.33	14.15
1982	.00	.00	.00	1.62	2.84	1.99	.17	.00	.33	.84	2.19	3.72	13.71
1983	.00	.00	.00	.00	1.55	.32	.15	.00	.00	.00	1.43	3.47	6.93
1984	.00	.00	.00	.30	.00	2.62	.84	.00	.30	1.07	2.99	3.46	11.59
1985	.00	.00	.00	.04	.41	.93	.04	.00	.02	1.09	2.85	3.35	8.73
1986	.14	.00	.00	.99	1.43	2.21	.37	.00	.14	.89	1.60	.05	7.83
1987	.00	.00	.00	.00	2.06	.77	.47	.00	.04	.44	2.82	3.05	9.64
1988	.00	.00	.00	.00	.00	2.13	.04	.00	.00	1.07	2.86	3.77	9.88
1989	.00	.00	.00	.62	1.40	.57	.00	.00	.47	1.09	2.49	3.71	10.36
1990	.25	.00	.00	.00	.21	.22	.87	.00	.00	1.09	2.90	3.22	8.77
1991	.00	.00	.00	2.03	.30	2.75	.64	.00	.47	1.09	2.60	3.68	13.56
1992	.51	.00	.00	1.41	.14	1.06	.00	.00	.47	1.09	2.94	3.13	10.76
1993	.00	.00	.00	.00	1.26	.00	.08	.00	.47	1.09	2.68	3.40	8.98
1994	.00	.00	.00	.45	1.86	.97	.00	.00	.41	1.03	2.91	3.69	11.32

Third phase irrigation water use for 2030 – CHELD75.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.22	.09	.19	.27	.33	.25	.19	.11	.00	.14	.24	.02
1926	.29	.11	.05	.21	.05	.07	.21	.14	.11	.05	.19	.43
1927	.13	.28	.00	.22	.29	.16	.14	.13	.11	.14	.17	.21
1928	.29	.28	.04	.22	.45	.00	.22	.13	.00	.02	.22	.00
1929	.25	.00	.02	.01	.39	.41	.03	.14	.11	.08	.18	.29
1930	.35	.33	.00	.00	.20	.34	.14	.14	.11	.11	.24	.44
1931	.34	.19	.18	.20	.06	.11	.18	.01	.10	.14	.24	.34
1932	.36	.16	.00	.49	.41	.16	.06	.14	.11	.07	.23	.43
1933	.40	.00	.00	.00	.39	.16	.09	.06	.11	.03	.09	.43
1934	.25	.02	.00	.23	.08	.11	.06	.11	.09	.14	.22	.32
1935	.35	.32	.15	.00	.13	.00	.19	.00	.11	.14	.24	.38
1936	.24	.00	.28	.00	.08	.37	.07	.14	.11	.14	.23	.31
1937	.40	.30	.00	.24	.29	.39	.01	.12	.00	.07	.16	.37
1938	.00	.25	.00	.17	.01	.19	.23	.03	.11	.04	.19	.31
1939	.31	.00	.00	.19	.16	.48	.09	.00	.00	.14	.23	.17
1940	.36	.04	.00	.21	.11	.13	.00	.14	.11	.14	.23	.34
1941	.31	.24	.04	.00	.04	.23	.07	.08	.04	.14	.16	.14
1942	.19	.00	.00	.00	.40	.06	.00	.08	.11	.00	.00	.40
1943	.00	.03	.00	.17	.00	.35	.24	.14	.00	.14	.24	.00
1944	.07	.28	.25	.39	.32	.01	.05	.13	.11	.14	.23	.41
1945	.48	.37	.36	.05	.25	.02	.21	.14	.11	.14	.24	.41
1946	.14	.04	.13	.38	.00	.22	.07	.14	.01	.13	.23	.35
1947	.31	.00	.00	.03	.28	.18	.16	.11	.11	.14	.24	.25
1948	.11	.18	.16	.00	.07	.19	.00	.14	.11	.14	.24	.30
1949	.12	.08	.00	.24	.28	.31	.00	.06	.10	.14	.16	.39
1950	.23	.21	.00	.33	.17	.28	.03	.11	.10	.06	.04	.39
1951	.16	.35	.00	.06	.52	.34	.07	.12	.11	.00	.23	.41
1952	.35	.01	.09	.00	.01	.30	.02	.14	.08	.14	.01	.38
1953	.34	.05	.14	.34	.00	.11	.17	.03	.08	.14	.24	.20
1954	.08	.00	.22	.02	.03	.25	.10	.14	.10	.14	.23	.41
1955	.14	.19	.08	.34	.08	.05	.22	.03	.11	.14	.23	.26
1956	.21	.00	.00	.17	.16	.04	.00	.13	.04	.00	.12	.03
1957	.01	.30	.16	.04	.12	.07	.00	.14	.11	.14	.24	.22
1958	.16	.11	.00	.31	.07	.31	.08	.04	.11	.11	.23	.33
1959	.11	.01	.05	.34	.14	.34	.00	.12	.11	.14	.15	.32
1960	.18	.10	.00	.51	.40	.05	.00	.09	.10	.14	.24	.25
1961	.33	.07	.10	.08	.10	.35	.12	.14	.11	.14	.15	.31
1962	.40	.14	.11	.03	.59	.20	.14	.11	.00	.00	.24	.44
1963	.17	.04	.22	.08	.36	.31	.01	.14	.01	.14	.18	.25
1964	.00	.09	.00	.08	.16	.52	.08	.14	.00	.10	.16	.31
1965	.15	.15	.16	.00	.34	.54	.04	.10	.11	.14	.14	.27
1966	.26	.09	.00	.00	.18	.28	.01	.13	.11	.14	.23	.39
1967	.31	.05	.02	.38	.57	.19	.12	.12	.11	.14	.09	.41
1968	.45	.10	.02	.12	.27	.01	.00	.10	.09	.10	.24	.34
1969	.01	.27	.04	.23	.12	.47	.08	.09	.09	.11	.06	.28
1970	.07	.19	.21	.00	.34	.29	.00	.01	.11	.09	.14	.32
1971	.21	.21	.00	.21	.07	.00	.16	.09	.10	.14	.23	.44
1972	.21	.10	.22	.29	.16	.35	.00	.14	.11	.14	.00	.18
1973	.37	.01	.10	.08	.04	.30	.00	.13	.04	.10	.19	.40
1974	.38	.00	.00	.08	.00	.40	.01	.13	.11	.14	.23	.00
1975	.38	.04	.00	.00	.13	.00	.01	.01	.11	.14	.23	.35
1976	.04	.23	.00	.03	.46	.14	.15	.13	.11	.14	.23	.28
1977	.20	.31	.00	.00	.16	.16	.02	.14	.11	.14	.11	.20
1978	.12	.17	.01	.25	.16	.47	.14	.12	.10	.04	.04	.18
1979	.40	.19	.02	.00	.05	.38	.16	.14	.11	.14	.23	.13
1980	.31	.17	.01	.19	.13	.50	.14	.14	.04	.14	.12	.17
1981	.29	.24	.22	.12	.52	.23	.20	.12	.11	.12	.24	.34
1982	.01	.34	.16	.26	.50	.28	.12	.07	.09	.12	.16	.41
1983	.09	.00	.00	.01	.37	.02	.10	.14	.06	.09	.04	.36
1984	.00	.23	.11	.00	.00	.48	.25	.14	.10	.14	.23	.33
1985	.01	.04	.00	.01	.06	.24	.04	.14	.06	.14	.22	.38
1986	.19	.16	.01	.12	.07	.34	.08	.14	.08	.14	.06	.00
1987	.04	.02	.00	.19	.19	.10	.16	.12	.04	.13	.23	.35
1988	.07	.24	.00	.16	.00	.34	.23	.13	.06	.14	.23	.44
1989	.20	.00	.00	.39	.25	.05	.06	.13	.11	.14	.19	.44
1990	.38	.39	.00	.05	.01	.26	.24	.12	.01	.14	.23	.30
1991	.00	.16	.00	.34	.00	.38	.14	.14	.11	.14	.09	.43
1992	.33	.17	.12	.45	.00	.37	.15	.14	.11	.14	.18	.35
1993	.00	.16	.01	.00	.14	.20	.11	.13	.11	.11	.16	.38
1994	.19	.30	.00	.06	.36	.08	.08	.11	.11	.14	.23	.44

Third phase irrigation water use for 2030 – KLIP75A.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.32	.51	.45	.03	.52	.39	.46	.24	.21	.35	.35	.01
1926	.24	.25	.40	.48	.25	.12	.46	.32	.31	.30	.24	.48
1927	.21	.57	.30	.56	.49	.26	.44	.29	.31	.35	.30	.23
1928	.39	.50	.05	.33	.37	.10	.31	.29	.04	.12	.30	.01
1929	.32	.00	.42	.13	.44	.02	.28	.32	.28	.31	.30	.18
1930	.50	.44	.15	.20	.43	.43	.35	.32	.31	.23	.35	.50
1931	.39	.58	.27	.45	.00	.25	.43	.08	.30	.34	.34	.30
1932	.46	.42	.36	.88	.42	.35	.26	.32	.31	.14	.35	.48
1933	.57	.00	.01	.05	.45	.15	.02	.14	.30	.31	.05	.48
1934	.40	.02	.00	.88	.31	.23	.44	.27	.23	.36	.31	.45
1935	.62	.33	.62	.54	.15	.35	.48	.00	.31	.36	.35	.45
1936	.40	.00	.33	.41	.02	.47	.37	.32	.30	.34	.35	.44
1937	.50	.49	.27	.31	.50	.45	.06	.32	.14	.18	.24	.43
1938	.37	.41	.37	.49	.01	.17	.48	.13	.31	.24	.30	.33
1939	.38	.08	.38	.68	.46	.23	.33	.10	.01	.36	.33	.27
1940	.51	.45	.43	.35	.38	.24	.18	.32	.31	.35	.35	.41
1941	.40	.58	.59	.52	.15	.10	.17	.31	.28	.34	.21	.31
1942	.51	.00	.14	.09	.60	.18	.00	.01	.30	.09	.00	.46
1943	.00	.10	.22	.46	.15	.26	.50	.25	.17	.36	.35	.01
1944	.46	.31	.77	.66	.44	.00	.42	.30	.28	.36	.35	.50
1945	.65	.56	.63	.55	.18	.27	.35	.31	.31	.35	.34	.50
1946	.17	.13	.55	.75	.07	.09	.34	.32	.12	.35	.35	.35
1947	.26	.29	.23	.02	.45	.13	.16	.26	.31	.36	.35	.40
1948	.37	.49	.29	.44	.24	.20	.23	.32	.31	.35	.26	.40
1949	.49	.26	.52	.70	.58	.03	.34	.12	.31	.33	.23	.28
1950	.44	.43	.02	.69	.51	.33	.30	.30	.28	.35	.06	.35
1951	.42	.68	.42	.00	.42	.21	.34	.29	.30	.15	.29	.40
1952	.36	.36	.30	.53	.01	.58	.24	.32	.31	.36	.26	.48
1953	.51	.33	.20	.71	.00	.44	.38	.15	.28	.36	.35	.21
1954	.22	.00	.41	.03	.10	.43	.38	.24	.31	.36	.35	.48
1955	.54	.48	.25	.90	.19	.06	.43	.30	.31	.36	.35	.33
1956	.57	.21	.00	.26	.64	.03	.21	.32	.28	.17	.12	.00
1957	.01	.48	.54	.37	.27	.48	.02	.31	.31	.36	.35	.30
1958	.47	.15	.33	.56	.35	.62	.26	.00	.31	.32	.35	.49
1959	.18	.29	.46	.70	.20	.03	.07	.30	.31	.34	.29	.43
1960	.41	.31	.23	.81	.49	.24	.17	.23	.29	.36	.32	.29
1961	.59	.35	.46	.09	.39	.39	.20	.26	.31	.36	.28	.42
1962	.62	.11	.28	.04	.66	.23	.31	.30	.16	.23	.35	.50
1963	.31	.24	.76	.26	.65	.19	.23	.32	.17	.35	.29	.19
1964	.04	.37	.49	.61	.50	.64	.34	.30	.02	.29	.08	.21
1965	.57	.40	.49	.01	.42	.68	.41	.23	.24	.36	.28	.46
1966	.51	.26	.15	.00	.19	.08	.01	.19	.31	.32	.34	.48
1967	.54	.52	.56	.71	.60	.43	.42	.31	.31	.33	.23	.47
1968	.57	.53	.51	.61	.57	.12	.29	.10	.30	.35	.34	.44
1969	.12	.53	.34	.51	.33	.62	.45	.24	.25	.35	.02	.16
1970	.38	.47	.65	.11	.48	.49	.35	.17	.31	.21	.24	.46
1971	.32	.42	.27	.37	.40	.03	.38	.20	.30	.35	.28	.50
1972	.39	.24	.66	.62	.25	.44	.08	.31	.31	.35	.01	.24
1973	.60	.13	.24	.28	.01	.08	.19	.26	.23	.33	.28	.48
1974	.56	.20	.11	.33	.05	.29	.28	.30	.31	.36	.33	.01
1975	.58	.09	.08	.07	.16	.00	.22	.10	.31	.36	.32	.29
1976	.22	.29	.43	.28	.68	.31	.27	.32	.31	.36	.34	.14
1977	.12	.27	.41	.00	.43	.11	.28	.31	.31	.36	.22	.21
1978	.09	.44	.01	.74	.00	.39	.34	.22	.30	.23	.01	.39
1979	.46	.39	.42	.47	.18	.40	.34	.27	.31	.36	.32	.06
1980	.52	.04	.00	.14	.00	.60	.40	.30	.16	.36	.14	.30
1981	.54	.29	.52	.28	.69	.32	.46	.31	.30	.31	.33	.37
1982	.16	.56	.40	.27	.68	.41	.39	.23	.27	.29	.29	.48
1983	.23	.16	.31	.51	.69	.18	.24	.32	.27	.33	.10	.44
1984	.37	.62	.66	.12	.01	.63	.50	.30	.28	.35	.35	.44
1985	.01	.15	.32	.31	.48	.24	.25	.32	.18	.36	.21	.47
1986	.01	.32	.00	.52	.00	.00	.44	.32	.22	.35	.01	.00
1987	.47	.32	.37	.51	.08	.08	.35	.31	.12	.18	.35	.39
1988	.29	.29	.08	.54	.00	.44	.41	.23	.25	.35	.34	.50
1989	.41	.00	.20	.75	.46	.34	.21	.30	.31	.35	.13	.45
1990	.48	.68	.15	.05	.21	.39	.50	.31	.24	.36	.35	.41
1991	.00	.33	.13	.71	.02	.41	.43	.32	.31	.36	.25	.50
1992	.54	.45	.39	.67	.32	.19	.30	.31	.31	.36	.34	.39
1993	.00	.30	.11	.33	.08	.23	.30	.30	.31	.30	.27	.49
1994	.48	.67	.46	.51	.41	.17	.40	.26	.30	.36	.35	.36

Third phase irrigation water use for 2030 – KLIP75B.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	1.46	2.33	2.06	.13	2.39	1.75	2.11	1.11	.98	1.61	1.58	.03
1926	1.11	1.12	1.82	2.17	1.14	.52	2.07	1.45	1.41	1.38	1.08	2.17
1927	.98	2.59	1.39	2.55	2.21	1.20	1.99	1.32	1.41	1.58	1.39	1.02
1928	1.80	2.27	.23	1.50	1.70	.47	1.43	1.32	.20	.55	1.39	.02
1929	1.44	.02	1.89	.57	2.03	.07	1.27	1.45	1.26	1.40	1.39	.82
1930	2.25	2.02	.71	.91	1.97	1.95	1.58	1.47	1.39	1.05	1.58	2.27
1931	1.75	2.65	1.22	2.04	.00	1.14	1.96	.39	1.35	1.55	1.56	1.39
1932	2.09	1.90	1.63	4.01	1.94	1.59	1.17	1.46	1.40	.62	1.58	2.21
1933	2.58	.00	.03	.20	2.03	.66	.10	.64	1.39	1.39	.20	2.18
1934	1.84	.08	.00	4.03	1.42	1.07	2.01	1.22	1.05	1.62	1.39	2.04
1935	2.83	1.48	2.82	2.47	.71	1.58	2.20	.00	1.40	1.62	1.58	2.05
1936	1.84	.01	1.52	1.86	.08	2.13	1.67	1.47	1.36	1.56	1.58	2.00
1937	2.30	2.24	1.21	1.43	2.29	2.05	.28	1.47	.62	.82	1.09	1.96
1938	1.68	1.85	1.69	2.23	.06	.80	2.16	.58	1.41	1.10	1.38	1.51
1939	1.71	.34	1.73	3.08	2.09	1.04	1.51	.43	.06	1.62	1.49	1.25
1940	2.32	2.03	1.95	1.58	1.75	1.12	.81	1.47	1.41	1.61	1.58	1.85
1941	1.80	2.65	2.69	2.39	.70	.46	.80	1.39	1.28	1.54	.98	1.42
1942	2.30	.00	.62	.40	2.76	.83	.00	.03	1.36	.41	.00	2.10
1943	.01	.47	.99	2.09	.66	1.18	2.28	1.12	.80	1.62	1.58	.02
1944	2.11	1.43	3.50	2.99	1.99	.00	1.92	1.38	1.28	1.62	1.58	2.26
1945	2.94	2.55	2.88	2.50	.82	1.23	1.62	1.39	1.41	1.62	1.55	2.25
1946	.79	.57	2.51	3.44	.32	.40	1.57	1.47	.57	1.61	1.58	1.61
1947	1.20	1.32	1.05	.07	2.06	.61	.73	1.20	1.41	1.62	1.58	1.84
1948	1.66	2.21	1.30	1.99	1.10	.89	1.07	1.45	1.40	1.62	1.20	1.84
1949	2.24	1.16	2.37	3.18	2.62	.13	1.53	.56	1.40	1.53	1.03	1.29
1950	2.03	1.94	.07	3.14	2.33	1.53	1.39	1.34	1.29	1.62	.25	1.61
1951	1.94	3.08	1.89	.00	1.90	.93	1.57	1.30	1.35	.68	1.32	1.81
1952	1.62	1.64	1.38	2.44	.03	2.64	1.12	1.45	1.40	1.62	1.20	2.17
1953	2.30	1.49	.93	3.26	.00	2.02	1.74	.69	1.29	1.62	1.58	.96
1954	1.01	.00	1.89	.13	.48	1.98	1.71	1.08	1.41	1.62	1.58	2.20
1955	2.44	2.18	1.14	4.09	.89	.25	1.98	1.35	1.41	1.62	1.58	1.49
1956	2.59	.98	.00	1.21	2.93	.16	.97	1.47	1.30	.76	.55	.00
1957	.02	2.17	2.46	1.68	1.21	2.20	.08	1.43	1.41	1.62	1.58	1.37
1958	2.15	.66	1.48	2.57	1.57	2.81	1.16	.01	1.41	1.47	1.58	2.22
1959	.81	1.33	2.07	3.20	.93	.13	.34	1.39	1.41	1.54	1.31	1.94
1960	1.86	1.41	1.06	3.68	2.22	1.12	.80	1.02	1.33	1.62	1.48	1.31
1961	2.67	1.60	2.08	.41	1.79	1.80	.91	1.16	1.41	1.62	1.29	1.93
1962	2.82	.49	1.28	.19	3.02	1.06	1.43	1.39	.74	1.07	1.58	2.26
1963	1.39	1.12	3.48	1.20	2.96	.84	1.05	1.47	.80	1.57	1.31	.87
1964	.19	1.69	2.25	2.76	2.26	2.92	1.53	1.34	.09	1.32	.34	.98
1965	2.57	1.83	2.23	.06	1.92	3.09	1.85	1.07	1.10	1.62	1.26	2.11
1966	2.31	1.20	.70	.00	.84	.34	.02	.86	1.41	1.48	1.54	2.18
1967	2.44	2.39	2.55	3.23	2.74	1.96	1.91	1.43	1.41	1.52	1.04	2.15
1968	2.59	2.40	2.34	2.80	2.62	.52	1.34	.48	1.34	1.58	1.56	1.99
1969	.52	2.43	1.57	2.30	1.51	2.81	2.06	1.11	1.13	1.57	.09	.72
1970	1.72	2.16	2.95	.48	2.20	2.21	1.61	.75	1.40	.95	1.10	2.11
1971	1.47	1.93	1.25	1.69	1.83	.15	1.71	.92	1.34	1.59	1.28	2.25
1972	1.78	1.08	3.01	2.84	1.16	2.01	.36	1.43	1.41	1.60	.04	1.07
1973	2.71	.60	1.11	1.27	.07	.39	.87	1.16	1.06	1.52	1.29	2.20
1974	2.56	.90	.52	1.49	.23	1.30	1.26	1.39	1.39	1.62	1.52	.03
1975	2.65	.39	.39	.34	.72	.00	1.01	.46	1.41	1.62	1.48	1.34
1976	1.00	1.32	1.95	1.26	3.12	1.41	1.24	1.45	1.39	1.62	1.53	.62
1977	.55	1.22	1.85	.01	1.96	.50	1.25	1.41	1.41	1.62	.99	.98
1978	.40	2.03	.02	3.39	.00	1.78	1.55	.98	1.39	1.04	.07	1.75
1979	2.09	1.79	1.91	2.13	.80	1.80	1.54	1.24	1.40	1.62	1.46	.28
1980	2.36	.19	.01	.64	.00	2.71	1.81	1.37	.71	1.62	.66	1.36
1981	2.47	1.33	2.35	1.29	3.13	1.47	2.08	1.41	1.36	1.43	1.49	1.66
1982	.72	2.57	1.80	1.21	3.08	1.85	1.79	1.04	1.25	1.31	1.31	2.21
1983	1.02	.73	1.43	2.35	3.12	.82	1.08	1.45	1.22	1.50	.43	2.00
1984	1.66	2.84	3.02	.55	.04	2.88	2.29	1.36	1.29	1.62	1.58	1.98
1985	.02	.66	1.44	1.41	2.20	1.12	1.14	1.47	.84	1.62	.97	2.16
1986	.07	1.47	.02	2.38	.00	.00	2.03	1.47	1.00	1.59	.02	.00
1987	2.14	1.48	1.66	2.32	.38	.36	1.62	1.40	.55	.82	1.58	1.79
1988	1.34	1.34	.38	2.45	.00	1.99	1.85	1.05	1.12	1.61	1.56	2.25
1989	1.87	.00	.93	3.40	2.11	1.56	.95	1.35	1.39	1.62	.57	2.07
1990	2.16	3.08	.71	.23	.95	1.80	2.27	1.43	1.07	1.62	1.58	1.86
1991	.00	1.51	.59	3.21	.08	1.85	1.98	1.47	1.41	1.62	1.13	2.25
1992	2.47	2.03	1.79	3.06	1.46	.84	1.37	1.41	1.41	1.62	1.56	1.77
1993	.02	1.39	.51	1.49	.39	1.02	1.39	1.39	1.41	1.39	1.24	2.25
1994	2.20	3.06	2.12	2.31	1.85	.78	1.81	1.18	1.39	1.62	1.58	1.63

Third phase irrigation water use for 2030 – LOCHS75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	1.04	1.97	2.30	.74	1.34	1.10	1.25	1.01	.38	.91	1.23	.11
1926	.69	1.42	.72	.87	1.15	.81	1.42	1.19	.86	.84	.64	1.54
1927	.66	2.24	.47	.71	1.90	.81	1.47	1.00	.87	.90	.97	.64
1928	1.29	2.06	1.21	.54	1.03	.50	1.21	1.02	.28	.01	1.07	.07
1929	1.35	1.15	1.94	.67	1.12	.11	.85	1.19	.76	.82	1.04	1.11
1930	1.45	1.85	1.78	.97	1.69	1.31	.83	1.18	.86	.56	1.23	1.62
1931	1.24	2.24	1.46	1.00	.26	1.03	1.17	.46	.79	.91	1.23	1.12
1932	1.79	.51	.89	2.01	.25	.39	1.05	1.19	.83	.38	1.22	1.57
1933	1.49	.00	1.19	.00	1.25	1.05	.78	.56	.87	.50	.56	1.37
1934	1.09	.20	.56	2.14	.43	.92	.83	.97	.67	.90	1.14	1.51
1935	1.92	1.89	1.55	.03	.00	1.20	1.46	.02	.87	.91	1.20	1.25
1936	1.39	.67	1.56	1.69	.62	1.46	1.42	1.19	.80	.91	1.22	1.42
1937	1.79	1.43	.94	1.10	.98	1.54	.16	1.16	.49	.19	.98	1.34
1938	.89	1.91	1.23	1.54	.00	1.03	1.04	.62	.87	.62	.88	.88
1939	.94	.59	.99	1.54	.86	.80	1.28	.00	.17	.88	1.21	.84
1940	1.85	1.32	.49	1.21	.00	.00	.64	1.19	.87	.82	1.23	1.51
1941	1.20	2.11	1.61	.47	.45	.34	.91	.86	.82	.76	.84	1.19
1942	1.44	.34	.79	.00	1.25	.75	.00	.34	.79	.00	.00	1.54
1943	.00	.92	1.50	1.52	.23	1.51	1.41	1.00	.45	.91	1.22	.25
1944	1.63	1.57	2.21	1.70	.98	.08	1.23	.88	.82	.91	1.22	1.61
1945	1.95	2.17	1.78	.94	.99	.88	1.21	1.10	.87	.90	1.21	1.54
1946	.92	1.17	1.67	1.53	.01	.61	1.06	1.19	.07	.86	1.23	1.01
1947	.97	.62	.62	.74	.85	.67	.74	1.10	.87	.91	1.20	1.39
1948	1.61	1.61	1.13	.71	.62	.06	.92	.96	.86	.88	1.22	1.06
1949	1.54	1.09	.93	1.90	1.50	.55	1.00	.86	.82	.65	.67	1.43
1950	1.62	1.93	.78	.78	1.15	.73	.94	1.10	.81	.89	.16	.89
1951	1.48	2.39	.72	.00	1.05	.74	1.34	1.05	.87	.44	1.01	1.37
1952	.96	1.46	.19	1.92	.19	1.42	1.00	1.15	.85	.86	.56	1.51
1953	1.39	.88	1.24	1.72	.69	1.18	.83	.52	.83	.91	1.22	.58
1954	.91	.77	1.00	.00	.79	.28	.95	.89	.86	.91	1.23	1.46
1955	1.70	2.04	.64	2.16	.41	.00	1.38	1.13	.87	.86	1.15	1.06
1956	1.75	1.25	.00	.16	.80	.41	.80	1.00	.83	.40	.49	.00
1957	.12	1.99	1.38	.77	.79	1.33	.48	1.13	.86	.87	1.23	1.28
1958	1.45	1.28	1.69	1.25	.28	1.57	.74	.00	.86	.65	1.10	1.51
1959	.67	1.15	1.21	1.60	.70	.42	.69	1.13	.87	.84	1.00	1.15
1960	1.26	.87	.20	1.87	.94	.62	.82	1.03	.82	.91	.98	1.02
1961	1.85	1.54	1.31	.00	.53	.44	.34	1.06	.87	.91	.92	1.48
1962	1.49	.60	1.17	.97	1.52	.34	1.03	1.11	.63	.50	1.23	1.54
1963	1.05	.76	1.73	.57	1.49	.82	1.04	1.12	.48	.86	1.19	.38
1964	.35	1.31	1.66	1.73	1.56	1.69	1.08	.92	.08	.51	.38	1.04
1965	1.68	1.63	1.23	.01	1.28	1.90	.94	.82	.77	.91	.86	1.38
1966	1.51	.81	1.29	.00	.00	.31	.23	.97	.86	.74	1.19	1.54
1967	1.51	.96	1.27	1.37	1.63	1.16	1.20	1.14	.87	.86	.94	1.45
1968	1.75	1.69	1.08	1.69	.89	.08	.98	.43	.83	.87	1.17	1.04
1969	.84	2.12	1.05	1.11	.27	1.76	1.51	1.03	.70	.90	.18	.53
1970	1.25	1.71	1.65	.64	1.49	1.59	1.03	.52	.86	.44	.72	1.54
1971	1.22	1.44	1.49	.83	1.17	.00	1.17	.74	.85	.81	1.08	1.54
1972	1.25	.69	2.12	1.13	.57	.72	.59	1.12	.87	.80	.14	.71
1973	1.96	1.06	1.07	.00	1.13	.88	.47	1.12	.50	.73	1.02	1.60
1974	1.79	1.15	.50	.11	.14	1.25	.86	.97	.87	.91	1.16	.00
1975	1.87	.52	.25	.41	.20	.00	1.16	.67	.87	.83	1.22	1.15
1976	.92	1.55	1.46	.34	1.83	.82	.75	1.15	.85	.88	1.16	.92
1977	.30	1.58	1.09	.60	1.51	.64	.47	1.19	.86	.91	.91	.66
1978	.92	1.63	.14	.87	1.12	1.09	1.10	.63	.87	.56	.44	1.34
1979	1.63	1.99	1.40	1.19	1.48	1.43	1.24	1.10	.87	.91	1.15	.73
1980	1.87	1.15	.00	.00	.52	1.51	1.27	1.15	.51	.91	.53	1.28
1981	1.81	.74	2.00	.86	1.66	.85	1.28	1.15	.78	.85	1.18	1.24
1982	.66	2.14	1.65	1.28	1.86	1.04	.95	.84	.83	.53	1.03	1.47
1983	1.23	.70	1.15	1.47	1.80	.81	.54	1.18	.62	.79	.49	1.47
1984	1.14	1.79	1.39	.53	.52	1.20	1.57	1.12	.78	.91	1.23	1.43
1985	.60	.79	1.22	1.19	.97	1.30	1.20	1.19	.52	.91	.73	1.49
1986	.85	1.46	1.36	1.13	.56	.29	1.48	1.17	.73	.88	.16	.00
1987	1.37	1.73	1.61	.63	.00	.57	1.13	.89	.23	.64	1.10	1.31
1988	1.67	1.78	.76	1.25	.39	1.50	1.35	1.08	.76	.86	1.22	1.61
1989	1.46	.58	1.31	1.66	1.61	1.12	.85	1.16	.79	.91	.67	1.57
1990	1.50	2.30	.28	.00	1.21	1.68	1.49	1.15	.65	.91	1.23	1.34
1991	.00	1.57	.00	1.54	.66	.93	.89	1.19	.87	.89	1.07	1.57
1992	1.61	1.62	.44	1.06	.39	.92	1.23	1.03	.87	.91	1.23	1.13
1993	.00	1.57	1.00	1.04	.70	.53	1.03	1.02	.87	.76	.94	1.62
1994	1.46	2.41	.94	1.03	1.75	.70	1.31	1.06	.83	.86	1.21	1.50

Third phase irrigation water use for 2030 – MAND75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.74	1.19	.87	2.01	2.47	.00	1.37	.31	.25	.76	1.00	.79
1926	.77	.47	.00	1.81	2.34	.00	1.13	.74	.59	.53	.62	1.51
1927	1.05	1.14	.00	.36	2.35	1.95	.75	.72	.58	.75	.70	.88
1928	1.37	1.28	.99	1.34	2.54	.00	1.18	.73	.00	.47	.88	.63
1929	.83	.44	1.23	.37	3.35	2.32	.98	.75	.59	.70	.60	.88
1930	1.35	.47	.00	1.61	2.45	2.38	.88	.74	.56	.64	.95	1.38
1931	1.50	.58	.00	1.46	.00	.38	.71	.09	.44	.72	.97	1.28
1932	1.42	.54	.00	1.60	2.62	2.17	.99	.77	.56	.50	.97	1.57
1933	1.51	.00	.00	.00	2.57	1.06	.46	.42	.47	.55	.53	1.55
1934	1.57	.25	.00	1.38	2.36	1.96	.67	.36	.00	.72	.89	1.61
1935	1.45	.98	.56	.57	.83	.96	.93	.06	.52	.67	1.00	1.00
1936	1.21	.00	1.28	1.72	1.82	2.37	1.10	.77	.45	.67	.88	1.36
1937	1.39	.88	.00	.29	1.90	2.87	.00	.73	.35	.19	.86	1.45
1938	.87	.64	.00	1.22	1.52	1.42	.85	.42	.56	.39	.83	.70
1939	1.37	.00	.00	1.79	2.84	2.28	.79	.00	.00	.76	.97	.94
1940	1.65	.00	.00	2.20	2.70	2.35	.11	.76	.52	.71	.86	1.15
1941	1.55	.67	.86	1.22	2.50	1.20	.83	.60	.44	.70	.59	.78
1942	1.15	.00	.00	1.78	2.39	1.98	.00	.62	.41	.03	.16	1.56
1943	.09	.00	.00	2.66	1.77	1.01	1.10	.72	.00	.69	.89	.08
1944	1.22	.64	.66	1.75	2.40	.00	1.22	.57	.56	.75	.95	1.57
1945	1.14	1.50	.41	.42	2.64	2.26	1.00	.67	.58	.76	.98	1.42
1946	1.05	.25	.00	.84	2.06	.97	.43	.68	.06	.69	.90	1.30
1947	1.18	.00	.00	.97	2.43	1.23	.58	.66	.58	.76	.92	1.49
1948	1.34	.61	.11	.88	2.33	1.74	.00	.68	.44	.69	.94	1.21
1949	.84	.00	.00	1.28	2.57	1.14	.90	.65	.53	.76	.67	1.46
1950	1.34	1.22	.00	1.65	2.93	2.14	1.03	.70	.50	.74	.00	1.25
1951	.85	1.52	.00	.89	2.63	1.79	.88	.51	.52	.50	.92	1.62
1952	1.51	.00	.00	1.19	2.14	2.33	.94	.71	.49	.74	.69	1.13
1953	1.43	.13	.00	.79	2.33	1.91	.33	.28	.44	.70	.89	.51
1954	.00	.33	.97	.00	2.42	1.09	.38	.64	.46	.76	.96	1.16
1955	.74	.00	.00	3.05	.91	1.72	1.06	.62	.45	.66	.76	1.07
1956	1.37	.12	.00	1.14	2.21	1.63	.14	.67	.49	.56	.84	.00
1957	.38	.70	.00	.39	2.18	2.58	.00	.71	.50	.74	.93	.94
1958	1.64	.11	.08	.98	2.31	2.95	1.03	.01	.57	.74	.67	1.16
1959	.73	.65	.08	2.08	2.24	1.95	.00	.64	.52	.70	.79	1.09
1960	1.23	.00	.00	.76	2.64	2.14	.00	.70	.14	.69	.91	.91
1961	1.21	.35	.21	1.61	2.68	1.53	.79	.67	.59	.74	.48	1.55
1962	1.05	.01	.00	1.02	2.71	1.02	.66	.76	.01	.07	.96	1.55
1963	1.28	.32	.92	.00	2.89	2.92	.32	.73	.44	.66	.85	1.12
1964	.64	.99	.08	2.23	2.66	2.95	.79	.53	.00	.52	.54	1.03
1965	1.11	.67	.04	.45	2.72	3.15	.48	.48	.45	.73	.74	1.21
1966	1.37	.60	.00	.00	2.14	.59	.22	.72	.49	.52	.97	1.47
1967	.99	.25	.79	.89	2.64	1.51	.98	.74	.50	.75	.40	1.02
1968	1.39	.71	.00	2.08	2.75	.03	.32	.38	.47	.63	.94	.86
1969	.49	.62	.00	2.14	2.60	2.70	.88	.35	.39	.72	.77	.62
1970	.33	.47	.46	1.03	2.46	1.68	.49	.00	.58	.36	.58	.99
1971	1.03	.49	.00	1.47	1.28	1.41	.91	.16	.28	.50	.92	1.46
1972	1.33	.50	.04	1.00	1.73	1.74	.45	.74	.54	.67	.25	.00
1973	1.15	.38	.00	.00	1.64	2.23	.70	.52	.42	.63	.93	1.63
1974	1.85	.19	.00	.00	1.63	2.39	.56	.62	.48	.70	.86	.00
1975	1.52	.46	.00	.00	2.05	.00	.13	.45	.59	.67	.76	1.19
1976	.86	.48	.53	.28	1.39	1.52	.91	.71	.52	.75	.65	.86
1977	.70	.67	.32	.79	2.50	1.22	.14	.75	.46	.68	.62	.92
1978	.37	.59	.00	1.37	2.69	2.37	.88	.58	.53	.50	.64	1.14
1979	1.29	.97	.03	2.05	3.12	2.73	.97	.68	.56	.74	.78	.00
1980	1.62	.17	.56	.00	2.15	2.85	.92	.23	.41	.62	.44	.79
1981	1.51	.00	.92	.52	2.72	.88	.59	.64	.57	.70	.97	1.24
1982	.28	1.04	.81	1.74	3.02	2.50	1.06	.63	.54	.47	.55	1.64
1983	1.16	.00	.00	.00	1.15	1.57	.17	.58	.43	.11	.55	1.56
1984	1.00	.55	.46	.44	.71	2.63	1.28	.75	.47	.72	.95	1.44
1985	.00	.53	.00	1.34	2.75	1.49	.67	.76	.35	.73	.83	1.32
1986	.82	.63	.00	.00	2.34	1.00	1.01	.47	.00	.67	.33	.00
1987	1.13	.12	.00	1.50	.70	.87	1.16	.52	.31	.56	.60	1.19
1988	1.15	.16	.00	2.13	1.48	2.76	.86	.57	.43	.74	.91	1.32
1989	1.04	.00	.00	2.27	2.47	1.06	.34	.63	.52	.76	.54	1.49
1990	.88	.67	.00	.00	1.15	.85	1.24	.58	.44	.64	.92	.93
1991	.92	1.39	.44	2.34	2.50	2.76	.65	.78	.57	.74	.90	1.42
1992	1.53	.38	.51	2.27	2.39	2.06	.96	.72	.58	.76	.79	.96
1993	.00	.94	.00	.67	3.04	1.24	1.23	.76	.57	.47	.00	1.55
1994	1.45	.93	.37	1.57	3.07	1.32	.34	.26	.02	.64	.89	1.51

Third phase irrigation water use for 2030 – MHL75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	1.23	1.13	.00	2.00	3.97	1.19	1.56	.58	.19	.97	1.22	.43
1926	.00	.00	.79	2.01	2.47	1.23	1.70	.76	.75	.57	.93	1.90
1927	1.53	1.47	.00	.00	3.52	2.78	1.54	.97	.75	.96	1.09	1.69
1928	1.77	1.49	1.47	1.40	3.48	1.18	1.27	.83	.20	.63	1.23	1.03
1929	1.21	.00	.08	.00	3.26	2.81	.56	.98	.71	.94	.99	1.19
1930	1.90	.41	.00	.13	3.49	3.24	.97	.99	.75	.88	1.28	2.15
1931	1.51	.77	.31	2.30	.24	1.07	1.41	.16	.56	.94	1.26	1.42
1932	2.26	.00	.00	3.01	3.20	3.30	1.38	.99	.74	.60	1.27	2.10
1933	1.98	.00	.00	.00	3.61	1.76	.01	.59	.67	.68	.62	2.05
1934	.96	.10	.00	2.32	3.02	2.20	.98	.75	.40	.97	1.27	2.09
1935	2.10	.94	.95	.29	1.67	2.24	1.01	.22	.74	.96	1.28	1.54
1936	1.53	.00	1.25	1.97	2.12	2.54	1.53	.99	.68	.96	1.24	1.90
1937	2.09	1.03	.00	.00	1.86	2.87	.00	.97	.28	.24	1.21	1.96
1938	1.40	1.14	.00	.96	.86	1.70	1.41	.56	.75	.68	.99	.97
1939	1.67	.00	.00	1.88	3.46	2.65	.93	.00	.00	.97	1.25	.70
1940	2.21	.00	.00	2.17	2.93	2.38	.00	.98	.73	.91	1.25	1.65
1941	1.69	1.31	.00	.70	2.27	1.61	1.13	.84	.58	.94	.92	1.36
1942	1.09	.00	.00	.92	2.70	2.82	.00	.57	.56	.03	.00	2.09
1943	.00	.00	.00	2.68	2.34	2.49	1.47	.96	.17	.92	1.23	.38
1944	1.26	1.05	.00	1.51	3.21	.34	1.38	.74	.74	.97	1.25	2.06
1945	2.13	2.12	.00	.17	3.74	2.22	1.34	.92	.74	.97	1.28	1.85
1946	.52	.28	.00	.79	2.68	2.19	.90	.83	.04	.91	1.23	1.39
1947	1.70	.00	.00	1.79	2.68	.97	.79	.86	.72	.97	1.23	1.88
1948	1.37	.85	.00	.01	2.20	1.67	.23	.93	.69	.79	1.24	1.79
1949	1.09	.00	.00	1.30	3.43	1.26	.91	.86	.72	.94	.94	1.97
1950	1.69	1.15	.00	1.86	3.56	2.55	1.33	.91	.66	.97	.00	1.54
1951	1.07	2.01	.00	.15	3.18	2.26	1.01	.76	.66	.58	1.20	2.18
1952	1.67	.00	.00	.96	1.49	2.71	1.06	.94	.44	.97	.70	1.64
1953	1.89	.00	.00	1.62	3.11	2.58	.72	.26	.61	.93	1.17	.85
1954	.00	.00	1.30	.00	2.75	1.41	.35	.88	.68	.97	1.27	1.90
1955	1.07	.00	.00	3.94	.83	2.71	1.44	.81	.67	.94	1.10	1.40
1956	1.23	.00	.00	1.22	3.13	2.57	.18	.93	.66	.53	1.02	.00
1957	.00	.75	.37	1.02	2.60	3.05	.00	.96	.73	.97	1.25	1.66
1958	1.85	.00	.00	.00	1.83	3.37	1.01	.35	.75	.93	.97	1.86
1959	.97	.90	.00	1.62	2.58	2.06	.04	.94	.74	.89	1.15	1.49
1960	1.40	.03	.00	.74	3.08	2.54	.21	.83	.58	.97	1.26	1.20
1961	1.82	.00	.00	1.37	3.55	1.50	.79	.87	.75	.94	.74	2.14
1962	1.25	.00	.00	1.00	3.91	.25	.69	.95	.39	.00	1.24	2.10
1963	1.65	.00	1.59	.00	3.57	3.64	.78	.88	.51	.90	1.16	1.32
1964	.94	1.06	.00	2.81	3.34	3.87	.91	.67	.04	.78	.81	1.38
1965	1.56	.37	.00	.00	3.17	3.97	.60	.80	.71	.96	1.01	1.85
1966	1.72	.00	.00	.00	1.82	.83	.44	.92	.70	.72	1.25	1.87
1967	1.36	.06	.76	1.08	3.29	1.76	1.17	.94	.74	.97	.89	1.56
1968	1.91	.92	.00	1.82	3.52	.25	.37	.70	.66	.82	1.22	1.51
1969	.71	1.20	.00	2.48	3.19	3.15	1.10	.57	.62	.97	.73	.86
1970	.74	.28	.39	1.80	3.32	2.66	.31	.00	.75	.54	.64	1.88
1971	1.33	.79	.00	1.09	2.70	1.94	1.21	.38	.56	.79	1.19	2.06
1972	1.48	.80	.46	.84	1.01	2.03	.55	.96	.73	.93	.47	.60
1973	1.86	.54	.00	.00	3.07	2.18	1.00	.76	.41	.86	1.19	2.14
1974	2.38	.00	.00	.34	2.60	3.40	.38	.74	.72	.97	1.13	.00
1975	2.14	.00	.00	.00	2.19	.64	.79	.67	.75	.95	1.10	1.76
1976	.74	.52	.00	.00	2.20	1.85	1.34	.83	.74	.95	1.02	1.19
1977	.52	.27	.00	.00	3.01	2.27	.52	.92	.74	.94	.88	1.27
1978	.18	.94	.00	1.21	2.89	3.07	.87	.85	.75	.76	.78	1.24
1979	1.93	1.37	.00	2.45	3.88	3.60	1.17	.86	.75	.97	1.13	1.10
1980	1.84	.41	.39	.69	3.45	3.70	1.37	.67	.51	.93	.93	1.20
1981	1.78	.00	1.13	1.11	3.21	.68	.72	.86	.74	.91	1.25	1.79
1982	.02	.86	.40	2.06	4.01	2.95	.92	.86	.75	.70	1.00	2.18
1983	1.32	.00	.00	.00	2.49	1.95	.37	.81	.55	.38	.83	1.80
1984	1.19	.74	.87	.74	1.20	3.16	1.71	.94	.70	.88	1.17	1.88
1985	.34	1.00	.00	1.72	3.27	1.93	.83	.94	.52	.97	1.13	1.81
1986	1.11	.76	.00	.00	3.20	1.48	1.31	.85	.10	.86	.65	.00
1987	1.45	.23	.00	1.64	2.23	1.84	1.28	.92	.49	.55	.98	1.43
1988	1.09	.00	.00	2.23	1.87	3.46	1.42	.74	.46	.97	1.16	1.92
1989	1.68	.00	.00	2.55	3.06	1.91	.70	.87	.75	.97	.64	1.92
1990	1.25	.87	.00	.00	2.32	1.37	1.57	.78	.60	.88	1.23	1.14
1991	.88	1.47	.00	2.29	2.92	3.19	1.17	.99	.74	.94	1.16	2.00
1992	1.93	.77	.24	2.57	3.13	2.45	1.34	.92	.75	.97	.99	1.57
1993	.00	1.31	.00	1.51	3.80	1.65	1.47	.90	.74	.77	.65	2.03
1994	1.48	1.57	.00	1.54	4.06	2.20	.94	.45	.04	.90	1.16	2.09

Third phase irrigation water use for 2030 – MNGWEN75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	1.55	3.01	3.38	.98	2.12	1.43	1.84	1.48	.56	1.31	1.76	.20
1926	1.02	2.13	1.28	1.28	1.75	1.21	2.14	1.70	1.25	1.21	.92	2.24
1927	1.01	3.23	.74	1.25	2.81	1.28	2.15	1.49	1.25	1.31	1.37	.76
1928	2.11	2.99	1.91	.79	1.63	.87	1.81	1.45	.52	.00	1.54	.00
1929	2.07	1.94	2.94	1.26	1.74	.21	1.09	1.71	1.13	1.18	1.49	1.50
1930	2.19	2.63	2.62	1.51	2.50	1.92	1.33	1.69	1.24	.94	1.76	2.32
1931	1.75	3.33	2.09	1.67	.50	1.58	1.61	.63	1.13	1.30	1.76	1.69
1932	2.63	.74	1.34	2.95	.34	.38	1.48	1.71	1.18	.58	1.76	2.24
1933	2.12	.00	1.86	.00	1.79	1.63	1.21	.83	1.25	.82	.90	1.98
1934	1.57	.32	1.03	3.07	.79	1.42	1.07	1.43	1.00	1.31	1.66	2.20
1935	2.77	2.71	2.26	.04	.00	1.89	2.16	.04	1.25	1.31	1.71	1.77
1936	2.08	1.06	2.25	2.58	.92	2.15	2.06	1.71	1.21	1.31	1.76	2.03
1937	2.57	2.02	1.51	1.73	1.35	2.33	.24	1.68	.67	.25	1.45	1.93
1938	1.52	2.84	2.00	2.25	.00	1.55	1.40	.90	1.25	.88	1.22	1.33
1939	1.34	.80	1.55	2.38	1.22	1.19	1.88	.00	.27	1.28	1.74	1.25
1940	2.72	1.96	.85	1.81	.00	.00	.91	1.71	1.25	1.20	1.76	2.19
1941	1.78	3.06	2.42	.80	.79	.58	1.42	1.25	1.18	1.11	1.25	1.69
1942	2.18	.51	1.26	.00	1.82	1.04	.00	.53	1.14	.00	.00	2.27
1943	.00	1.51	2.23	2.30	.42	2.20	1.98	1.44	.67	1.31	1.75	.47
1944	2.40	2.34	3.21	2.54	1.45	.14	1.83	1.26	1.18	1.31	1.75	2.31
1945	2.84	3.13	2.57	1.50	1.61	1.36	1.79	1.59	1.25	1.31	1.72	2.20
1946	1.31	1.81	2.50	2.15	.00	.98	1.54	1.70	.09	1.21	1.76	1.44
1947	1.46	.89	.93	1.24	1.28	1.11	1.10	1.60	1.25	1.30	1.72	2.00
1948	2.40	2.27	1.69	1.12	.88	.02	1.35	1.38	1.24	1.27	1.75	1.58
1949	2.16	1.72	1.40	2.92	2.32	1.02	1.49	1.31	1.16	.94	1.04	2.11
1950	2.30	2.87	1.35	1.12	1.68	1.20	1.33	1.58	1.15	1.27	.21	1.28
1951	2.20	3.47	.99	.00	1.57	1.28	1.94	1.54	1.25	.63	1.48	2.00
1952	1.36	2.18	.31	2.99	.35	2.09	1.46	1.66	1.23	1.22	.83	2.18
1953	2.11	1.25	1.96	2.51	1.26	1.79	1.17	.77	1.19	1.31	1.74	.82
1954	1.34	1.23	1.54	.00	1.45	.34	1.49	1.34	1.25	1.31	1.76	2.12
1955	2.47	2.95	1.04	3.16	.74	.00	2.02	1.61	1.25	1.23	1.67	1.52
1956	2.57	1.96	.00	.28	1.15	.67	1.25	1.45	1.21	.57	.74	.00
1957	.16	2.93	2.03	1.29	1.27	1.96	.71	1.64	1.25	1.24	1.76	1.85
1958	2.09	1.93	2.60	1.92	.52	2.36	1.12	.00	1.24	.96	1.60	2.18
1959	.87	1.74	1.90	2.42	1.21	.68	1.11	1.63	1.25	1.20	1.45	1.66
1960	1.84	1.23	.38	2.64	1.47	1.02	1.28	1.46	1.18	1.31	1.40	1.50
1961	2.66	2.30	1.96	.00	.94	.74	.50	1.53	1.25	1.31	1.36	2.12
1962	2.14	.92	1.79	1.49	2.21	.61	1.48	1.61	.92	.69	1.76	2.21
1963	1.50	1.14	2.55	.83	2.14	1.27	1.53	1.61	.71	1.22	1.70	.62
1964	.66	1.97	2.58	2.67	2.30	2.41	1.63	1.31	.14	.70	.58	1.51
1965	2.41	2.36	1.70	.01	1.85	2.76	1.32	1.22	1.13	1.31	1.27	2.01
1966	2.24	1.32	1.99	.00	.00	.57	.41	1.40	1.24	1.03	1.71	2.22
1967	2.24	1.42	1.83	2.00	2.48	1.77	1.77	1.64	1.25	1.23	1.37	2.11
1968	2.54	2.55	1.57	2.66	1.32	.14	1.51	.62	1.22	1.25	1.68	1.55
1969	1.28	3.12	1.61	1.63	.38	2.61	2.20	1.47	1.01	1.31	.33	.83
1970	1.88	2.44	2.39	1.00	2.20	2.38	1.48	.80	1.22	.66	1.06	2.24
1971	1.85	2.12	2.20	1.21	1.85	.00	1.72	1.06	1.22	1.18	1.55	2.21
1972	1.90	1.04	3.08	1.76	.84	1.04	.91	1.63	1.25	1.17	.19	1.13
1973	2.88	1.59	1.61	.00	1.93	1.61	.68	1.59	.71	1.07	1.44	2.29
1974	2.62	1.71	.67	.21	.25	1.84	1.22	1.34	1.24	1.30	1.67	.00
1975	2.76	.72	.46	.75	.38	.00	1.72	1.04	1.25	1.17	1.76	1.67
1976	1.44	2.19	2.14	.49	2.68	1.30	1.22	1.66	1.22	1.27	1.70	1.39
1977	.34	2.31	1.63	1.11	2.31	.97	.72	1.70	1.24	1.31	1.31	.94
1978	1.42	2.49	.26	1.25	1.74	1.66	1.53	1.07	1.25	.84	.71	1.96
1979	2.39	2.93	2.07	1.87	2.26	2.16	1.80	1.57	1.25	1.31	1.69	1.14
1980	2.71	1.74	.00	.00	.97	2.22	1.88	1.66	.74	1.31	.86	1.86
1981	2.60	.97	3.02	1.29	2.37	1.46	1.93	1.65	1.12	1.22	1.69	2.10
1982	.96	3.07	2.40	1.98	2.73	1.63	1.42	1.22	1.19	.79	1.51	2.12
1983	1.88	1.05	1.79	2.32	2.71	1.37	.71	1.70	.86	1.17	.67	2.11
1984	1.72	2.60	2.00	.91	.95	1.69	2.26	1.62	1.14	1.30	1.76	2.09
1985	1.02	1.26	1.73	1.90	1.42	1.92	1.78	1.70	.75	1.31	1.13	2.15
1986	1.29	2.13	2.03	1.68	.89	.41	2.15	1.66	1.04	1.26	.31	.00
1987	1.96	2.47	2.28	.97	.00	1.03	1.66	1.34	.39	.92	1.57	1.89
1988	2.44	2.68	1.22	1.88	.62	2.27	1.99	1.57	1.11	1.24	1.75	2.31
1989	2.15	.85	1.86	2.53	2.46	1.73	1.22	1.67	1.13	1.31	1.08	2.30
1990	2.17	3.48	.53	.00	1.93	2.49	2.13	1.67	.93	1.31	1.76	1.97
1991	.00	2.29	.00	2.15	1.05	1.25	1.24	1.71	1.25	1.28	1.54	2.26
1992	2.33	2.39	.78	1.63	.67	1.39	1.79	1.48	1.25	1.31	1.76	1.64
1993	.00	2.32	1.54	1.59	1.10	.86	1.51	1.47	1.25	1.10	1.37	2.32
1994	2.13	3.46	1.47	1.59	2.54	1.10	1.89	1.54	1.19	1.25	1.73	2.15

Third phase irrigation water use for 2030 – MUNGU75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.31	.43	.80	.06	.51	.33	.53	.30	.14	.30	.43	.05
1926	.35	.36	.53	.50	.06	.17	.56	.40	.30	.21	.27	.57
1927	.33	.62	.29	.32	.44	.21	.50	.30	.30	.30	.39	.40
1928	.46	.70	.55	.38	.44	.10	.44	.36	.09	.16	.40	.08
1929	.59	.14	.44	.14	.27	.37	.44	.39	.28	.27	.33	.42
1930	.53	.69	.34	.05	.30	.37	.49	.39	.30	.24	.43	.60
1931	.51	.57	.53	.36	.00	.30	.56	.09	.24	.29	.43	.45
1932	.66	.53	.44	.71	.33	.27	.47	.39	.29	.17	.43	.58
1933	.66	.03	.28	.02	.40	.28	.49	.20	.24	.14	.17	.59
1934	.40	.43	.11	.53	.35	.24	.28	.36	.26	.30	.43	.51
1935	.65	.71	.65	.20	.02	.17	.56	.00	.30	.30	.43	.53
1936	.43	.06	.71	.27	.08	.34	.53	.40	.29	.30	.43	.48
1937	.65	.65	.21	.35	.21	.46	.37	.39	.03	.12	.36	.46
1938	.11	.56	.14	.42	.02	.45	.53	.14	.29	.14	.38	.33
1939	.54	.00	.36	.40	.42	.40	.46	.00	.13	.30	.43	.33
1940	.53	.33	.22	.44	.24	.38	.08	.40	.30	.27	.43	.52
1941	.54	.67	.30	.19	.14	.19	.42	.32	.26	.30	.29	.39
1942	.47	.02	.38	.01	.36	.36	.02	.04	.29	.00	.00	.56
1943	.01	.11	.36	.52	.01	.52	.58	.39	.03	.30	.43	.03
1944	.54	.62	.58	.58	.40	.02	.48	.35	.29	.30	.43	.58
1945	.71	.76	.82	.37	.53	.24	.55	.36	.30	.30	.43	.54
1946	.22	.10	.63	.65	.02	.32	.47	.38	.06	.30	.42	.44
1947	.47	.17	.46	.29	.51	.27	.43	.34	.30	.30	.43	.46
1948	.33	.49	.58	.12	.22	.36	.26	.36	.27	.30	.43	.45
1949	.38	.53	.22	.58	.36	.38	.35	.23	.29	.30	.31	.58
1950	.47	.49	.33	.62	.50	.34	.40	.33	.27	.26	.03	.48
1951	.50	.81	.24	.08	.55	.32	.36	.27	.29	.08	.42	.57
1952	.53	.34	.65	.30	.00	.41	.31	.38	.27	.30	.12	.55
1953	.63	.13	.63	.59	.01	.29	.46	.12	.27	.30	.43	.30
1954	.14	.01	.62	.00	.12	.44	.46	.38	.29	.30	.43	.57
1955	.37	.44	.55	.73	.23	.24	.60	.21	.30	.30	.42	.40
1956	.46	.16	.02	.14	.39	.30	.38	.39	.21	.00	.24	.00
1957	.11	.65	.68	.36	.25	.27	.03	.40	.30	.30	.43	.42
1958	.46	.31	.37	.56	.14	.53	.40	.11	.30	.24	.40	.52
1959	.29	.36	.63	.35	.32	.33	.21	.38	.30	.30	.30	.46
1960	.43	.27	.22	.73	.36	.12	.24	.23	.27	.30	.43	.39
1961	.59	.36	.62	.05	.21	.49	.33	.38	.30	.30	.29	.49
1962	.64	.36	.29	.33	.62	.06	.44	.36	.12	.00	.43	.60
1963	.42	.42	.70	.14	.49	.38	.38	.39	.12	.29	.39	.30
1964	.14	.44	.48	.19	.35	.63	.45	.37	.02	.23	.33	.43
1965	.47	.49	.65	.02	.47	.67	.32	.29	.28	.30	.29	.51
1966	.55	.47	.40	.02	.28	.01	.24	.36	.30	.29	.43	.55
1967	.56	.35	.55	.71	.55	.33	.53	.36	.30	.30	.21	.58
1968	.65	.47	.49	.45	.20	.00	.29	.29	.28	.24	.43	.55
1969	.21	.70	.46	.36	.14	.57	.45	.30	.26	.26	.08	.38
1970	.37	.46	.76	.12	.50	.29	.33	.08	.29	.17	.25	.54
1971	.33	.55	.26	.07	.17	.08	.55	.29	.25	.30	.36	.56
1972	.47	.40	.72	.44	.00	.51	.19	.38	.30	.30	.07	.30
1973	.62	.09	.62	.00	.21	.40	.26	.38	.17	.27	.37	.60
1974	.64	.26	.31	.26	.03	.44	.28	.34	.30	.30	.40	.00
1975	.63	.28	.33	.05	.06	.02	.33	.19	.30	.30	.38	.49
1976	.17	.53	.41	.17	.52	.07	.37	.34	.30	.30	.41	.29
1977	.21	.52	.51	.00	.29	.24	.35	.39	.29	.30	.27	.27
1978	.06	.49	.59	.42	.02	.54	.50	.31	.29	.05	.14	.24
1979	.60	.51	.52	.27	.24	.33	.49	.37	.30	.30	.43	.21
1980	.47	.34	.26	.11	.09	.57	.43	.36	.10	.30	.24	.31
1981	.58	.46	.70	.38	.62	.20	.55	.38	.29	.26	.43	.37
1982	.04	.59	.67	.36	.60	.36	.48	.26	.26	.24	.31	.57
1983	.38	.11	.26	.02	.49	.17	.30	.39	.21	.24	.15	.49
1984	.27	.63	.51	.03	.00	.60	.60	.38	.30	.30	.43	.49
1985	.03	.27	.33	.08	.17	.29	.38	.40	.14	.30	.39	.55
1986	.49	.60	.25	.40	.12	.02	.49	.38	.27	.30	.12	.00
1987	.37	.36	.51	.28	.06	.28	.43	.39	.15	.08	.43	.40
1988	.27	.51	.21	.37	.01	.43	.50	.36	.23	.30	.42	.60
1989	.49	.00	.37	.57	.43	.40	.24	.37	.30	.30	.24	.60
1990	.49	.68	.21	.22	.03	.43	.57	.33	.19	.29	.43	.47
1991	.12	.54	.17	.53	.17	.44	.33	.40	.30	.30	.35	.58
1992	.65	.47	.59	.52	.20	.26	.47	.40	.30	.30	.35	.48
1993	.01	.36	.27	.29	.24	.15	.44	.39	.30	.26	.25	.56
1994	.58	.68	.49	.35	.59	.30	.47	.24	.29	.30	.41	.56

Third phase irrigation water use for 2030 – NON75.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.22	.39	.54	.17	.70	.49	.44	.20	.16	.41	.67	.16
1926	.16	.22	.19	.67	.26	.32	.47	.30	.30	.34	.50	.82
1927	.20	.46	.14	.58	.64	.37	.42	.25	.30	.41	.62	.55
1928	.34	.50	.23	.49	.52	.11	.28	.25	.02	.16	.61	.14
1929	.47	.08	.27	.21	.46	.26	.29	.29	.28	.37	.55	.58
1930	.46	.48	.11	.16	.53	.52	.36	.29	.30	.32	.67	.85
1931	.38	.51	.19	.58	.00	.37	.39	.08	.26	.41	.67	.62
1932	.62	.32	.26	1.06	.51	.44	.28	.29	.30	.22	.67	.83
1933	.62	.04	.08	.02	.49	.41	.24	.14	.25	.24	.33	.83
1934	.30	.18	.01	.95	.48	.34	.17	.26	.25	.41	.65	.78
1935	.64	.50	.56	.34	.11	.42	.44	.00	.30	.41	.67	.77
1936	.39	.03	.35	.48	.25	.52	.39	.30	.29	.41	.67	.76
1937	.58	.48	.07	.58	.36	.61	.16	.30	.02	.18	.58	.69
1938	.18	.43	.19	.67	.24	.56	.44	.12	.30	.25	.58	.61
1939	.45	.02	.25	.76	.75	.53	.35	.03	.06	.41	.66	.47
1940	.48	.31	.08	.66	.38	.31	.04	.30	.30	.37	.67	.77
1941	.50	.52	.26	.43	.11	.09	.23	.27	.26	.41	.50	.66
1942	.38	.04	.07	.16	.41	.42	.00	.02	.29	.04	.00	.79
1943	.00	.04	.08	.69	.14	.66	.51	.27	.06	.41	.67	.15
1944	.53	.36	.52	.86	.59	.03	.41	.26	.29	.41	.67	.83
1945	.70	.51	.54	.58	.56	.43	.41	.26	.30	.41	.67	.79
1946	.06	.10	.46	.98	.19	.22	.28	.29	.02	.41	.66	.59
1947	.37	.06	.14	.28	.64	.31	.18	.28	.30	.41	.67	.74
1948	.31	.33	.27	.29	.38	.29	.06	.27	.28	.40	.67	.67
1949	.41	.28	.19	1.02	.67	.47	.11	.19	.29	.40	.52	.79
1950	.40	.27	.04	.85	.58	.42	.22	.27	.25	.41	.12	.64
1951	.38	.58	.14	.02	.70	.25	.27	.22	.29	.16	.62	.79
1952	.39	.28	.26	.62	.14	.54	.22	.28	.28	.41	.38	.81
1953	.52	.23	.34	.79	.11	.39	.26	.08	.28	.41	.67	.49
1954	.05	.01	.30	.06	.16	.60	.34	.26	.30	.41	.67	.80
1955	.38	.35	.20	1.10	.21	.16	.47	.23	.30	.41	.66	.62
1956	.54	.14	.00	.17	.66	.37	.12	.30	.26	.06	.46	.00
1957	.01	.43	.52	.52	.50	.41	.00	.29	.30	.41	.67	.64
1958	.41	.21	.14	.70	.19	.74	.23	.03	.30	.34	.65	.80
1959	.08	.28	.40	.64	.37	.36	.01	.29	.30	.41	.57	.74
1960	.28	.27	.08	.95	.47	.25	.01	.21	.27	.41	.65	.58
1961	.58	.31	.35	.14	.23	.52	.15	.28	.30	.41	.52	.74
1962	.58	.21	.00	.44	.67	.03	.29	.27	.14	.11	.67	.84
1963	.33	.19	.59	.40	.79	.41	.16	.29	.12	.40	.61	.53
1964	.11	.32	.33	.44	.38	.83	.31	.25	.01	.31	.44	.56
1965	.45	.31	.50	.08	.58	.90	.23	.20	.26	.41	.50	.75
1966	.48	.23	.16	.10	.48	.08	.04	.22	.30	.37	.66	.83
1967	.50	.37	.33	.86	.73	.55	.42	.28	.30	.41	.47	.79
1968	.66	.40	.44	.62	.48	.01	.14	.14	.27	.37	.64	.76
1969	.08	.56	.10	.75	.39	.79	.38	.24	.24	.38	.25	.48
1970	.34	.35	.52	.31	.68	.59	.25	.09	.29	.24	.51	.76
1971	.20	.30	.09	.44	.52	.16	.38	.19	.28	.41	.57	.84
1972	.38	.14	.55	.66	.21	.69	.03	.29	.30	.41	.16	.51
1973	.61	.16	.38	.41	.25	.16	.22	.28	.19	.37	.62	.84
1974	.63	.23	.00	.30	.27	.65	.15	.28	.30	.41	.65	.11
1975	.64	.15	.19	.26	.19	.01	.20	.13	.30	.41	.64	.66
1976	.23	.31	.22	.34	.69	.31	.23	.28	.30	.41	.64	.47
1977	.11	.27	.37	.03	.71	.18	.16	.29	.30	.41	.51	.47
1978	.06	.33	.16	.74	.13	.61	.31	.21	.30	.23	.28	.58
1979	.47	.39	.31	.59	.56	.64	.30	.26	.30	.41	.65	.33
1980	.52	.19	.05	.22	.27	.77	.31	.28	.17	.41	.44	.61
1981	.61	.30	.46	.41	.84	.52	.46	.29	.26	.34	.67	.65
1982	.04	.44	.20	.44	.91	.49	.34	.22	.28	.31	.56	.81
1983	.35	.23	.01	.50	.84	.35	.08	.30	.25	.37	.44	.74
1984	.23	.51	.52	.11	.15	.78	.50	.26	.25	.41	.67	.78
1985	.03	.34	.26	.27	.60	.25	.22	.30	.11	.41	.57	.80
1986	.11	.38	.04	.41	.08	.08	.44	.30	.20	.41	.11	.00
1987	.43	.35	.16	.34	.28	.26	.23	.28	.11	.12	.66	.65
1988	.14	.44	.04	.74	.11	.64	.44	.22	.24	.41	.64	.83
1989	.41	.01	.05	.82	.61	.43	.12	.28	.30	.41	.38	.85
1990	.46	.55	.02	.17	.30	.64	.47	.26	.19	.41	.67	.64
1991	.01	.36	.09	.65	.25	.56	.39	.30	.30	.41	.56	.80
1992	.62	.30	.15	.80	.32	.23	.32	.30	.30	.41	.64	.61
1993	.01	.27	.03	.34	.50	.14	.31	.26	.30	.36	.51	.83
1994	.53	.49	.41	.12	.70	.23	.40	.26	.28	.41	.65	.65

Third phase irrigation water use for 2030 – RORK75B.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	1.07	.75	.62	1.61	1.74	1.17	.86	.61	.00	.60	.97	.34
1926	.95	.51	.46	1.24	.05	.41	.91	.75	.45	.15	.85	1.72
1927	.68	1.38	.00	1.20	1.83	1.12	.81	.75	.45	.60	.73	.92
1928	1.10	1.24	.38	.87	1.83	.00	.68	.77	.00	.29	.94	.08
1929	1.09	.01	.46	.71	1.61	1.52	.15	.77	.44	.38	.75	1.14
1930	1.27	1.38	.00	.00	1.14	1.64	.66	.78	.45	.44	.97	1.79
1931	1.39	1.10	1.40	1.33	.00	.29	.81	.10	.40	.58	.97	1.51
1932	1.59	.89	.00	2.09	1.55	1.01	.48	.77	.43	.11	.94	1.73
1933	1.39	.00	.00	.02	1.40	.80	.58	.38	.45	.10	.36	1.69
1934	1.32	.11	.00	1.39	1.18	1.12	.09	.65	.38	.58	.90	1.40
1935	1.59	1.25	.07	.00	.20	.05	.89	.00	.45	.58	.97	1.57
1936	.99	.00	1.18	.00	.49	1.16	.57	.78	.44	.59	.97	1.35
1937	1.65	1.22	.00	.70	.81	1.28	.18	.77	.00	.15	.83	1.54
1938	.03	1.20	.00	.79	.44	.96	.88	.27	.44	.22	.86	1.19
1939	1.25	.00	.03	1.33	1.27	1.59	.05	.00	.00	.58	.94	.93
1940	.85	.36	.00	.90	.81	.97	.00	.78	.45	.56	.97	1.38
1941	1.35	.92	.18	.00	.54	.94	.89	.60	.23	.60	.71	.71
1942	.83	.00	.00	.07	1.76	1.57	.00	.19	.40	.00	.00	1.60
1943	.00	.08	.00	.97	.03	1.48	.89	.77	.00	.60	.97	.04
1944	.90	1.39	.63	1.65	1.42	.00	.32	.72	.45	.60	.97	1.69
1945	1.87	1.47	1.41	.77	1.89	.60	.77	.77	.45	.59	.96	1.68
1946	.36	.18	.61	1.83	.06	1.17	.54	.77	.03	.57	.90	1.38
1947	1.12	.00	.00	.52	.75	.83	.48	.66	.45	.56	.97	1.23
1948	.45	.79	.54	.03	.88	.77	.07	.77	.43	.57	.97	1.24
1949	.56	.85	.00	1.48	1.53	1.22	.03	.30	.41	.59	.68	1.68
1950	1.08	.69	.00	1.60	1.63	.89	.53	.58	.44	.52	.16	1.36
1951	1.01	1.55	.00	.84	2.22	1.33	.25	.66	.44	.18	.95	1.69
1952	1.73	.23	.39	.53	.00	1.31	.05	.77	.38	.60	.36	1.62
1953	1.72	.26	.85	1.63	.01	.99	.56	.10	.38	.59	.96	.75
1954	.38	.01	1.09	.00	.12	1.27	.58	.72	.44	.60	.94	1.70
1955	.86	.48	.54	1.86	.00	1.05	.96	.15	.45	.60	.96	1.14
1956	.79	.00	.00	.57	1.23	.55	.00	.74	.26	.00	.48	.00
1957	.00	1.27	.82	.51	1.46	.92	.00	.77	.45	.60	.97	1.34
1958	.93	.49	.09	1.57	.93	1.83	.44	.31	.45	.32	.92	1.43
1959	.81	.28	.30	1.46	.93	1.31	.00	.73	.45	.59	.77	1.11
1960	.90	.15	.00	2.09	1.38	.75	.00	.34	.35	.60	.97	1.10
1961	1.29	.34	.87	.51	1.05	1.47	.32	.68	.45	.60	.74	1.42
1962	1.57	.32	.00	.66	2.48	.57	.44	.64	.00	.00	.97	1.79
1963	.54	.03	1.16	.03	1.65	1.47	.27	.75	.02	.57	.77	.83
1964	.00	.45	.09	.12	1.29	2.14	.53	.75	.00	.42	.66	1.29
1965	.90	.71	.87	.02	1.30	2.21	.29	.48	.43	.60	.65	1.40
1966	1.38	.71	.00	.11	.63	1.09	.09	.71	.45	.57	.96	1.64
1967	1.14	.34	.02	1.64	2.16	1.08	.75	.66	.45	.58	.42	1.67
1968	1.84	.56	.00	1.15	1.08	.03	.01	.55	.39	.49	.96	1.48
1969	.22	1.17	.02	.25	.64	1.74	.42	.59	.38	.45	.03	.95
1970	.26	.66	.96	.40	2.02	1.57	.00	.20	.45	.29	.67	1.57
1971	.39	.91	.00	.99	.63	.10	.79	.40	.32	.57	.92	1.72
1972	.88	.33	.77	.97	.41	1.49	.00	.75	.45	.59	.03	1.03
1973	1.79	.03	1.08	.01	.92	1.55	.01	.69	.15	.44	.81	1.74
1974	1.70	.00	.00	.54	.07	1.42	.00	.67	.45	.59	.92	.01
1975	1.63	.31	.00	.38	.73	.67	.10	.16	.45	.60	.95	1.43
1976	.02	1.01	.00	.38	1.98	.54	.70	.75	.45	.60	.94	.58
1977	.58	.73	.49	.01	.59	1.36	.30	.73	.44	.59	.55	.95
1978	.10	.51	.61	.81	.81	1.87	.51	.65	.44	.20	.14	.66
1979	1.71	1.00	.20	.07	1.32	1.66	.66	.75	.45	.60	.92	.61
1980	1.42	.60	.00	.12	.99	1.79	.46	.69	.08	.59	.51	.75
1981	1.50	.83	1.03	1.03	1.85	.64	.87	.74	.44	.51	.97	1.12
1982	.03	1.29	.33	1.20	2.03	1.10	.68	.45	.38	.44	.60	1.72
1983	.88	.00	.00	.00	1.42	.03	.51	.77	.29	.39	.29	1.34
1984	.38	.99	1.02	.53	.00	1.90	.97	.77	.45	.49	.96	1.27
1985	.08	.25	.24	.24	.83	.96	.38	.78	.18	.60	.90	1.46
1986	1.21	1.03	.00	.96	1.10	.62	.50	.73	.32	.59	.29	.00
1987	.71	.59	.45	.20	1.20	.90	.62	.71	.20	.38	.92	1.23
1988	.48	.76	.00	1.25	.02	1.46	.84	.71	.27	.60	.95	1.77
1989	1.08	.00	.42	1.77	1.33	1.07	.00	.73	.45	.57	.63	1.78
1990	1.23	1.33	.00	.60	.00	1.27	.84	.47	.08	.56	.95	1.35
1991	.13	.89	.01	1.30	1.09	1.53	.55	.78	.45	.59	.77	1.72
1992	1.57	.62	.06	1.74	.42	.76	.67	.77	.45	.60	.70	1.53
1993	.00	.53	.00	.81	1.26	.81	.41	.76	.45	.45	.77	1.50
1994	1.18	1.30	.05	1.03	2.03	.71	.66	.58	.44	.58	.95	1.78

Third phase irrigation water use for 2030 – THDRIE75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.16	.00	.00	.03	.13	.01	.15	.13	.08	.28	.52	.04
1926	.01	.00	.00	.00	.10	.00	.05	.15	.18	.20	.44	.54
1927	.00	.04	.00	.04	.14	.00	.15	.11	.19	.28	.47	.48
1928	.19	.00	.00	.06	.03	.00	.03	.09	.00	.07	.50	.00
1929	.18	.00	.00	.06	.14	.00	.14	.10	.10	.19	.39	.40
1930	.21	.08	.00	.00	.18	.00	.00	.16	.19	.09	.52	.56
1931	.20	.04	.00	.15	.00	.00	.14	.08	.16	.27	.51	.48
1932	.23	.00	.00	.14	.22	.14	.03	.15	.19	.14	.52	.55
1933	.25	.00	.00	.00	.11	.00	.00	.03	.19	.15	.25	.50
1934	.00	.00	.00	.23	.00	.00	.17	.14	.11	.27	.50	.49
1935	.31	.00	.00	.03	.08	.00	.15	.00	.18	.28	.52	.49
1936	.07	.00	.00	.00	.00	.11	.15	.16	.19	.28	.52	.50
1937	.19	.00	.00	.00	.18	.18	.00	.16	.08	.11	.38	.46
1938	.00	.00	.00	.00	.00	.00	.21	.06	.19	.11	.45	.41
1939	.00	.00	.00	.13	.11	.00	.10	.00	.02	.28	.50	.30
1940	.28	.00	.00	.00	.03	.14	.00	.16	.19	.25	.52	.50
1941	.12	.03	.00	.04	.06	.00	.00	.14	.14	.28	.34	.40
1942	.05	.00	.00	.00	.20	.00	.00	.01	.19	.00	.01	.54
1943	.00	.00	.00	.02	.00	.10	.20	.13	.00	.28	.52	.08
1944	.16	.00	.00	.14	.19	.00	.08	.15	.18	.28	.52	.56
1945	.31	.01	.00	.00	.04	.00	.13	.15	.19	.28	.52	.56
1946	.00	.00	.00	.21	.00	.00	.09	.15	.10	.28	.50	.42
1947	.00	.00	.00	.00	.13	.00	.00	.13	.19	.28	.52	.49
1948	.15	.00	.00	.04	.12	.00	.00	.13	.17	.28	.46	.41
1949	.19	.00	.00	.12	.11	.00	.11	.08	.17	.24	.36	.47
1950	.16	.00	.00	.21	.09	.07	.08	.15	.17	.28	.30	.38
1951	.14	.08	.00	.00	.01	.00	.11	.14	.19	.06	.47	.47
1952	.05	.00	.00	.08	.00	.16	.01	.15	.19	.28	.47	.53
1953	.16	.00	.00	.08	.00	.00	.15	.04	.16	.28	.52	.32
1954	.09	.00	.00	.00	.00	.00	.09	.11	.18	.28	.52	.53
1955	.23	.00	.00	.25	.00	.00	.19	.13	.19	.28	.52	.43
1956	.22	.00	.00	.00	.11	.00	.00	.14	.16	.12	.30	.00
1957	.00	.00	.00	.00	.11	.03	.00	.15	.19	.28	.52	.37
1958	.20	.00	.00	.10	.08	.15	.00	.00	.19	.22	.52	.56
1959	.00	.00	.00	.12	.02	.00	.00	.15	.19	.27	.47	.47
1960	.16	.00	.00	.17	.21	.00	.00	.11	.19	.28	.52	.38
1961	.29	.00	.00	.00	.09	.07	.00	.13	.19	.28	.47	.50
1962	.30	.00	.00	.00	.21	.00	.09	.16	.05	.19	.52	.56
1963	.03	.00	.01	.00	.23	.00	.04	.16	.07	.28	.47	.28
1964	.00	.00	.00	.12	.25	.29	.01	.14	.00	.24	.23	.36
1965	.24	.00	.00	.00	.14	.31	.15	.13	.16	.28	.46	.50
1966	.18	.00	.00	.00	.02	.00	.00	.14	.19	.26	.52	.54
1967	.20	.00	.00	.16	.23	.06	.13	.14	.19	.28	.39	.52
1968	.28	.00	.00	.16	.11	.00	.00	.08	.15	.26	.51	.44
1969	.00	.00	.00	.10	.11	.16	.15	.14	.16	.28	.27	.25
1970	.11	.00	.00	.00	.10	.03	.04	.08	.18	.14	.39	.54
1971	.04	.00	.00	.06	.06	.00	.11	.09	.18	.28	.46	.53
1972	.11	.00	.00	.16	.01	.04	.00	.15	.19	.26	.24	.28
1973	.25	.00	.00	.00	.00	.00	.00	.13	.08	.24	.47	.55
1974	.26	.00	.00	.00	.00	.00	.02	.15	.19	.28	.51	.02
1975	.23	.00	.00	.00	.00	.00	.00	.05	.19	.28	.50	.34
1976	.00	.00	.00	.05	.15	.00	.00	.16	.19	.28	.50	.27
1977	.00	.00	.00	.00	.03	.00	.00	.15	.19	.28	.39	.36
1978	.00	.00	.00	.15	.00	.00	.11	.09	.19	.18	.16	.47
1979	.11	.00	.00	.02	.00	.00	.11	.14	.19	.28	.47	.19
1980	.26	.00	.00	.00	.00	.25	.12	.14	.10	.28	.25	.42
1981	.27	.00	.00	.05	.21	.00	.00	.15	.19	.24	.52	.44
1982	.01	.00	.00	.08	.23	.16	.11	.12	.18	.08	.47	.51
1983	.00	.00	.00	.08	.14	.00	.00	.15	.15	.25	.31	.50
1984	.12	.03	.00	.00	.00	.25	.21	.16	.19	.28	.52	.50
1985	.00	.00	.00	.00	.16	.00	.00	.16	.14	.28	.36	.51
1986	.00	.00	.00	.14	.00	.00	.19	.16	.16	.28	.19	.00
1987	.17	.00	.00	.10	.00	.00	.09	.13	.04	.17	.48	.46
1988	.09	.00	.00	.04	.00	.00	.06	.11	.14	.28	.52	.56
1989	.16	.00	.00	.14	.15	.04	.01	.14	.18	.27	.38	.56
1990	.18	.07	.00	.00	.05	.00	.23	.16	.14	.28	.52	.48
1991	.00	.00	.00	.17	.00	.00	.13	.16	.19	.28	.44	.54
1992	.19	.00	.00	.11	.00	.00	.07	.15	.19	.28	.49	.47
1993	.00	.00	.00	.00	.00	.00	.01	.16	.19	.25	.46	.55
1994	.16	.08	.00	.04	.15	.00	.04	.14	.19	.28	.52	.42

Third phase irrigation water use for 2030 – THLTUG75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	2.75	2.12	2.06	.55	2.14	1.61	2.80	1.79	1.37	2.65	2.84	.56
1926	1.91	.96	1.54	1.81	1.24	.52	2.48	2.26	2.14	2.25	2.06	3.66
1927	1.58	2.87	1.15	2.33	2.05	1.10	2.78	1.76	2.20	2.59	2.54	2.66
1928	3.11	2.14	.25	1.56	1.46	.53	2.12	1.63	.46	.99	2.61	.16
1929	2.84	.25	1.78	.93	1.94	.00	2.29	1.98	1.92	2.38	2.36	2.29
1930	3.23	2.45	1.00	.88	2.00	1.63	1.87	2.28	2.16	1.37	2.87	3.81
1931	3.07	2.79	1.61	2.15	.00	.91	2.82	1.07	2.08	2.54	2.81	2.71
1932	3.31	1.67	1.60	3.59	2.01	1.72	1.84	2.24	2.16	1.31	2.86	3.74
1933	3.76	.00	.00	.28	1.88	.56	.01	.90	2.18	2.02	.87	3.44
1934	2.59	.00	.00	3.82	1.13	1.00	2.89	1.85	1.63	2.60	2.57	3.40
1935	4.27	1.51	2.54	2.27	.86	1.37	2.84	.00	2.13	2.63	2.87	3.47
1936	2.57	.00	1.62	1.61	.04	2.03	2.35	2.31	2.09	2.60	2.85	3.41
1937	3.49	2.26	1.22	1.32	2.25	2.09	.20	2.30	1.22	1.40	1.94	3.29
1938	1.64	1.75	1.57	1.92	.00	.67	3.05	1.01	2.20	1.69	2.44	2.70
1939	2.29	.35	1.57	2.88	1.89	.97	2.03	.38	.48	2.63	2.68	2.27
1940	3.67	1.87	1.96	1.42	1.54	1.46	1.28	2.31	2.20	2.57	2.84	3.29
1941	2.99	2.83	2.68	2.20	.81	.42	1.06	2.13	1.98	2.57	1.86	2.51
1942	3.02	.00	.63	.60	2.63	.76	.00	.09	2.17	.56	.09	3.65
1943	.00	.41	1.13	1.94	.64	1.22	3.20	1.82	.89	2.66	2.85	.52
1944	3.17	1.46	3.33	2.83	1.98	.00	2.43	2.12	1.98	2.65	2.84	3.80
1945	4.27	2.60	2.82	2.23	.78	.99	2.24	2.16	2.20	2.65	2.82	3.86
1946	1.67	.63	2.54	3.27	.33	.38	2.13	2.24	1.22	2.64	2.74	2.97
1947	1.89	1.31	1.02	.11	1.88	.49	1.20	1.84	2.20	2.65	2.85	3.28
1948	2.97	2.12	1.42	2.01	1.19	.83	1.46	2.11	2.15	2.65	2.33	2.99
1949	3.51	1.14	2.29	2.91	2.31	.00	2.20	.93	2.12	2.41	1.79	2.66
1950	3.28	1.93	.00	3.07	2.06	1.50	2.03	2.14	2.02	2.64	1.12	2.80
1951	3.01	3.35	1.94	.09	1.54	.98	2.26	2.09	2.11	1.31	2.41	3.09
1952	2.59	1.62	1.11	2.32	.00	2.44	1.66	2.24	2.17	2.66	2.18	3.62
1953	3.12	1.43	1.11	2.94	.00	1.82	2.51	.93	2.06	2.66	2.86	2.11
1954	2.10	.04	1.85	.23	.47	1.72	2.15	1.50	2.05	2.64	2.87	3.64
1955	3.74	2.06	1.05	3.86	.76	.28	2.69	2.11	2.20	2.63	2.76	2.84
1956	3.70	.92	.00	1.26	2.57	.18	1.20	2.14	2.00	1.57	1.25	.00
1957	.55	2.14	2.36	1.34	1.22	2.03	.34	2.19	2.18	2.66	2.87	2.61
1958	3.35	.66	1.46	2.44	1.54	2.54	1.63	.04	2.18	2.24	2.76	3.78
1959	1.72	1.26	2.00	3.02	.86	.00	.64	2.20	2.20	2.56	2.45	3.21
1960	3.06	1.37	1.11	3.41	2.21	1.00	1.00	1.77	2.11	2.64	2.75	2.54
1961	4.06	1.54	2.00	.53	1.72	1.66	1.17	1.81	2.20	2.65	2.37	3.41
1962	4.07	.49	1.33	.21	2.78	1.03	2.11	2.20	1.24	2.00	2.87	3.82
1963	1.95	1.00	3.31	1.07	2.78	.74	1.55	2.28	1.34	2.61	2.51	1.62
1964	.18	1.50	2.06	2.76	2.40	3.13	1.76	2.05	.15	2.26	.84	2.22
1965	3.76	1.71	2.20	.16	1.83	3.27	2.60	1.76	1.85	2.66	2.36	3.42
1966	3.32	1.17	.67	.00	.71	.41	.05	1.63	2.16	2.47	2.80	3.67
1967	3.55	2.28	2.51	3.02	2.63	1.77	2.44	2.11	2.18	2.55	2.08	3.49
1968	3.93	2.18	2.11	2.81	2.35	.50	1.69	.94	2.03	2.56	2.76	3.01
1969	1.13	2.27	1.46	2.24	1.43	2.55	2.73	1.94	1.89	2.60	.64	1.47
1970	2.62	2.03	2.86	.62	1.93	1.96	1.96	1.15	2.15	1.65	1.93	3.61
1971	2.31	1.85	1.37	1.74	1.63	.19	2.16	1.30	2.14	2.60	2.48	3.69
1972	2.73	1.16	2.91	2.79	1.05	1.79	.71	2.22	2.18	2.55	.84	1.90
1973	3.88	.62	1.07	1.00	.14	.41	.74	2.02	1.46	2.40	2.49	3.76
1974	3.70	.73	.58	1.39	.25	1.05	1.70	2.21	2.20	2.65	2.76	.29
1975	3.76	.43	.36	.44	.64	.00	1.32	.77	2.20	2.65	2.73	2.30
1976	1.36	1.30	1.92	1.41	2.76	1.28	1.44	2.26	2.18	2.65	2.68	1.61
1977	.97	1.21	1.76	.05	1.61	.60	1.43	2.22	2.15	2.66	1.98	2.31
1978	.74	2.03	.00	3.16	.00	1.55	2.18	1.29	2.19	1.87	.62	3.14
1979	2.93	1.58	1.78	1.96	.70	1.57	1.95	2.01	2.20	2.65	2.54	1.08
1980	3.67	.41	.06	.56	.00	2.68	2.41	2.08	1.35	2.66	1.07	2.69
1981	3.77	1.11	2.17	1.41	2.86	1.35	2.05	2.22	2.08	2.38	2.76	2.78
1982	1.66	2.52	2.00	1.42	2.85	1.85	2.23	1.72	2.04	1.52	2.43	3.57
1983	1.44	.64	1.49	2.26	2.71	.64	1.62	2.24	1.88	2.42	1.26	3.49
1984	2.72	2.76	2.88	.66	.00	2.86	3.16	2.20	2.07	2.65	2.84	3.40
1985	.00	.58	1.32	1.36	2.10	1.13	1.31	2.30	1.57	2.66	1.64	3.55
1986	.50	1.34	.14	2.42	.00	.09	2.91	2.30	1.71	2.58	.47	.00
1987	3.07	1.28	1.74	2.30	.34	.30	2.03	1.92	.90	1.61	2.69	3.10
1988	2.42	1.18	.49	2.24	.00	1.77	2.27	1.66	1.75	2.62	2.85	3.83
1989	2.95	.00	1.13	3.14	2.00	1.49	1.43	2.11	2.12	2.64	1.51	3.62
1990	3.19	3.13	.73	.28	.98	1.57	3.23	2.25	1.74	2.65	2.82	3.20
1991	.08	1.45	.77	3.09	.02	1.61	2.61	2.31	2.20	2.66	2.27	3.74
1992	3.43	1.98	1.75	2.84	1.19	.82	1.99	2.21	2.20	2.65	2.72	3.22
1993	.52	1.37	.67	1.45	.36	1.03	2.03	2.25	2.18	2.35	2.32	3.76
1994	3.17	3.37	2.17	2.23	1.78	.71	2.18	1.91	2.16	2.64	2.86	2.85

Third phase irrigation water use for 2030 – THSKDS75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.28	.49	.39	.01	.47	.35	.39	.20	.16	.19	.17	.00
1926	.23	.31	.37	.28	.31	.18	.38	.25	.23	.16	.11	.27
1927	.22	.52	.31	.34	.45	.28	.37	.23	.23	.18	.15	.11
1928	.32	.47	.14	.19	.38	.18	.29	.23	.06	.04	.15	.00
1929	.27	.14	.38	.08	.43	.01	.27	.25	.20	.16	.15	.08
1930	.38	.43	.21	.13	.42	.38	.31	.25	.22	.11	.17	.28
1931	.31	.52	.28	.27	.00	.27	.37	.10	.22	.18	.17	.16
1932	.35	.42	.33	.54	.41	.34	.25	.25	.23	.04	.17	.28
1933	.43	.00	.07	.02	.43	.19	.03	.14	.23	.16	.00	.27
1934	.33	.00	.00	.55	.33	.25	.38	.22	.17	.19	.15	.25
1935	.47	.35	.50	.34	.25	.34	.40	.00	.23	.19	.17	.25
1936	.33	.14	.31	.25	.14	.41	.32	.25	.22	.18	.17	.25
1937	.39	.47	.28	.18	.47	.39	.13	.25	.12	.08	.11	.25
1938	.32	.41	.36	.29	.00	.21	.40	.13	.23	.12	.15	.19
1939	.31	.21	.36	.42	.42	.25	.30	.11	.03	.19	.16	.15
1940	.40	.45	.40	.20	.39	.26	.21	.25	.23	.19	.17	.23
1941	.31	.52	.50	.32	.24	.18	.20	.24	.20	.18	.10	.17
1942	.41	.00	.19	.05	.52	.23	.00	.00	.22	.03	.00	.26
1943	.00	.22	.25	.28	.24	.26	.41	.20	.15	.19	.17	.00
1944	.37	.35	.60	.40	.41	.01	.36	.24	.20	.19	.17	.28
1945	.48	.51	.51	.35	.25	.28	.31	.24	.23	.19	.17	.28
1946	.19	.24	.47	.46	.19	.16	.31	.25	.11	.19	.17	.20
1947	.23	.35	.25	.00	.41	.19	.19	.21	.23	.19	.17	.23
1948	.31	.47	.28	.28	.29	.24	.25	.25	.23	.19	.12	.23
1949	.39	.31	.45	.42	.50	.00	.31	.12	.23	.17	.10	.14
1950	.36	.42	.02	.42	.47	.32	.28	.23	.20	.19	.01	.19
1951	.34	.58	.38	.00	.40	.24	.31	.23	.22	.06	.14	.22
1952	.30	.38	.29	.33	.07	.49	.25	.25	.23	.19	.13	.27
1953	.39	.37	.23	.44	.10	.40	.34	.14	.20	.19	.17	.11
1954	.23	.14	.38	.01	.21	.38	.33	.19	.23	.19	.17	.28
1955	.42	.47	.26	.56	.27	.15	.37	.24	.23	.19	.17	.18
1956	.44	.30	.00	.16	.55	.12	.23	.25	.21	.08	.03	.00
1957	.07	.46	.45	.22	.30	.43	.11	.25	.23	.19	.17	.16
1958	.38	.25	.32	.34	.37	.50	.25	.00	.23	.16	.17	.28
1959	.19	.34	.40	.44	.26	.09	.14	.24	.23	.18	.14	.24
1960	.34	.35	.27	.50	.45	.28	.21	.19	.21	.19	.16	.16
1961	.44	.38	.41	.05	.41	.35	.23	.20	.23	.19	.14	.24
1962	.47	.22	.29	.01	.56	.27	.29	.24	.14	.12	.17	.28
1963	.26	.31	.59	.15	.55	.23	.24	.25	.14	.18	.14	.09
1964	.10	.38	.43	.40	.47	.51	.31	.23	.04	.15	.00	.11
1965	.44	.41	.41	.00	.41	.53	.36	.19	.17	.19	.14	.27
1966	.40	.32	.21	.00	.24	.16	.10	.16	.23	.16	.17	.27
1967	.41	.49	.48	.43	.52	.38	.35	.25	.23	.17	.11	.27
1968	.43	.49	.44	.38	.51	.19	.28	.11	.22	.19	.17	.25
1969	.15	.49	.34	.31	.34	.50	.38	.20	.19	.18	.00	.07
1970	.31	.46	.52	.06	.44	.42	.32	.15	.22	.10	.11	.27
1971	.28	.42	.29	.23	.40	.14	.33	.17	.21	.18	.14	.28
1972	.32	.31	.52	.38	.31	.38	.15	.25	.23	.19	.00	.13
1973	.45	.24	.26	.16	.15	.16	.21	.21	.17	.17	.14	.28
1974	.42	.28	.18	.20	.17	.28	.28	.24	.22	.19	.16	.00
1975	.44	.21	.16	.04	.25	.08	.24	.11	.23	.19	.16	.16
1976	.21	.34	.39	.16	.58	.31	.27	.25	.22	.19	.16	.06
1977	.15	.32	.37	.00	.41	.19	.27	.24	.23	.19	.10	.11
1978	.14	.44	.03	.46	.06	.35	.31	.19	.22	.11	.00	.23
1979	.36	.40	.38	.28	.25	.35	.31	.22	.23	.19	.16	.01
1980	.40	.17	.06	.08	.00	.49	.34	.23	.13	.19	.05	.16
1981	.41	.34	.44	.16	.57	.31	.38	.24	.22	.16	.16	.20
1982	.18	.51	.37	.16	.56	.37	.34	.19	.20	.14	.14	.28
1983	.22	.25	.32	.31	.57	.23	.25	.25	.19	.17	.02	.25
1984	.31	.56	.53	.08	.04	.50	.41	.23	.21	.19	.17	.25
1985	.07	.24	.31	.19	.44	.27	.25	.25	.14	.19	.09	.27
1986	.08	.35	.11	.32	.07	.04	.38	.25	.16	.18	.00	.00
1987	.37	.36	.34	.31	.19	.16	.32	.24	.11	.08	.17	.23
1988	.26	.34	.16	.32	.00	.39	.34	.19	.18	.19	.17	.28
1989	.33	.04	.24	.46	.43	.33	.23	.23	.22	.19	.04	.25
1990	.38	.58	.21	.02	.28	.36	.41	.25	.18	.19	.17	.23
1991	.08	.37	.19	.44	.08	.36	.37	.25	.23	.19	.11	.28
1992	.41	.44	.36	.41	.34	.23	.28	.24	.23	.19	.17	.22
1993	.08	.35	.18	.20	.18	.26	.28	.24	.23	.16	.13	.28
1994	.38	.58	.40	.32	.39	.23	.34	.21	.22	.19	.17	.20

Third phase irrigation water use for 2030 – THSKOP75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	2.67	3.10	5.80	.00	5.48	3.07	4.27	2.78	2.12	2.92	2.92	.47
1926	3.77	3.39	4.81	3.07	1.59	.11	3.65	3.18	2.93	1.79	2.17	3.91
1927	.00	6.38	2.98	4.11	4.98	.08	4.15	3.29	2.93	2.90	2.60	2.57
1928	4.07	6.07	3.63	3.54	.70	.00	1.16	2.39	1.01	1.31	2.69	.00
1929	2.84	1.02	.00	.50	5.02	3.98	1.88	2.53	2.87	2.44	2.48	2.95
1930	4.76	5.77	5.45	.00	4.51	3.29	2.78	3.29	2.93	1.75	2.95	3.92
1931	3.40	5.70	6.90	5.65	.16	1.22	3.90	1.16	2.38	2.41	2.93	3.35
1932	5.06	3.22	3.90	5.60	5.59	3.93	2.69	3.23	2.86	1.82	2.95	3.93
1933	5.10	.00	2.25	.00	4.24	3.07	1.57	.77	2.93	1.22	.16	3.76
1934	1.54	2.51	.00	5.60	3.85	3.12	3.80	3.05	2.30	2.92	2.54	3.41
1935	4.65	6.05	4.83	4.64	1.93	1.51	4.19	.00	2.85	2.92	2.95	3.05
1936	2.74	.00	5.77	.00	1.40	4.78	3.69	3.29	2.93	2.84	2.95	3.26
1937	4.02	5.82	2.79	1.27	4.28	5.46	.34	3.28	.98	1.07	1.95	2.68
1938	.68	4.61	2.84	1.40	.00	.79	4.01	1.99	2.31	1.68	2.18	2.26
1939	1.77	.02	2.65	4.75	5.28	4.22	3.50	.00	1.09	2.92	2.70	1.36
1940	5.08	2.84	2.84	.04	2.26	4.55	1.63	3.29	2.82	2.42	2.95	3.64
1941	2.99	5.34	6.05	3.16	1.44	1.61	1.05	2.89	2.17	2.92	1.07	2.89
1942	1.77	.00	1.57	2.84	6.10	1.75	.00	1.45	1.99	.42	.00	3.36
1943	.00	.35	2.30	2.35	.00	4.38	4.54	2.50	.00	2.92	2.93	.00
1944	1.61	3.32	6.90	5.09	3.21	.00	3.86	3.08	2.81	2.92	2.92	3.78
1945	4.87	5.99	7.64	2.28	2.54	.93	3.84	2.73	2.93	2.86	2.95	4.01
1946	.50	1.34	5.99	6.11	1.10	.89	3.09	3.29	2.00	2.71	2.90	1.93
1947	1.75	1.26	3.19	1.25	4.07	.00	2.62	2.71	2.93	2.90	2.87	3.06
1948	2.75	4.88	5.42	3.28	3.67	1.95	2.24	2.54	2.68	2.91	2.95	1.39
1949	3.21	2.82	3.75	3.16	3.62	.00	3.29	1.62	2.63	2.54	1.63	3.46
1950	2.54	5.05	.08	5.05	4.15	2.93	2.60	2.80	2.47	2.80	.62	1.52
1951	2.82	6.64	3.86	.29	.89	2.77	3.14	2.99	2.92	.72	2.61	3.02
1952	2.46	4.31	3.14	2.64	.00	3.70	2.11	2.72	2.93	2.91	2.01	3.74
1953	3.73	2.94	4.61	4.61	.11	2.74	3.88	1.75	2.34	2.86	2.94	1.28
1954	1.82	1.31	5.42	.07	.78	3.43	4.00	2.55	2.93	2.91	2.93	3.81
1955	4.27	3.04	2.88	5.83	.94	.01	4.21	2.02	2.93	2.92	2.95	2.72
1956	4.07	2.51	.00	1.10	3.05	1.41	2.75	3.06	2.59	.48	.88	.00
1957	.00	5.40	4.16	.00	4.44	2.50	1.25	3.13	2.93	2.92	2.95	1.21
1958	3.73	1.88	1.67	3.41	2.20	3.86	2.57	.00	2.93	2.44	2.91	3.83
1959	.16	2.51	4.96	4.54	2.21	2.24	1.09	3.20	2.93	2.74	2.13	3.01
1960	2.54	3.98	.94	5.47	5.63	.41	1.48	2.00	2.80	2.89	2.95	1.93
1961	4.88	2.68	4.24	.04	2.94	4.05	2.04	3.23	2.93	2.92	2.42	3.36
1962	4.90	2.98	3.22	.00	6.50	2.30	3.64	3.19	1.22	1.92	2.95	3.97
1963	3.41	4.11	6.26	.23	5.68	2.47	3.16	3.29	1.12	2.88	2.26	1.17
1964	.04	3.37	1.42	3.30	5.30	6.00	2.09	2.87	.86	2.71	.03	1.96
1965	4.77	3.05	6.26	.14	3.59	6.02	4.23	2.87	2.62	2.92	2.22	3.29
1966	4.27	3.59	.00	.00	.94	3.13	1.73	3.05	2.93	2.92	2.95	3.91
1967	4.06	5.35	3.79	5.49	5.82	4.27	4.38	2.98	2.93	2.92	1.36	3.68
1968	4.76	4.98	5.35	4.88	2.95	1.31	2.93	1.32	2.54	2.85	2.87	3.17
1969	.33	5.53	4.19	2.79	3.82	5.43	4.53	3.07	2.23	2.81	.50	1.10
1970	2.41	5.31	6.14	.19	3.00	3.13	2.51	1.24	2.66	1.69	2.24	3.84
1971	2.36	4.32	2.93	4.63	2.23	.09	3.91	2.54	2.75	2.92	2.40	4.02
1972	3.14	3.70	7.01	4.93	.00	5.09	1.37	3.29	2.93	2.85	.00	.64
1973	5.27	2.58	3.01	2.81	.00	1.14	1.85	3.29	1.59	2.79	2.61	4.00
1974	5.29	.56	3.95	1.68	.00	3.81	1.69	3.01	2.93	2.92	2.95	.01
1975	4.70	3.38	1.26	.14	2.97	.00	3.38	1.62	2.93	2.92	2.82	2.65
1976	.08	2.84	4.17	3.90	5.45	2.80	3.60	3.29	2.93	2.90	2.81	1.50
1977	.07	3.93	4.95	.00	3.15	2.39	3.05	3.28	2.92	2.84	1.89	1.88
1978	.07	4.67	1.90	4.26	2.97	3.02	3.42	2.38	2.93	1.46	.00	3.20
1979	1.41	2.34	5.11	3.05	.28	.78	4.42	2.94	2.93	2.92	2.87	.44
1980	5.09	2.64	1.76	.00	.00	4.44	3.74	3.11	2.32	2.85	.59	2.55
1981	4.97	3.40	3.63	2.20	7.40	2.93	2.11	3.16	2.84	2.67	2.92	3.72
1982	1.82	4.08	6.83	5.34	5.53	4.85	3.80	2.69	2.93	2.38	2.26	3.67
1983	1.25	.20	3.73	2.47	5.43	.06	1.46	3.29	2.47	2.67	.84	3.04
1984	2.43	5.99	5.96	1.61	.00	5.30	4.70	3.29	2.93	2.92	2.95	3.55
1985	.08	1.55	2.68	.88	5.38	3.05	2.86	3.29	2.45	2.92	1.42	3.37
1986	.97	3.97	4.60	2.23	1.37	.95	4.49	3.29	2.75	2.80	.16	.00
1987	4.09	2.82	2.14	3.86	2.45	1.51	4.39	3.29	1.44	1.91	2.78	3.02
1988	2.36	3.55	1.59	1.97	.00	2.24	3.95	2.79	2.65	2.80	2.91	3.98
1989	3.59	.16	4.85	4.85	3.62	2.26	1.92	3.11	2.87	2.57	.88	4.02
1990	4.45	6.89	2.59	.00	3.09	4.45	4.73	3.26	2.44	2.92	2.95	3.28
1991	.00	2.28	4.63	5.02	4.12	2.19	4.02	3.29	2.93	2.92	1.94	4.02
1992	4.61	2.49	5.69	4.07	.00	1.28	3.88	3.29	2.93	2.92	2.57	3.47
1993	.00	3.63	3.15	1.37	.70	1.02	2.09	3.29	2.93	2.63	2.48	3.98
1994	3.65	7.14	6.14	1.10	4.90	1.33	2.84	3.12	2.84	2.92	2.84	3.31

Third phase irrigation water use for 2030 – THWOOD75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.52	.00	.31	.00	.18	.00	.60	.48	.38	.56	.78	.15
1926	.65	.00	.21	.03	.00	.00	.50	.55	.50	.31	.63	.91
1927	.00	.22	.01	.14	.09	.00	.49	.48	.50	.56	.74	.72
1928	.48	.00	.16	.00	.17	.00	.30	.47	.00	.18	.71	.00
1929	.65	.00	.14	.00	.19	.00	.31	.52	.45	.54	.70	.76
1930	.59	.07	.10	.00	.11	.00	.19	.56	.50	.18	.78	.91
1931	.64	.00	.39	.18	.00	.00	.60	.31	.41	.56	.78	.72
1932	.68	.00	.21	.22	.08	.00	.43	.52	.44	.47	.78	.89
1933	.79	.00	.00	.00	.00	.00	.34	.22	.50	.11	.32	.91
1934	.26	.00	.00	.23	.00	.00	.36	.47	.44	.56	.74	.78
1935	.74	.00	.30	.23	.00	.00	.53	.03	.50	.56	.78	.83
1936	.41	.00	.19	.00	.00	.06	.58	.56	.49	.56	.77	.79
1937	.64	.12	.07	.12	.01	.19	.00	.55	.11	.29	.43	.76
1938	.14	.00	.00	.04	.00	.00	.55	.34	.50	.28	.56	.66
1939	.28	.00	.14	.31	.00	.02	.25	.07	.23	.55	.76	.40
1940	.79	.00	.04	.00	.00	.10	.31	.44	.50	.42	.77	.74
1941	.54	.15	.26	.04	.08	.00	.23	.45	.41	.56	.49	.60
1942	.25	.00	.00	.14	.15	.00	.00	.28	.50	.00	.12	.83
1943	.00	.00	.01	.01	.00	.13	.61	.38	.00	.56	.77	.08
1944	.30	.00	.34	.22	.00	.00	.38	.49	.48	.56	.76	.85
1945	.67	.10	.43	.00	.00	.00	.47	.41	.50	.54	.78	.89
1946	.00	.00	.28	.31	.01	.00	.33	.53	.46	.55	.70	.52
1947	.29	.00	.11	.00	.05	.00	.17	.45	.50	.56	.76	.76
1948	.39	.00	.31	.12	.05	.00	.19	.47	.45	.56	.77	.56
1949	.41	.00	.08	.01	.00	.00	.26	.34	.44	.46	.48	.82
1950	.39	.10	.00	.26	.04	.00	.32	.47	.42	.53	.41	.56
1951	.39	.23	.22	.00	.00	.00	.38	.50	.47	.31	.70	.74
1952	.47	.00	.02	.14	.00	.00	.23	.41	.44	.56	.62	.81
1953	.52	.00	.08	.16	.00	.00	.50	.29	.39	.55	.78	.52
1954	.36	.00	.15	.00	.00	.00	.38	.37	.45	.56	.78	.84
1955	.64	.00	.15	.21	.00	.00	.45	.29	.49	.55	.77	.67
1956	.47	.00	.00	.01	.00	.00	.28	.47	.40	.24	.40	.00
1957	.00	.00	.10	.00	.02	.00	.01	.50	.49	.56	.78	.52
1958	.59	.00	.02	.16	.00	.14	.15	.00	.49	.39	.77	.86
1959	.04	.00	.12	.17	.01	.00	.09	.52	.50	.50	.58	.70
1960	.38	.00	.00	.13	.14	.00	.05	.34	.44	.52	.76	.66
1961	.76	.00	.14	.03	.00	.00	.24	.54	.50	.55	.72	.76
1962	.64	.00	.18	.00	.19	.00	.37	.51	.21	.44	.78	.91
1963	.44	.00	.26	.00	.23	.00	.41	.56	.19	.56	.66	.58
1964	.00	.00	.13	.03	.23	.11	.14	.51	.14	.50	.25	.64
1965	.73	.00	.33	.00	.04	.29	.50	.48	.44	.56	.69	.74
1966	.55	.00	.01	.00	.00	.00	.04	.43	.47	.53	.76	.85
1967	.65	.00	.15	.25	.18	.00	.28	.42	.49	.56	.54	.79
1968	.75	.00	.08	.19	.03	.00	.29	.25	.33	.52	.74	.74
1969	.11	.00	.00	.13	.02	.04	.51	.48	.38	.48	.39	.51
1970	.38	.01	.32	.00	.00	.00	.20	.28	.44	.39	.62	.86
1971	.58	.00	.18	.00	.00	.00	.43	.39	.49	.56	.68	.88
1972	.53	.00	.38	.25	.00	.00	.31	.54	.50	.53	.22	.42
1973	.74	.00	.11	.00	.00	.00	.09	.56	.25	.54	.70	.89
1974	.67	.00	.17	.00	.00	.00	.23	.56	.50	.54	.76	.28
1975	.58	.00	.01	.00	.00	.00	.28	.25	.49	.56	.76	.64
1976	.07	.00	.11	.00	.00	.00	.13	.52	.49	.56	.74	.32
1977	.16	.00	.04	.00	.00	.00	.26	.56	.47	.56	.55	.55
1978	.04	.00	.00	.24	.00	.00	.46	.37	.50	.32	.17	.64
1979	.25	.00	.11	.04	.00	.00	.52	.52	.50	.55	.72	.34
1980	.74	.00	.12	.00	.00	.07	.38	.53	.40	.52	.35	.70
1981	.74	.00	.11	.20	.21	.00	.18	.54	.49	.50	.76	.76
1982	.23	.02	.38	.27	.22	.09	.49	.40	.48	.23	.70	.81
1983	.24	.00	.04	.19	.08	.00	.34	.53	.44	.52	.41	.83
1984	.47	.00	.38	.00	.00	.19	.54	.56	.49	.56	.76	.80
1985	.00	.00	.00	.00	.14	.00	.11	.56	.41	.56	.48	.77
1986	.19	.00	.11	.27	.00	.00	.44	.56	.45	.53	.23	.00
1987	.46	.00	.26	.07	.00	.00	.36	.44	.29	.41	.67	.61
1988	.31	.00	.02	.00	.00	.05	.24	.41	.36	.56	.78	.91
1989	.50	.00	.06	.15	.04	.00	.34	.48	.47	.55	.60	.89
1990	.57	.22	.08	.00	.00	.00	.61	.55	.41	.56	.76	.74
1991	.11	.00	.06	.31	.00	.00	.41	.56	.50	.56	.66	.86
1992	.58	.03	.36	.15	.00	.00	.43	.56	.50	.56	.73	.70
1993	.15	.00	.12	.00	.00	.00	.28	.56	.48	.52	.66	.86
1994	.61	.21	.32	.01	.13	.00	.23	.49	.35	.53	.77	.66

Third phase irrigation water use for 2030 – TM0275.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.25	.00	.00	.00	.00	.00	.29	.23	.19	.27	.38	.08
1926	.31	.00	.00	.00	.00	.00	.24	.26	.24	.15	.31	.44
1927	.00	.11	.00	.00	.00	.00	.23	.23	.24	.27	.35	.34
1928	.23	.00	.00	.00	.00	.00	.15	.23	.00	.09	.34	.00
1929	.31	.00	.00	.00	.00	.00	.15	.25	.22	.25	.34	.37
1930	.28	.04	.00	.00	.00	.00	.10	.26	.24	.09	.38	.44
1931	.31	.00	.00	.00	.00	.00	.28	.15	.20	.27	.38	.34
1932	.33	.00	.00	.00	.00	.00	.21	.25	.21	.23	.38	.43
1933	.38	.00	.00	.00	.00	.00	.17	.11	.24	.05	.16	.44
1934	.13	.00	.00	.00	.00	.00	.17	.23	.21	.26	.36	.38
1935	.35	.00	.00	.00	.00	.00	.25	.01	.24	.27	.38	.40
1936	.20	.00	.00	.00	.00	.03	.28	.27	.23	.26	.37	.38
1937	.31	.06	.00	.00	.00	.09	.00	.26	.05	.14	.21	.37
1938	.08	.00	.00	.00	.00	.00	.26	.16	.24	.14	.27	.32
1939	.14	.00	.00	.00	.00	.01	.13	.04	.11	.26	.37	.19
1940	.38	.00	.00	.00	.00	.05	.15	.21	.24	.20	.37	.36
1941	.26	.08	.00	.00	.00	.00	.11	.22	.19	.27	.23	.29
1942	.13	.00	.00	.00	.00	.00	.00	.14	.24	.00	.07	.41
1943	.00	.00	.00	.00	.00	.06	.29	.18	.00	.27	.37	.04
1944	.15	.00	.00	.00	.00	.00	.19	.23	.23	.26	.37	.41
1945	.32	.04	.00	.00	.00	.00	.23	.19	.24	.26	.38	.43
1946	.00	.00	.00	.00	.00	.00	.16	.25	.22	.26	.34	.25
1947	.14	.00	.00	.00	.00	.00	.09	.22	.24	.26	.37	.37
1948	.19	.00	.00	.00	.00	.00	.10	.23	.22	.27	.37	.27
1949	.20	.00	.00	.00	.00	.00	.13	.16	.21	.22	.23	.40
1950	.19	.05	.00	.00	.00	.00	.16	.23	.20	.25	.20	.27
1951	.19	.11	.00	.00	.00	.00	.18	.24	.23	.15	.34	.35
1952	.23	.00	.00	.00	.00	.00	.11	.19	.21	.27	.30	.39
1953	.25	.00	.00	.00	.00	.00	.24	.14	.19	.26	.38	.25
1954	.18	.00	.00	.00	.00	.00	.18	.18	.22	.27	.38	.41
1955	.31	.00	.00	.00	.00	.00	.22	.14	.23	.26	.38	.33
1956	.23	.00	.00	.00	.00	.00	.14	.23	.19	.12	.19	.00
1957	.00	.00	.00	.00	.00	.00	.01	.24	.23	.27	.38	.25
1958	.28	.00	.00	.00	.00	.07	.08	.00	.23	.19	.37	.41
1959	.03	.00	.00	.00	.00	.00	.04	.25	.24	.24	.28	.34
1960	.19	.00	.00	.00	.00	.00	.03	.16	.21	.25	.37	.31
1961	.37	.00	.00	.00	.00	.00	.12	.25	.24	.26	.34	.37
1962	.31	.00	.00	.00	.00	.00	.18	.25	.11	.21	.38	.44
1963	.21	.00	.00	.00	.00	.00	.20	.27	.09	.26	.32	.28
1964	.00	.00	.00	.00	.00	.05	.07	.25	.07	.24	.13	.31
1965	.35	.00	.00	.00	.00	.14	.24	.23	.22	.27	.33	.35
1966	.27	.00	.00	.00	.00	.00	.02	.21	.23	.25	.36	.41
1967	.31	.00	.00	.00	.00	.00	.14	.20	.23	.26	.26	.38
1968	.36	.00	.00	.00	.00	.00	.14	.12	.16	.25	.36	.36
1969	.06	.00	.00	.00	.00	.02	.25	.23	.18	.23	.19	.25
1970	.19	.01	.00	.00	.00	.00	.11	.14	.21	.19	.29	.41
1971	.28	.00	.00	.00	.00	.00	.21	.19	.23	.27	.33	.43
1972	.26	.00	.00	.00	.00	.00	.15	.26	.24	.25	.11	.21
1973	.35	.00	.00	.00	.00	.00	.04	.27	.12	.26	.34	.43
1974	.32	.00	.00	.00	.00	.00	.12	.27	.24	.26	.36	.14
1975	.28	.00	.00	.00	.00	.00	.14	.13	.23	.27	.37	.31
1976	.04	.00	.00	.00	.00	.00	.07	.25	.23	.27	.35	.16
1977	.09	.00	.00	.00	.00	.00	.13	.27	.23	.26	.26	.27
1978	.02	.00	.00	.00	.00	.00	.22	.18	.24	.16	.09	.31
1979	.13	.00	.00	.00	.00	.00	.25	.25	.24	.26	.34	.16
1980	.35	.00	.00	.00	.00	.04	.18	.25	.19	.25	.17	.34
1981	.35	.00	.00	.00	.00	.00	.09	.26	.23	.24	.37	.37
1982	.11	.01	.00	.00	.00	.04	.24	.19	.23	.11	.34	.39
1983	.12	.00	.00	.00	.00	.00	.17	.25	.21	.25	.20	.40
1984	.23	.00	.00	.00	.00	.09	.26	.27	.23	.26	.37	.39
1985	.00	.00	.00	.00	.00	.00	.06	.27	.19	.27	.23	.38
1986	.10	.00	.00	.00	.00	.00	.22	.26	.22	.25	.11	.00
1987	.23	.00	.00	.00	.00	.00	.17	.22	.14	.19	.32	.29
1988	.15	.00	.00	.00	.00	.03	.12	.19	.17	.26	.38	.44
1989	.24	.00	.00	.00	.00	.00	.16	.23	.23	.26	.29	.43
1990	.28	.11	.00	.00	.00	.00	.29	.26	.20	.27	.37	.36
1991	.06	.00	.00	.00	.00	.00	.19	.27	.24	.27	.31	.41
1992	.28	.02	.00	.00	.00	.00	.20	.27	.24	.27	.35	.34
1993	.08	.00	.00	.00	.00	.00	.14	.27	.23	.25	.31	.41
1994	.29	.11	.00	.00	.00	.00	.12	.23	.17	.25	.37	.32

Third phase irrigation water use for 2030 – TM0675.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.67	.79	1.42	.00	1.34	.78	1.02	.67	.51	.69	.69	.16
1926	.92	.86	1.19	.80	.47	.11	.88	.76	.69	.44	.52	.93
1927	.00	1.52	.79	1.03	1.22	.08	.99	.78	.69	.69	.62	.63
1928	.98	1.46	.93	.91	.27	.00	.32	.58	.27	.33	.64	.00
1929	.71	.33	.00	.23	1.24	.98	.48	.61	.67	.58	.59	.71
1930	1.14	1.39	1.34	.00	1.12	.83	.69	.78	.69	.43	.70	.93
1931	.84	1.37	1.66	1.38	.15	.37	.94	.31	.57	.58	.70	.80
1932	1.21	.83	.99	1.37	1.36	.97	.67	.76	.67	.44	.70	.93
1933	1.22	.00	.62	.00	1.06	.78	.42	.22	.69	.31	.08	.89
1934	.42	.67	.00	1.37	.97	.79	.92	.73	.56	.69	.61	.82
1935	1.12	1.46	1.20	1.15	.55	.44	1.00	.00	.67	.69	.70	.74
1936	.69	.00	1.41	.00	.43	1.16	.89	.78	.69	.67	.70	.78
1937	.97	1.40	.74	.41	1.07	1.31	.14	.77	.26	.28	.47	.65
1938	.23	1.13	.75	.44	.00	.27	.96	.49	.56	.41	.52	.56
1939	.47	.02	.71	1.18	1.29	1.03	.85	.00	.28	.69	.64	.36
1940	1.22	.74	.75	.04	.62	1.11	.43	.78	.67	.58	.70	.87
1941	.75	1.30	1.47	.83	.44	.45	.30	.69	.52	.69	.28	.70
1942	.47	.00	.47	.75	1.48	.49	.00	.37	.49	.14	.00	.80
1943	.00	.18	.63	.64	.00	1.07	1.08	.60	.00	.69	.69	.00
1944	.44	.85	1.66	1.25	.83	.00	.92	.74	.67	.69	.69	.90
1945	1.16	1.44	1.82	.63	.68	.30	.92	.65	.69	.67	.70	.95
1946	.19	.41	1.46	1.49	.36	.29	.76	.78	.49	.64	.69	.49
1947	.47	.38	.83	.40	1.02	.00	.65	.64	.69	.69	.68	.74
1948	.69	1.19	1.33	.85	.93	.53	.56	.61	.64	.69	.70	.37
1949	.79	.74	.96	.83	.92	.00	.79	.41	.63	.61	.41	.83
1950	.64	1.23	.08	1.25	1.04	.75	.64	.67	.59	.66	.18	.40
1951	.70	1.58	.98	.19	.31	.71	.76	.71	.69	.20	.62	.73
1952	.63	1.06	.82	.70	.00	.92	.53	.65	.69	.69	.49	.88
1953	.91	.76	1.15	1.15	.11	.70	.93	.44	.56	.67	.70	.34
1954	.49	.40	1.33	.07	.28	.86	.96	.62	.69	.69	.70	.91
1955	1.03	.78	.76	1.42	.32	.01	1.00	.50	.69	.69	.70	.66
1956	.98	.67	.00	.37	.79	.41	.67	.73	.62	.15	.23	.00
1957	.00	1.31	1.05	.00	1.10	.65	.34	.74	.69	.69	.70	.32
1958	.92	.52	.50	.88	.61	.95	.64	.00	.69	.58	.69	.91
1959	.11	.67	1.22	1.13	.61	.59	.31	.76	.69	.65	.52	.73
1960	.64	.99	.33	1.34	1.37	.19	.40	.49	.66	.68	.70	.49
1961	1.17	.70	1.06	.04	.77	1.00	.52	.76	.69	.69	.58	.80
1962	1.17	.77	.84	.00	1.57	.61	.88	.76	.31	.47	.70	.94
1963	.84	1.02	1.51	.17	1.38	.64	.77	.78	.29	.68	.55	.31
1964	.04	.86	.44	.86	1.30	1.43	.53	.68	.23	.64	.03	.50
1965	1.14	.79	1.51	.14	.92	1.44	1.01	.68	.62	.69	.54	.79
1966	1.03	.91	.00	.00	.32	.79	.45	.72	.69	.69	.70	.92
1967	.98	1.30	.97	1.34	1.41	1.05	1.04	.71	.69	.69	.34	.88
1968	1.14	1.22	1.31	1.21	.77	.39	.72	.34	.61	.67	.68	.76
1969	.15	1.34	1.06	.74	.97	1.31	1.07	.73	.54	.67	.15	.30
1970	.62	1.29	1.49	.16	.79	.79	.62	.32	.63	.41	.54	.92
1971	.61	1.06	.77	1.15	.61	.09	.94	.62	.65	.69	.58	.95
1972	.78	.93	1.69	1.22	.00	1.23	.37	.78	.69	.67	.00	.20
1973	1.25	.68	.79	.74	.00	.35	.47	.78	.40	.66	.62	.94
1974	1.26	.23	1.00	.50	.00	.94	.44	.72	.69	.69	.70	.01
1975	1.13	.86	.40	.14	.78	.00	.82	.41	.69	.69	.67	.64
1976	.08	.74	1.05	.99	1.33	.72	.87	.78	.69	.69	.67	.39
1977	.07	.98	1.22	.00	.82	.63	.74	.77	.69	.67	.47	.47
1978	.07	1.15	.54	1.06	.78	.76	.83	.58	.69	.37	.00	.76
1979	.40	.63	1.26	.80	.18	.27	1.05	.70	.69	.69	.68	.16
1980	1.22	.69	.51	.00	.00	1.09	.90	.74	.56	.67	.17	.62
1981	1.19	.86	.93	.61	1.76	.75	.53	.75	.67	.64	.69	.88
1982	.49	1.01	1.64	1.31	1.35	1.18	.91	.64	.69	.57	.55	.87
1983	.36	.15	.95	.67	1.33	.06	.39	.78	.59	.64	.23	.74
1984	.62	1.44	1.45	.48	.00	1.28	1.11	.78	.69	.69	.70	.85
1985	.08	.45	.72	.31	1.31	.77	.70	.78	.58	.69	.36	.81
1986	.29	.99	1.15	.62	.42	.31	1.06	.78	.65	.66	.08	.00
1987	.99	.74	.60	.98	.66	.43	1.04	.78	.36	.47	.66	.73
1988	.61	.89	.47	.56	.00	.59	.94	.67	.63	.66	.69	.94
1989	.88	.14	1.20	1.20	.92	.60	.50	.74	.68	.62	.24	.95
1990	1.07	1.64	.70	.00	.80	1.09	1.12	.77	.58	.69	.70	.79
1991	.00	.62	1.15	1.24	1.03	.58	.96	.78	.69	.69	.47	.95
1992	1.11	.66	1.39	1.03	.00	.38	.93	.78	.69	.69	.62	.83
1993	.00	.92	.83	.42	.27	.32	.53	.78	.69	.62	.59	.94
1994	.89	1.69	1.49	.36	1.21	.39	.70	.74	.67	.69	.67	.79

Third phase irrigation water use for 2030 – TM0875A.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.50	.00	.00	.00	.00	.00	.35	.30	.20	.46	.59	.23
1926	.34	.00	.00	.00	.00	.00	.27	.36	.34	.40	.45	.70
1927	.25	.14	.00	.00	.00	.00	.37	.24	.36	.45	.55	.66
1928	.54	.00	.00	.00	.00	.00	.32	.20	.10	.19	.56	.07
1929	.56	.00	.00	.00	.00	.00	.40	.30	.32	.46	.50	.61
1930	.45	.13	.00	.00	.00	.00	.19	.37	.35	.18	.60	.73
1931	.54	.09	.00	.00	.00	.00	.41	.25	.34	.45	.59	.58
1932	.54	.00	.00	.00	.00	.04	.29	.36	.35	.28	.59	.72
1933	.56	.00	.00	.00	.00	.00	.00	.15	.35	.31	.30	.63
1934	.40	.00	.00	.00	.00	.00	.38	.28	.27	.45	.55	.65
1935	.67	.00	.00	.00	.00	.00	.33	.00	.33	.46	.60	.68
1936	.36	.00	.00	.00	.00	.01	.30	.38	.33	.46	.59	.66
1937	.56	.04	.00	.00	.00	.04	.00	.38	.22	.26	.43	.63
1938	.07	.00	.00	.00	.00	.00	.41	.19	.36	.29	.52	.56
1939	.34	.00	.00	.00	.00	.00	.24	.00	.14	.46	.56	.49
1940	.58	.00	.00	.00	.00	.09	.20	.38	.36	.44	.59	.67
1941	.54	.12	.00	.00	.00	.00	.13	.34	.33	.45	.44	.51
1942	.39	.00	.00	.00	.00	.00	.00	.04	.36	.08	.04	.72
1943	.00	.00	.00	.00	.00	.01	.44	.31	.09	.46	.59	.21
1944	.49	.00	.00	.00	.00	.00	.29	.34	.31	.46	.59	.72
1945	.64	.08	.00	.00	.00	.00	.29	.34	.36	.46	.59	.74
1946	.34	.00	.00	.00	.00	.00	.25	.36	.24	.46	.55	.62
1947	.31	.00	.00	.00	.00	.00	.18	.30	.36	.46	.59	.66
1948	.54	.00	.00	.00	.00	.00	.16	.32	.35	.46	.53	.57
1949	.56	.00	.00	.00	.00	.00	.27	.16	.33	.41	.39	.61
1950	.55	.00	.00	.00	.00	.00	.28	.35	.33	.46	.35	.58
1951	.48	.17	.00	.00	.00	.00	.30	.34	.34	.28	.52	.61
1952	.45	.00	.00	.00	.00	.00	.23	.36	.35	.46	.44	.69
1953	.41	.00	.00	.00	.00	.00	.34	.14	.35	.46	.59	.51
1954	.39	.00	.00	.00	.00	.00	.22	.21	.31	.46	.60	.69
1955	.58	.00	.00	.00	.00	.00	.33	.35	.36	.46	.56	.61
1956	.53	.00	.00	.00	.00	.00	.11	.32	.32	.33	.35	.00
1957	.19	.02	.00	.00	.00	.00	.08	.35	.35	.46	.60	.57
1958	.53	.00	.00	.00	.00	.00	.22	.02	.35	.36	.56	.73
1959	.37	.00	.00	.00	.00	.00	.08	.36	.36	.45	.53	.61
1960	.50	.00	.00	.00	.00	.00	.08	.33	.35	.46	.59	.56
1961	.63	.00	.00	.00	.00	.00	.12	.29	.36	.46	.50	.69
1962	.59	.00	.00	.00	.00	.00	.30	.36	.22	.38	.60	.73
1963	.27	.00	.00	.00	.00	.00	.20	.37	.23	.46	.56	.37
1964	.00	.00	.00	.00	.00	.16	.14	.32	.02	.41	.26	.55
1965	.56	.00	.00	.00	.00	.16	.32	.30	.33	.46	.50	.63
1966	.48	.00	.00	.00	.00	.00	.00	.31	.35	.44	.58	.70
1967	.53	.00	.00	.00	.00	.00	.28	.33	.35	.46	.49	.65
1968	.62	.00	.00	.00	.00	.00	.17	.19	.32	.44	.57	.52
1969	.24	.00	.00	.00	.00	.03	.33	.35	.33	.46	.25	.36
1970	.39	.00	.00	.00	.00	.00	.19	.18	.35	.31	.41	.69
1971	.37	.00	.00	.00	.00	.00	.22	.19	.35	.45	.55	.69
1972	.43	.00	.00	.00	.00	.00	.10	.36	.35	.44	.35	.40
1973	.56	.00	.00	.00	.00	.00	.00	.38	.21	.41	.56	.73
1974	.54	.00	.00	.00	.00	.00	.20	.37	.36	.46	.58	.12
1975	.55	.00	.00	.00	.00	.00	.15	.14	.36	.46	.58	.48
1976	.20	.00	.00	.00	.00	.00	.11	.37	.35	.46	.55	.43
1977	.16	.00	.00	.00	.00	.00	.11	.36	.35	.46	.46	.57
1978	.15	.00	.00	.00	.00	.00	.28	.16	.35	.35	.25	.62
1979	.42	.00	.00	.00	.00	.00	.19	.34	.36	.46	.52	.35
1980	.58	.00	.00	.00	.00	.06	.28	.33	.26	.46	.25	.59
1981	.59	.00	.00	.00	.00	.00	.13	.36	.32	.42	.59	.53
1982	.33	.05	.00	.00	.00	.01	.22	.30	.35	.18	.52	.66
1983	.22	.00	.00	.00	.00	.00	.23	.36	.30	.42	.37	.69
1984	.45	.03	.00	.00	.00	.09	.42	.37	.34	.46	.59	.67
1985	.00	.00	.00	.00	.00	.00	.12	.38	.29	.46	.35	.67
1986	.13	.00	.00	.00	.00	.00	.40	.38	.29	.45	.19	.00
1987	.44	.00	.00	.00	.00	.00	.19	.26	.14	.31	.54	.62
1988	.43	.00	.00	.00	.00	.00	.25	.28	.29	.45	.60	.74
1989	.47	.00	.00	.00	.00	.00	.19	.34	.33	.46	.41	.71
1990	.47	.08	.00	.00	.00	.00	.44	.37	.29	.46	.58	.62
1991	.00	.00	.00	.00	.00	.00	.32	.38	.36	.46	.53	.71
1992	.48	.00	.00	.00	.00	.00	.27	.36	.36	.46	.56	.66
1993	.19	.00	.00	.00	.00	.00	.31	.38	.35	.42	.50	.72
1994	.46	.17	.00	.00	.00	.00	.23	.32	.35	.46	.59	.57

Third phase irrigation water use for 2030 – TM0875B.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	1.36	.00	.00	.00	.00	.00	.93	.80	.54	1.26	1.59	.62
1926	.91	.00	.00	.00	.00	.00	.73	.99	.91	1.08	1.21	1.90
1927	.67	.37	.00	.00	.00	.00	1.01	.65	.97	1.22	1.48	1.77
1928	1.47	.00	.00	.00	.00	.00	.85	.54	.26	.51	1.53	.18
1929	1.51	.00	.00	.00	.00	.00	1.08	.80	.88	1.23	1.35	1.64
1930	1.21	.36	.00	.00	.00	.00	.52	1.00	.94	.50	1.61	1.96
1931	1.46	.25	.00	.00	.00	.00	1.10	.69	.91	1.20	1.58	1.56
1932	1.45	.00	.00	.00	.00	.11	.77	.98	.93	.75	1.61	1.95
1933	1.52	.00	.00	.00	.00	.00	.00	.41	.96	.84	.80	1.70
1934	1.09	.00	.00	.00	.00	.00	1.04	.76	.73	1.20	1.48	1.76
1935	1.81	.00	.00	.00	.00	.00	.90	.00	.91	1.23	1.61	1.83
1936	.98	.00	.00	.00	.00	.03	.80	1.03	.90	1.26	1.61	1.80
1937	1.52	.11	.00	.00	.00	.12	.00	1.01	.61	.70	1.16	1.70
1938	.20	.00	.00	.00	.00	.00	1.10	.51	.97	.77	1.39	1.50
1939	.91	.00	.00	.00	.00	.00	.65	.00	.38	1.23	1.52	1.34
1940	1.56	.00	.00	.00	.00	.26	.54	1.03	.97	1.19	1.59	1.80
1941	1.45	.34	.00	.00	.00	.00	.34	.93	.89	1.22	1.18	1.39
1942	1.07	.00	.00	.00	.00	.00	.00	.10	.97	.22	.11	1.95
1943	.00	.00	.00	.00	.00	.03	1.19	.84	.26	1.26	1.60	.58
1944	1.31	.00	.00	.00	.00	.00	.77	.91	.85	1.26	1.59	1.96
1945	1.72	.20	.00	.00	.00	.00	.77	.91	.97	1.25	1.61	2.01
1946	.93	.00	.00	.00	.00	.00	.69	.97	.64	1.25	1.50	1.69
1947	.85	.00	.00	.00	.00	.00	.49	.80	.97	1.26	1.61	1.80
1948	1.47	.00	.00	.00	.00	.00	.44	.87	.94	1.26	1.43	1.53
1949	1.53	.00	.00	.00	.00	.00	.73	.44	.90	1.11	1.04	1.64
1950	1.50	.00	.00	.00	.00	.00	.74	.96	.89	1.24	.93	1.58
1951	1.30	.45	.00	.00	.00	.00	.81	.91	.93	.76	1.39	1.66
1952	1.20	.00	.00	.00	.00	.00	.64	.98	.93	1.26	1.19	1.85
1953	1.12	.00	.00	.00	.00	.00	.91	.37	.94	1.26	1.61	1.39
1954	1.07	.00	.00	.00	.00	.00	.61	.56	.82	1.23	1.61	1.85
1955	1.56	.00	.00	.00	.00	.00	.91	.93	.97	1.24	1.50	1.66
1956	1.43	.00	.00	.00	.00	.00	.29	.87	.86	.89	.93	.01
1957	.53	.05	.00	.00	.00	.00	.20	.94	.94	1.26	1.61	1.55
1958	1.43	.00	.00	.00	.00	.00	.60	.05	.94	.98	1.50	1.96
1959	1.01	.00	.00	.00	.00	.00	.22	.98	.97	1.23	1.43	1.65
1960	1.36	.00	.00	.00	.00	.00	.23	.89	.94	1.24	1.59	1.51
1961	1.70	.00	.00	.00	.00	.00	.33	.79	.97	1.26	1.36	1.87
1962	1.59	.00	.00	.00	.00	.00	.80	.98	.59	1.02	1.61	1.98
1963	.73	.00	.00	.00	.00	.00	.54	1.00	.64	1.25	1.51	1.00
1964	.00	.00	.00	.00	.00	.45	.39	.88	.07	1.12	.72	1.48
1965	1.50	.00	.00	.00	.00	.45	.87	.82	.88	1.26	1.37	1.70
1966	1.30	.00	.00	.00	.00	.00	.00	.85	.93	1.19	1.58	1.91
1967	1.45	.00	.00	.00	.00	.00	.74	.88	.94	1.23	1.31	1.75
1968	1.67	.00	.00	.00	.00	.00	.45	.51	.88	1.19	1.53	1.42
1969	.64	.00	.00	.00	.00	.07	.88	.96	.89	1.23	.67	.98
1970	1.07	.00	.00	.00	.00	.00	.52	.49	.94	.84	1.10	1.87
1971	1.01	.00	.00	.00	.00	.00	.61	.52	.96	1.22	1.50	1.87
1972	1.18	.00	.00	.00	.00	.00	.28	.97	.94	1.19	.93	1.08
1973	1.53	.00	.00	.00	.00	.00	.00	1.02	.55	1.10	1.50	1.98
1974	1.47	.00	.00	.00	.00	.00	.54	1.00	.97	1.26	1.56	.33
1975	1.48	.00	.00	.00	.00	.00	.40	.37	.97	1.25	1.58	1.30
1976	.54	.00	.00	.00	.00	.00	.30	1.00	.96	1.26	1.48	1.16
1977	.44	.00	.00	.00	.00	.00	.30	.99	.93	1.26	1.26	1.54
1978	.39	.00	.00	.00	.00	.00	.76	.42	.96	.96	.69	1.69
1979	1.12	.00	.00	.00	.00	.00	.51	.93	.97	1.26	1.41	.93
1980	1.56	.00	.00	.00	.00	.17	.75	.91	.71	1.26	.69	1.59
1981	1.59	.00	.00	.00	.00	.00	.34	.99	.87	1.15	1.59	1.45
1982	.90	.12	.00	.00	.00	.03	.61	.80	.93	.48	1.41	1.80
1983	.61	.00	.00	.00	.00	.00	.64	.98	.80	1.13	.99	1.87
1984	1.23	.08	.00	.00	.00	.23	1.12	1.00	.91	1.26	1.59	1.80
1985	.00	.00	.00	.00	.00	.00	.31	1.02	.77	1.26	.94	1.81
1986	.36	.00	.00	.00	.00	.00	1.09	1.02	.77	1.20	.52	.00
1987	1.20	.00	.00	.00	.00	.00	.51	.71	.38	.85	1.47	1.66
1988	1.18	.00	.00	.00	.00	.00	.67	.75	.77	1.22	1.61	1.99
1989	1.28	.00	.00	.00	.00	.00	.51	.93	.91	1.26	1.10	1.92
1990	1.28	.23	.00	.00	.00	.00	1.20	1.00	.77	1.26	1.57	1.69
1991	.00	.00	.00	.00	.00	.00	.86	1.03	.97	1.26	1.42	1.91
1992	1.30	.01	.00	.00	.00	.00	.73	.98	.97	1.26	1.52	1.78
1993	.51	.00	.00	.00	.00	.00	.82	1.02	.94	1.12	1.35	1.93
1994	1.26	.47	.00	.00	.00	.00	.62	.87	.94	1.24	1.61	1.55

Third phase irrigation water use for 2030 – TM1175A.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.37	.33	.61	.00	.40	.35	.47	.31	.19	.30	.45	.03
1926	.33	.29	.35	.28	.03	.02	.44	.37	.30	.19	.37	.57
1927	.16	.56	.27	.34	.26	.05	.43	.30	.30	.30	.39	.38
1928	.48	.62	.12	.35	.11	.00	.23	.32	.05	.09	.41	.00
1929	.48	.05	.19	.03	.32	.33	.34	.34	.28	.26	.36	.46
1930	.60	.59	.46	.01	.00	.36	.46	.37	.30	.20	.45	.58
1931	.48	.55	.50	.44	.00	.25	.48	.17	.23	.24	.45	.47
1932	.62	.44	.41	.52	.29	.35	.35	.37	.29	.17	.45	.58
1933	.67	.00	.12	.00	.38	.31	.19	.15	.30	.13	.13	.58
1934	.46	.24	.01	.55	.29	.16	.36	.35	.24	.30	.42	.48
1935	.63	.63	.56	.32	.04	.10	.47	.00	.29	.30	.45	.51
1936	.37	.02	.46	.00	.27	.44	.35	.37	.30	.30	.45	.49
1937	.60	.61	.24	.37	.22	.42	.16	.37	.01	.07	.32	.41
1938	.26	.39	.07	.24	.02	.11	.51	.18	.30	.11	.39	.41
1939	.45	.00	.14	.52	.24	.45	.39	.05	.15	.30	.44	.25
1940	.51	.30	.06	.06	.02	.38	.17	.37	.30	.26	.45	.54
1941	.58	.59	.43	.20	.00	.08	.21	.30	.23	.30	.25	.41
1942	.27	.00	.10	.00	.43	.11	.00	.24	.30	.00	.00	.56
1943	.01	.35	.22	.25	.00	.41	.53	.35	.00	.30	.45	.00
1944	.30	.55	.66	.56	.23	.00	.44	.36	.28	.30	.45	.53
1945	.69	.73	.76	.00	.10	.01	.47	.35	.30	.30	.45	.58
1946	.18	.11	.50	.49	.00	.17	.33	.37	.07	.28	.45	.40
1947	.38	.08	.25	.10	.34	.09	.33	.34	.30	.30	.45	.49
1948	.38	.48	.61	.11	.11	.11	.23	.32	.29	.28	.45	.39
1949	.41	.27	.35	.37	.25	.06	.34	.24	.29	.29	.32	.50
1950	.40	.62	.31	.42	.21	.30	.32	.34	.25	.28	.15	.43
1951	.46	.68	.40	.00	.15	.18	.35	.32	.30	.07	.41	.54
1952	.43	.40	.62	.13	.00	.30	.27	.36	.30	.30	.29	.56
1953	.57	.31	.41	.43	.00	.19	.34	.16	.23	.30	.45	.24
1954	.19	.00	.32	.00	.00	.40	.43	.33	.30	.30	.45	.55
1955	.49	.32	.41	.62	.00	.00	.51	.16	.30	.30	.45	.43
1956	.47	.14	.00	.14	.19	.09	.31	.36	.25	.00	.30	.00
1957	.17	.57	.46	.07	.26	.19	.10	.37	.30	.30	.45	.25
1958	.47	.30	.20	.26	.00	.48	.38	.00	.30	.28	.45	.56
1959	.17	.36	.41	.32	.03	.28	.12	.36	.30	.29	.36	.50
1960	.38	.37	.01	.63	.44	.01	.20	.25	.29	.30	.45	.36
1961	.62	.24	.38	.01	.13	.49	.27	.35	.30	.30	.35	.48
1962	.68	.28	.34	.00	.48	.31	.44	.35	.12	.15	.45	.59
1963	.51	.38	.71	.15	.54	.26	.39	.36	.12	.30	.36	.39
1964	.06	.46	.28	.19	.22	.57	.28	.34	.05	.26	.25	.35
1965	.57	.46	.53	.00	.20	.57	.36	.25	.29	.30	.35	.50
1966	.57	.40	.11	.00	.18	.00	.12	.33	.30	.29	.45	.56
1967	.58	.56	.28	.55	.45	.43	.49	.36	.30	.30	.30	.55
1968	.66	.57	.58	.33	.27	.00	.22	.15	.28	.27	.45	.52
1969	.17	.68	.29	.25	.16	.55	.45	.30	.22	.27	.14	.32
1970	.33	.49	.58	.00	.34	.41	.36	.12	.29	.13	.35	.52
1971	.33	.45	.18	.15	.03	.06	.45	.31	.28	.30	.32	.58
1972	.43	.30	.58	.40	.04	.53	.00	.37	.30	.30	.01	.21
1973	.59	.19	.24	.17	.03	.22	.28	.27	.25	.28	.41	.57
1974	.66	.20	.41	.02	.00	.20	.33	.35	.30	.30	.43	.00
1975	.61	.10	.04	.00	.00	.00	.14	.16	.30	.30	.43	.48
1976	.16	.30	.33	.14	.35	.07	.11	.37	.30	.30	.45	.19
1977	.18	.44	.40	.00	.22	.09	.33	.37	.30	.30	.31	.25
1978	.08	.35	.17	.51	.00	.41	.42	.18	.21	.12	.01	.33
1979	.55	.48	.36	.12	.09	.39	.45	.31	.30	.30	.44	.16
1980	.51	.29	.12	.09	.00	.59	.44	.36	.20	.30	.27	.32
1981	.58	.31	.46	.20	.51	.26	.50	.36	.29	.27	.45	.48
1982	.14	.58	.59	.33	.50	.35	.44	.31	.27	.27	.40	.58
1983	.14	.12	.04	.11	.46	.09	.35	.36	.27	.27	.11	.47
1984	.35	.63	.54	.00	.00	.54	.52	.37	.28	.30	.45	.51
1985	.09	.05	.19	.07	.41	.16	.32	.37	.21	.30	.34	.56
1986	.29	.41	.21	.34	.00	.00	.43	.37	.26	.29	.04	.00
1987	.52	.30	.28	.51	.00	.13	.51	.37	.13	.18	.45	.47
1988	.39	.29	.25	.17	.00	.26	.39	.30	.22	.30	.44	.59
1989	.46	.00	.52	.52	.26	.23	.32	.35	.30	.30	.28	.59
1990	.55	.73	.32	.00	.00	.27	.53	.37	.19	.30	.45	.53
1991	.00	.45	.25	.48	.01	.50	.45	.37	.30	.30	.36	.59
1992	.64	.49	.45	.31	.09	.16	.38	.37	.30	.30	.44	.41
1993	.03	.39	.35	.18	.00	.21	.35	.37	.30	.27	.34	.57
1994	.50	.73	.56	.36	.34	.25	.37	.30	.28	.30	.40	.47

Third phase irrigation water use for 2030 – TM1175B.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.73	.65	1.17	.00	.78	.67	.90	.60	.37	.58	.87	.05
1926	.65	.57	.69	.54	.07	.05	.86	.73	.58	.37	.72	1.12
1927	.31	1.08	.52	.67	.51	.09	.83	.58	.58	.58	.76	.75
1928	.94	1.20	.22	.68	.22	.00	.44	.62	.11	.17	.81	.00
1929	.93	.11	.38	.05	.63	.64	.66	.66	.55	.50	.70	.89
1930	1.16	1.15	.89	.01	.01	.70	.88	.73	.57	.39	.88	1.12
1931	.92	1.06	.96	.86	.00	.49	.94	.34	.46	.46	.88	.90
1932	1.20	.84	.81	1.00	.56	.67	.67	.72	.57	.33	.88	1.12
1933	1.31	.00	.22	.00	.75	.60	.37	.30	.58	.25	.25	1.14
1934	.89	.47	.01	1.08	.55	.30	.69	.68	.48	.58	.82	.94
1935	1.22	1.22	1.10	.62	.08	.20	.90	.00	.57	.58	.88	1.00
1936	.73	.04	.89	.00	.53	.85	.69	.73	.58	.58	.87	.94
1937	1.16	1.18	.46	.73	.44	.82	.32	.73	.03	.14	.61	.81
1938	.51	.76	.15	.46	.04	.22	.98	.34	.58	.21	.75	.80
1939	.86	.00	.28	1.02	.46	.87	.76	.09	.29	.58	.84	.49
1940	1.00	.57	.13	.11	.05	.73	.34	.73	.58	.50	.88	1.04
1941	1.12	1.15	.83	.38	.00	.16	.41	.58	.46	.58	.49	.79
1942	.53	.00	.19	.00	.83	.20	.00	.46	.57	.00	.00	1.10
1943	.02	.68	.42	.49	.00	.81	1.03	.68	.00	.58	.87	.01
1944	.58	1.06	1.28	1.08	.44	.00	.85	.70	.53	.58	.86	1.03
1945	1.34	1.43	1.48	.00	.18	.01	.92	.68	.58	.58	.88	1.14
1946	.36	.20	.96	.96	.00	.33	.63	.73	.15	.53	.87	.79
1947	.73	.16	.49	.18	.66	.17	.64	.65	.58	.57	.86	.96
1948	.75	.93	1.18	.20	.21	.20	.45	.63	.57	.55	.87	.76
1949	.81	.53	.68	.71	.48	.13	.65	.46	.56	.57	.62	.96
1950	.79	1.20	.61	.81	.40	.58	.63	.65	.48	.53	.29	.84
1951	.89	1.31	.77	.00	.29	.36	.67	.62	.58	.13	.81	1.05
1952	.84	.77	1.21	.26	.00	.59	.51	.69	.58	.58	.57	1.10
1953	1.12	.61	.81	.83	.00	.36	.65	.32	.44	.58	.87	.48
1954	.37	.01	.63	.00	.00	.77	.84	.64	.58	.58	.86	1.06
1955	.95	.62	.81	1.21	.00	.00	1.00	.30	.58	.58	.87	.84
1956	.92	.26	.00	.28	.37	.17	.61	.71	.49	.00	.59	.00
1957	.32	1.12	.89	.13	.51	.37	.18	.72	.58	.58	.88	.50
1958	.90	.57	.40	.51	.00	.94	.74	.00	.58	.53	.86	1.08
1959	.32	.70	.79	.61	.05	.55	.22	.71	.58	.55	.71	.96
1960	.75	.71	.01	1.22	.86	.01	.38	.48	.56	.58	.88	.71
1961	1.21	.48	.75	.01	.26	.94	.51	.68	.58	.58	.69	.93
1962	1.32	.54	.66	.00	.94	.60	.84	.68	.22	.29	.88	1.14
1963	1.00	.74	1.39	.30	1.05	.50	.77	.70	.22	.57	.70	.76
1964	.13	.88	.53	.36	.43	1.11	.54	.65	.11	.50	.48	.68
1965	1.11	.88	1.04	.00	.38	1.12	.71	.49	.56	.58	.67	.98
1966	1.10	.79	.22	.00	.36	.01	.22	.64	.58	.55	.86	1.10
1967	1.14	1.09	.54	1.07	.88	.83	.95	.71	.58	.58	.58	1.06
1968	1.27	1.10	1.13	.64	.53	.00	.43	.29	.55	.51	.87	1.02
1969	.33	1.31	.57	.49	.32	1.08	.86	.58	.44	.51	.27	.62
1970	.64	.94	1.14	.00	.65	.79	.71	.23	.57	.26	.69	1.01
1971	.63	.88	.34	.28	.06	.13	.88	.59	.55	.58	.63	1.14
1972	.83	.57	1.12	.79	.08	1.04	.00	.73	.58	.58	.02	.42
1973	1.14	.38	.47	.33	.06	.44	.55	.51	.49	.55	.81	1.12
1974	1.27	.38	.80	.04	.00	.38	.63	.68	.57	.58	.84	.00
1975	1.18	.20	.07	.01	.01	.00	.27	.31	.58	.58	.83	.94
1976	.31	.59	.64	.27	.69	.14	.20	.73	.58	.58	.86	.36
1977	.34	.84	.77	.00	.42	.17	.64	.72	.58	.58	.61	.50
1978	.15	.68	.34	.99	.00	.81	.81	.35	.41	.22	.02	.65
1979	1.08	.94	.70	.24	.17	.76	.88	.59	.58	.58	.84	.30
1980	1.00	.56	.23	.17	.00	1.15	.84	.70	.38	.58	.51	.62
1981	1.14	.61	.88	.39	1.00	.51	.96	.70	.57	.51	.87	.94
1982	.27	1.14	1.14	.65	.97	.68	.85	.61	.51	.51	.78	1.12
1983	.27	.24	.07	.21	.88	.17	.67	.71	.52	.51	.20	.90
1984	.69	1.22	1.05	.00	.00	1.04	1.02	.73	.55	.57	.87	.99
1985	.17	.11	.37	.15	.81	.30	.61	.73	.42	.58	.65	1.09
1986	.55	.80	.41	.66	.00	.00	.83	.73	.50	.56	.08	.00
1987	1.02	.58	.55	.98	.00	.25	.98	.72	.24	.36	.86	.91
1988	.76	.57	.49	.32	.00	.50	.75	.58	.44	.58	.85	1.15
1989	.88	.01	1.00	1.02	.50	.44	.61	.69	.57	.58	.55	1.15
1990	1.07	1.42	.61	.00	.01	.53	1.04	.73	.36	.58	.87	1.04
1991	.00	.86	.48	.92	.01	.97	.87	.73	.58	.58	.71	1.15
1992	1.24	.94	.86	.61	.17	.32	.73	.71	.58	.58	.84	.81
1993	.06	.76	.69	.34	.00	.41	.69	.73	.58	.51	.66	1.11
1994	.97	1.41	1.10	.69	.66	.49	.73	.58	.53	.58	.77	.90

Third phase irrigation water use for 2030 – TM1275.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.13	.22	.23	.13	.10	.14	.19	.10	.07	.16	.20	.01
1926	.09	.11	.13	.20	.03	.03	.20	.15	.12	.14	.14	.25
1927	.08	.23	.12	.24	.16	.06	.18	.15	.12	.16	.18	.14
1928	.15	.22	.11	.04	.08	.00	.15	.14	.00	.04	.18	.00
1929	.16	.01	.23	.11	.10	.00	.11	.15	.11	.14	.17	.16
1930	.21	.19	.05	.11	.15	.13	.13	.16	.12	.11	.20	.26
1931	.17	.26	.17	.19	.00	.07	.14	.04	.11	.15	.20	.17
1932	.23	.11	.13	.39	.11	.06	.10	.15	.12	.05	.20	.26
1933	.26	.00	.09	.01	.11	.09	.00	.06	.12	.11	.06	.25
1934	.18	.00	.00	.38	.05	.01	.17	.13	.11	.16	.19	.24
1935	.27	.20	.34	.14	.01	.12	.14	.00	.12	.16	.20	.23
1936	.19	.00	.03	.24	.00	.17	.12	.16	.12	.15	.20	.25
1937	.23	.23	.08	.10	.14	.16	.01	.15	.03	.06	.15	.24
1938	.19	.23	.23	.22	.00	.10	.19	.08	.12	.11	.16	.19
1939	.20	.01	.25	.34	.18	.17	.12	.04	.00	.16	.19	.15
1940	.22	.19	.11	.19	.04	.00	.05	.16	.12	.15	.20	.23
1941	.16	.22	.31	.12	.00	.00	.05	.14	.11	.14	.15	.20
1942	.21	.00	.08	.16	.07	.08	.00	.01	.11	.04	.00	.23
1943	.00	.00	.06	.26	.00	.09	.21	.12	.08	.16	.20	.03
1944	.21	.16	.34	.35	.10	.00	.19	.13	.12	.16	.20	.26
1945	.28	.23	.20	.32	.00	.15	.12	.14	.12	.16	.20	.26
1946	.08	.05	.27	.32	.00	.00	.12	.16	.03	.16	.19	.16
1947	.14	.07	.01	.00	.05	.01	.04	.14	.12	.16	.20	.22
1948	.18	.17	.08	.27	.05	.01	.07	.14	.12	.15	.20	.18
1949	.22	.11	.25	.38	.19	.00	.09	.08	.12	.15	.14	.19
1950	.19	.00	.00	.24	.09	.03	.09	.14	.10	.16	.06	.15
1951	.19	.27	.16	.00	.14	.02	.16	.15	.11	.07	.18	.21
1952	.14	.12	.04	.19	.00	.16	.10	.15	.12	.16	.14	.25
1953	.19	.13	.11	.34	.00	.14	.11	.08	.11	.16	.20	.12
1954	.07	.00	.19	.07	.00	.15	.14	.11	.12	.16	.20	.25
1955	.24	.22	.03	.41	.00	.00	.17	.15	.12	.15	.20	.18
1956	.28	.09	.00	.16	.16	.00	.02	.16	.12	.08	.09	.00
1957	.01	.20	.18	.20	.00	.20	.00	.15	.12	.16	.20	.19
1958	.19	.08	.16	.27	.06	.23	.08	.01	.12	.13	.20	.26
1959	.04	.10	.21	.35	.00	.00	.00	.14	.12	.15	.19	.23
1960	.18	.11	.09	.35	.05	.07	.00	.14	.11	.15	.18	.17
1961	.25	.14	.21	.08	.00	.07	.06	.14	.12	.16	.18	.23
1962	.27	.03	.00	.13	.06	.03	.10	.14	.08	.12	.20	.25
1963	.16	.00	.28	.13	.23	.02	.08	.15	.06	.16	.19	.08
1964	.01	.02	.25	.29	.16	.22	.14	.14	.00	.11	.07	.14
1965	.24	.16	.21	.01	.09	.26	.17	.09	.07	.16	.15	.25
1966	.19	.02	.07	.08	.00	.05	.00	.07	.12	.14	.20	.25
1967	.23	.19	.33	.22	.14	.07	.14	.15	.12	.14	.16	.25
1968	.26	.17	.19	.23	.16	.00	.12	.04	.11	.16	.19	.24
1969	.05	.24	.11	.32	.01	.19	.18	.14	.09	.16	.02	.08
1970	.16	.16	.31	.05	.17	.15	.12	.07	.12	.09	.16	.25
1971	.16	.11	.11	.21	.13	.00	.15	.08	.11	.16	.18	.26
1972	.17	.02	.31	.28	.04	.16	.00	.15	.12	.15	.01	.13
1973	.27	.05	.18	.12	.00	.00	.04	.15	.08	.14	.17	.26
1974	.23	.10	.00	.08	.00	.11	.09	.15	.12	.16	.19	.00
1975	.27	.00	.08	.10	.00	.00	.14	.06	.12	.16	.20	.16
1976	.12	.13	.22	.07	.19	.08	.14	.15	.12	.16	.19	.13
1977	.01	.14	.15	.00	.12	.02	.08	.15	.12	.16	.14	.11
1978	.08	.18	.00	.27	.00	.11	.13	.11	.12	.11	.05	.23
1979	.18	.16	.16	.22	.08	.16	.11	.14	.12	.16	.19	.06
1980	.24	.01	.00	.04	.00	.21	.14	.14	.08	.16	.10	.19
1981	.26	.14	.23	.15	.24	.14	.18	.15	.09	.14	.20	.19
1982	.04	.22	.16	.16	.25	.13	.16	.08	.11	.11	.16	.25
1983	.13	.10	.01	.25	.22	.01	.04	.16	.11	.15	.11	.24
1984	.10	.25	.29	.00	.04	.19	.21	.14	.10	.16	.20	.23
1985	.02	.15	.09	.16	.12	.12	.16	.16	.05	.16	.15	.25
1986	.00	.16	.04	.14	.00	.00	.19	.16	.08	.16	.00	.00
1987	.18	.16	.09	.10	.00	.05	.11	.14	.04	.08	.19	.20
1988	.08	.21	.04	.28	.00	.16	.19	.11	.10	.16	.19	.26
1989	.18	.00	.06	.31	.13	.11	.08	.14	.12	.16	.09	.26
1990	.20	.27	.02	.04	.00	.17	.20	.14	.08	.16	.20	.20
1991	.00	.14	.10	.25	.04	.16	.17	.16	.12	.16	.16	.25
1992	.25	.11	.15	.30	.01	.04	.13	.16	.12	.16	.20	.19
1993	.01	.10	.02	.10	.11	.00	.14	.13	.12	.13	.15	.26
1994	.20	.25	.26	.02	.17	.00	.18	.14	.12	.16	.20	.17

Third phase irrigation water use for 2030 – TM1475B.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.61	.48	1.35	.00	.71	.30	.91	.59	.34	.93	1.59	.26
1926	.81	.41	.79	.61	.00	.01	.96	.86	.72	.62	1.03	1.98
1927	.55	.98	.14	.30	.59	.02	.81	.62	.72	.93	1.45	1.40
1928	1.12	1.10	.63	.29	.61	.00	.64	.79	.06	.48	1.47	.37
1929	1.47	.00	.50	.00	.11	.45	.68	.85	.66	.81	1.25	1.52
1930	1.43	1.19	.22	.00	.25	.38	.81	.86	.72	.66	1.59	2.06
1931	1.31	.64	.69	.24	.00	.25	.99	.05	.55	.91	1.59	1.60
1932	1.73	.69	.61	1.12	.35	.02	.69	.85	.71	.51	1.58	2.00
1933	1.89	.00	.20	.00	.48	.24	.74	.34	.50	.41	.77	2.03
1934	.91	.56	.00	.69	.41	.04	.35	.77	.60	.93	1.57	1.77
1935	1.71	1.35	1.04	.07	.00	.00	.97	.00	.72	.92	1.59	1.87
1936	1.09	.00	1.08	.16	.00	.34	.91	.86	.69	.93	1.58	1.68
1937	1.72	1.14	.11	.34	.16	.68	.49	.86	.00	.44	1.31	1.50
1938	.00	.86	.00	.43	.00	.67	.89	.09	.71	.41	1.37	1.13
1939	1.35	.00	.31	.38	.51	.41	.75	.00	.38	.92	1.56	1.29
1940	1.33	.08	.16	.55	.07	.53	.00	.86	.72	.81	1.57	1.80
1941	1.24	1.13	.16	.06	.00	.00	.44	.62	.61	.93	1.12	1.45
1942	1.12	.00	.56	.00	.41	.26	.00	.00	.72	.00	.00	1.97
1943	.00	.00	.30	.65	.00	.91	1.06	.85	.00	.93	1.59	.19
1944	1.33	.96	.86	.85	.45	.00	.82	.76	.71	.93	1.57	2.00
1945	1.89	1.38	1.36	.35	.72	.03	.92	.75	.72	.93	1.59	1.87
1946	.44	.00	.95	1.04	.00	.31	.72	.86	.00	.89	1.55	1.56
1947	1.21	.00	.55	.21	.87	.24	.65	.73	.72	.92	1.59	1.62
1948	.75	.68	.84	.00	.14	.51	.14	.78	.66	.93	1.59	1.58
1949	.84	.75	.14	.78	.33	.44	.44	.39	.69	.91	1.19	1.97
1950	1.14	.66	.39	.92	.74	.37	.57	.74	.66	.77	.24	1.73
1951	1.25	1.47	.11	.00	.81	.29	.39	.50	.71	.15	1.55	1.96
1952	1.30	.16	1.18	.17	.00	.51	.21	.85	.67	.93	.57	1.90
1953	1.61	.00	.93	.89	.00	.24	.82	.24	.64	.93	1.59	1.10
1954	.12	.00	.93	.00	.00	.64	.69	.85	.70	.93	1.58	1.97
1955	.78	.55	.74	1.13	.23	.02	1.07	.37	.72	.93	1.54	1.44
1956	1.13	.00	.00	.00	.45	.22	.55	.85	.42	.00	.96	.00
1957	.01	1.07	1.00	.38	.03	.06	.00	.86	.72	.93	1.59	1.40
1958	1.08	.08	.34	.82	.00	.84	.53	.07	.72	.79	1.52	1.83
1959	.50	.24	1.04	.26	.39	.32	.05	.81	.72	.93	1.06	1.69
1960	1.00	.06	.16	1.16	.41	.00	.17	.43	.65	.93	1.59	1.41
1961	1.57	.28	.88	.00	.02	.89	.39	.86	.72	.93	1.14	1.66
1962	1.72	.34	.32	.24	.95	.00	.66	.78	.22	.00	1.59	2.06
1963	1.19	.61	1.11	.00	.68	.37	.55	.86	.19	.89	1.45	1.15
1964	.17	.50	.64	.00	.32	1.08	.64	.81	.00	.69	1.29	1.58
1965	1.26	.78	1.00	.00	.67	1.25	.23	.61	.66	.93	1.14	1.75
1966	1.38	.51	.44	.00	.33	.00	.09	.79	.72	.92	1.58	1.89
1967	1.64	.34	.81	1.22	.79	.31	.93	.79	.72	.93	.92	2.01
1968	1.68	.68	.70	.44	.00	.00	.23	.60	.68	.74	1.59	1.95
1969	.24	1.14	.66	.43	.00	1.07	.62	.60	.59	.79	.61	1.50
1970	.95	.68	1.28	.00	.72	.13	.40	.11	.70	.55	1.05	1.89
1971	1.21	.99	.27	.00	.00	.00	.95	.69	.63	.92	1.28	1.92
1972	1.39	.56	1.28	.61	.00	.79	.01	.85	.72	.93	.40	.97
1973	1.55	.00	.78	.00	.01	.46	.03	.83	.39	.86	1.44	2.04
1974	1.66	.06	.40	.19	.00	.57	.29	.72	.72	.93	1.49	.00
1975	1.51	.06	.29	.00	.00	.00	.28	.43	.72	.91	1.36	1.73
1976	.39	.71	.60	.00	.78	.00	.31	.72	.72	.92	1.54	1.10
1977	.22	.81	.60	.00	.28	.00	.41	.86	.70	.93	1.07	.95
1978	.00	.62	.77	.47	.00	.89	.83	.64	.71	.13	.74	.91
1979	1.51	.67	.81	.23	.03	.19	.85	.78	.72	.93	1.57	.85
1980	1.05	.09	.08	.00	.00	.89	.60	.79	.14	.93	.98	1.02
1981	1.42	.55	1.08	.45	1.03	.02	.93	.81	.68	.86	1.59	1.31
1982	.00	1.01	1.11	.19	.93	.44	.77	.49	.61	.75	1.24	1.95
1983	.70	.00	.34	.00	.73	.00	.30	.86	.44	.78	.56	1.71
1984	.59	1.01	.60	.00	.00	1.05	1.07	.82	.72	.93	1.58	1.71
1985	.00	.06	.18	.00	.00	.30	.60	.86	.26	.93	1.43	1.94
1986	1.21	.96	.26	.53	.00	.00	.81	.85	.66	.93	.51	.00
1987	.97	.27	.64	.33	.00	.34	.46	.84	.22	.12	1.58	1.42
1988	.52	.74	.05	.22	.00	.41	.74	.79	.52	.93	1.55	2.04
1989	1.12	.00	.54	.85	.56	.57	.26	.82	.72	.93	.98	2.06
1990	1.27	1.10	.00	.05	.00	.59	1.06	.80	.34	.89	1.56	1.75
1991	.00	.61	.00	.95	.00	.70	.12	.86	.72	.93	1.27	2.02
1992	1.69	.57	1.10	.65	.01	.34	.75	.86	.72	.93	1.38	1.80
1993	.00	.21	.17	.12	.04	.00	.70	.86	.72	.76	.95	2.02
1994	1.41	1.22	.64	.37	.96	.27	.74	.41	.72	.93	1.54	1.88

Third phase irrigation water use for 2030 – TM14_MUN.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.54	.48	1.23	.02	.67	.32	.83	.52	.29	.77	1.29	.20
1926	.69	.41	.74	.60	.02	.06	.87	.75	.62	.52	.83	1.62
1927	.50	.90	.20	.31	.57	.08	.74	.55	.62	.77	1.17	1.14
1928	.96	1.02	.63	.33	.58	.03	.60	.69	.07	.39	1.19	.30
1929	1.25	.05	.50	.04	.17	.44	.63	.74	.56	.67	1.01	1.23
1930	1.21	1.08	.27	.01	.27	.39	.74	.74	.61	.55	1.29	1.68
1931	1.11	.64	.67	.29	.00	.27	.90	.06	.47	.75	1.29	1.30
1932	1.46	.67	.58	1.04	.36	.10	.65	.74	.60	.42	1.28	1.63
1933	1.58	.01	.24	.00	.47	.26	.69	.31	.44	.34	.61	1.65
1934	.78	.54	.04	.67	.40	.11	.34	.67	.52	.77	1.27	1.44
1935	1.45	1.20	.96	.11	.00	.05	.88	.00	.62	.76	1.29	1.52
1936	.92	.02	1.01	.20	.02	.36	.83	.75	.59	.77	1.28	1.36
1937	1.45	1.03	.15	.35	.18	.64	.47	.75	.01	.36	1.06	1.23
1938	.04	.80	.04	.44	.01	.62	.81	.11	.61	.34	1.12	.92
1939	1.14	.00	.34	.40	.50	.42	.69	.00	.32	.76	1.26	1.04
1940	1.13	.16	.19	.53	.12	.51	.03	.75	.62	.67	1.27	1.47
1941	1.07	1.03	.21	.11	.04	.06	.45	.55	.52	.77	.90	1.17
1942	.96	.00	.52	.00	.41	.30	.01	.01	.62	.00	.00	1.61
1943	.00	.04	.33	.63	.00	.82	.95	.74	.01	.77	1.29	.14
1944	1.13	.89	.81	.80	.45	.00	.74	.66	.60	.77	1.27	1.63
1945	1.59	1.24	1.25	.37	.69	.10	.84	.65	.62	.77	1.29	1.52
1946	.38	.03	.89	.96	.00	.32	.67	.75	.02	.74	1.26	1.27
1947	1.03	.06	.54	.24	.79	.26	.60	.64	.62	.76	1.29	1.32
1948	.65	.64	.79	.04	.17	.48	.19	.68	.57	.77	1.29	1.29
1949	.72	.71	.17	.75	.35	.44	.43	.35	.59	.75	.96	1.61
1950	.97	.63	.39	.86	.70	.37	.54	.64	.57	.64	.18	1.41
1951	1.07	1.32	.15	.03	.76	.31	.40	.45	.61	.14	1.25	1.60
1952	1.11	.23	1.06	.22	.00	.50	.25	.73	.57	.77	.45	1.55
1953	1.37	.04	.87	.83	.00	.26	.74	.21	.55	.77	1.29	.89
1954	.13	.00	.87	.00	.04	.61	.64	.74	.60	.77	1.28	1.60
1955	.68	.53	.71	1.05	.24	.09	.97	.33	.62	.77	1.25	1.17
1956	.97	.05	.00	.05	.45	.25	.51	.74	.37	.00	.77	.00
1957	.04	.98	.94	.39	.10	.13	.01	.75	.62	.77	1.29	1.14
1958	.93	.16	.36	.77	.04	.77	.51	.08	.62	.65	1.23	1.49
1959	.46	.28	.95	.30	.38	.34	.10	.71	.62	.77	.86	1.37
1960	.86	.13	.18	1.07	.41	.04	.20	.38	.55	.77	1.29	1.14
1961	1.33	.32	.83	.02	.08	.80	.39	.74	.62	.77	.91	1.35
1962	1.45	.36	.32	.28	.88	.02	.62	.68	.20	.00	1.29	1.68
1963	.99	.58	1.02	.05	.65	.38	.52	.75	.17	.73	1.17	.93
1964	.17	.50	.61	.06	.35	.98	.61	.70	.01	.57	1.04	1.28
1965	1.06	.72	.93	.00	.63	1.11	.26	.54	.57	.77	.91	1.42
1966	1.17	.52	.45	.00	.33	.00	.14	.69	.62	.75	1.28	1.54
1967	1.36	.35	.76	1.11	.75	.33	.84	.69	.62	.77	.73	1.64
1968	1.42	.64	.66	.46	.06	.00	.26	.52	.58	.61	1.29	1.59
1969	.24	1.05	.62	.43	.04	.95	.59	.53	.51	.66	.47	1.20
1970	.80	.64	1.16	.04	.68	.19	.40	.11	.60	.45	.84	1.54
1971	.98	.89	.28	.02	.05	.03	.86	.59	.54	.76	1.04	1.57
1972	1.16	.53	1.15	.58	.00	.74	.06	.74	.62	.77	.31	.80
1973	1.32	.03	.76	.00	.08	.46	.10	.72	.34	.71	1.16	1.67
1974	1.41	.12	.39	.22	.01	.56	.30	.63	.62	.77	1.20	.00
1975	1.29	.13	.32	.01	.02	.01	.31	.37	.62	.76	1.11	1.41
1976	.34	.68	.57	.05	.73	.02	.34	.63	.62	.76	1.24	.89
1977	.22	.75	.60	.00	.29	.07	.40	.75	.60	.77	.86	.77
1978	.02	.60	.74	.47	.01	.81	.76	.56	.60	.11	.58	.73
1979	1.29	.64	.75	.25	.10	.24	.77	.68	.62	.77	1.27	.68
1980	.91	.17	.14	.03	.03	.83	.57	.68	.14	.77	.79	.84
1981	1.21	.54	1.01	.45	.94	.08	.85	.70	.59	.71	1.29	1.07
1982	.01	.92	1.02	.25	.86	.43	.71	.43	.52	.62	1.00	1.59
1983	.63	.03	.33	.00	.68	.05	.31	.75	.39	.64	.46	1.39
1984	.51	.93	.59	.01	.00	.95	.97	.72	.62	.77	1.28	1.39
1985	.01	.13	.24	.03	.06	.31	.55	.75	.23	.77	1.16	1.58
1986	1.03	.89	.26	.51	.04	.00	.74	.73	.56	.77	.41	.00
1987	.82	.31	.62	.33	.02	.34	.47	.73	.21	.11	1.28	1.15
1988	.46	.69	.10	.28	.00	.43	.70	.68	.45	.77	1.26	1.67
1989	.96	.00	.51	.79	.54	.54	.27	.71	.62	.77	.78	1.68
1990	1.08	1.01	.07	.11	.01	.56	.94	.69	.30	.74	1.26	1.41
1991	.04	.61	.06	.86	.05	.64	.19	.75	.62	.77	1.03	1.65
1992	1.43	.56	.98	.64	.07	.33	.69	.75	.61	.77	1.11	1.46
1993	.00	.26	.21	.18	.10	.05	.64	.75	.62	.63	.76	1.64
1994	1.20	1.10	.62	.38	.88	.29	.68	.37	.62	.77	1.24	1.54

Third phase irrigation water use for 2030 – TM2475.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.77	.35	.68	1.00	1.15	.89	.62	.39	.00	.48	.78	.04
1926	1.00	.44	.25	.79	.19	.28	.70	.46	.37	.19	.64	1.40
1927	.50	.96	.00	.81	1.05	.62	.50	.42	.37	.48	.59	.74
1928	1.00	.96	.20	.82	1.52	.00	.71	.42	.00	.10	.74	.00
1929	.88	.00	.05	.00	1.33	1.35	.12	.44	.35	.30	.62	.98
1930	1.19	1.10	.00	.00	.77	1.17	.48	.47	.37	.36	.78	1.42
1931	1.15	.69	.65	.79	.25	.45	.59	.03	.32	.47	.78	1.15
1932	1.22	.58	.00	1.64	1.40	.60	.23	.46	.36	.25	.77	1.40
1933	1.34	.00	.00	.00	1.34	.61	.33	.23	.37	.13	.34	1.39
1934	.91	.07	.00	.87	.31	.42	.24	.38	.30	.48	.72	1.09
1935	1.19	1.07	.58	.00	.50	.00	.62	.00	.37	.47	.78	1.25
1936	.85	.00	.97	.00	.31	1.24	.25	.47	.36	.48	.78	1.03
1937	1.34	1.00	.00	.88	1.05	1.32	.04	.41	.00	.25	.56	1.22
1938	.00	.87	.00	.68	.00	.69	.76	.13	.36	.16	.64	1.06
1939	1.06	.00	.00	.76	.60	1.60	.34	.00	.00	.47	.77	.63
1940	1.22	.17	.00	.81	.46	.52	.00	.47	.37	.46	.77	1.15
1941	1.07	.83	.14	.00	.11	.83	.25	.27	.16	.48	.55	.52
1942	.71	.00	.00	.00	1.36	.26	.00	.27	.34	.00	.00	1.31
1943	.00	.09	.00	.67	.00	1.21	.78	.46	.00	.48	.78	.00
1944	.30	.96	.86	1.36	1.13	.00	.22	.43	.34	.48	.76	1.37
1945	1.57	1.22	1.20	.17	.90	.03	.69	.44	.37	.48	.78	1.36
1946	.52	.19	.51	1.34	.00	.80	.27	.47	.01	.43	.76	1.18
1947	1.08	.00	.00	.04	1.00	.67	.56	.36	.37	.47	.78	.86
1948	.44	.64	.58	.00	.28	.69	.00	.45	.35	.48	.78	1.01
1949	.47	.34	.00	.89	1.00	1.07	.00	.23	.34	.46	.53	1.28
1950	.80	.74	.00	1.17	.68	.99	.14	.38	.32	.23	.14	1.28
1951	.63	1.15	.00	.23	1.72	1.16	.28	.39	.37	.00	.76	1.36
1952	1.20	.00	.36	.00	.00	1.05	.08	.47	.28	.48	.03	1.23
1953	1.13	.23	.54	1.20	.00	.43	.59	.11	.25	.48	.78	.71
1954	.35	.00	.77	.02	.08	.87	.36	.45	.34	.48	.75	1.34
1955	.52	.69	.34	1.18	.35	.23	.72	.11	.34	.48	.77	.91
1956	.75	.00	.00	.68	.62	.16	.00	.44	.16	.00	.43	.10
1957	.01	1.01	.62	.11	.47	.28	.00	.45	.36	.48	.78	.76
1958	.62	.41	.00	1.11	.25	1.10	.30	.15	.37	.35	.76	1.10
1959	.43	.00	.20	1.20	.57	1.16	.00	.41	.37	.47	.52	1.09
1960	.67	.38	.00	1.70	1.36	.21	.00	.31	.32	.48	.78	.85
1961	1.13	.28	.41	.30	.39	1.19	.41	.47	.37	.48	.51	1.06
1962	1.34	.52	.44	.04	1.96	.74	.50	.38	.00	.00	.78	1.43
1963	.64	.18	.76	.31	1.25	1.08	.03	.46	.00	.47	.60	.86
1964	.00	.36	.00	.34	.63	1.73	.30	.44	.00	.34	.55	1.06
1965	.57	.57	.62	.00	1.17	1.77	.16	.32	.35	.48	.50	.92
1966	.92	.37	.00	.00	.70	.96	.01	.43	.37	.47	.78	1.29
1967	1.09	.23	.06	1.33	1.88	.73	.43	.39	.37	.47	.33	1.34
1968	1.49	.40	.04	.49	.97	.00	.00	.32	.31	.34	.78	1.15
1969	.02	.91	.14	.87	.48	1.53	.28	.31	.31	.36	.23	.94
1970	.30	.69	.76	.00	1.20	1.02	.00	.01	.35	.31	.49	1.08
1971	.75	.74	.00	.81	.26	.00	.54	.31	.33	.47	.74	1.43
1972	.76	.39	.77	1.04	.62	1.19	.00	.46	.37	.47	.00	.65
1973	1.25	.00	.38	.29	.14	1.03	.00	.42	.15	.34	.67	1.31
1974	1.25	.00	.00	.36	.00	1.33	.01	.42	.37	.48	.76	.00
1975	1.26	.19	.00	.00	.51	.00	.04	.07	.37	.47	.76	1.17
1976	.11	.79	.00	.05	1.54	.57	.51	.44	.37	.47	.77	.94
1977	.74	1.04	.00	.00	.63	.63	.10	.46	.37	.48	.38	.71
1978	.48	.63	.00	.90	.63	1.55	.47	.40	.33	.15	.18	.65
1979	1.31	.66	.06	.00	.18	1.26	.55	.45	.37	.48	.75	.49
1980	1.07	.62	.01	.72	.52	1.62	.48	.45	.18	.48	.43	.64
1981	1.01	.84	.79	.49	1.71	.84	.67	.41	.36	.41	.78	1.15
1982	.01	1.14	.60	.95	1.66	.98	.43	.23	.30	.40	.55	1.37
1983	.36	.00	.00	.00	1.27	.03	.35	.46	.23	.32	.17	1.20
1984	.00	.77	.46	.00	.00	1.57	.80	.46	.32	.46	.78	1.11
1985	.02	.17	.00	.00	.25	.86	.16	.47	.23	.48	.74	1.26
1986	.72	.58	.00	.48	.25	1.15	.31	.45	.29	.48	.23	.00
1987	.17	.07	.00	.74	.74	.39	.56	.41	.18	.42	.77	1.18
1988	.29	.82	.00	.67	.00	1.16	.74	.43	.22	.48	.77	1.41
1989	.73	.00	.00	1.34	.93	.19	.24	.44	.37	.46	.63	1.44
1990	1.28	1.27	.00	.21	.00	.94	.79	.41	.01	.48	.76	1.00
1991	.00	.59	.00	1.20	.00	1.30	.49	.47	.37	.47	.34	1.39
1992	1.13	.62	.46	1.54	.00	1.26	.51	.47	.37	.48	.62	1.19
1993	.00	.60	.00	.00	.57	.75	.38	.42	.37	.36	.56	1.27
1994	.70	1.00	.00	.23	1.25	.35	.30	.39	.37	.48	.78	1.44

Third phase irrigation water use for 2030 – TM2675.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.00	.00	.00	.25	.04	.25	.19	.00	.00	.26	.75	.34
1926	.19	.00	.00	.18	.00	.31	.00	.00	.12	.01	.75	.89
1927	.00	.00	.00	.29	.00	.08	.00	.00	.12	.26	.69	.52
1928	.00	.00	.00	.09	.34	.00	.05	.00	.00	.19	.66	.30
1929	.00	.00	.00	.00	.42	.44	.00	.00	.08	.17	.62	.94
1930	.38	.00	.00	.00	.00	.36	.00	.00	.12	.03	.75	.93
1931	.19	.00	.00	.28	.00	.00	.07	.00	.00	.25	.75	.86
1932	.04	.00	.00	.58	.00	.40	.00	.00	.08	.18	.75	.85
1933	.04	.00	.00	.00	.46	.14	.00	.00	.08	.01	.44	.93
1934	.03	.00	.00	.01	.04	.00	.05	.00	.03	.27	.74	.81
1935	.02	.00	.00	.00	.38	.00	.10	.00	.09	.27	.75	.76
1936	.00	.00	.00	.00	.00	.60	.16	.00	.12	.27	.75	.62
1937	.00	.00	.00	.24	.69	.34	.00	.00	.00	.16	.61	.83
1938	.00	.00	.00	.00	.00	.09	.21	.00	.12	.00	.50	.79
1939	.08	.00	.00	.09	.32	.26	.03	.00	.00	.27	.75	.72
1940	.04	.00	.00	.00	.00	.35	.00	.00	.12	.27	.72	.82
1941	.13	.00	.00	.00	.34	.04	.00	.00	.00	.27	.60	.39
1942	.00	.00	.00	.00	.00	.04	.00	.00	.12	.00	.42	.70
1943	.00	.00	.00	.25	.00	.34	.17	.00	.00	.27	.75	.26
1944	.00	.00	.00	.37	.11	.00	.14	.00	.12	.27	.71	.92
1945	.34	.00	.13	.00	.14	.00	.18	.00	.12	.26	.72	.91
1946	.00	.00	.00	.16	.00	.17	.00	.00	.00	.18	.75	.72
1947	.19	.00	.00	.00	.59	.00	.04	.00	.12	.27	.75	.58
1948	.00	.00	.00	.00	.34	.07	.00	.00	.11	.27	.75	.58
1949	.00	.00	.00	.05	.31	.46	.00	.00	.04	.27	.41	.74
1950	.00	.00	.00	.07	.58	.58	.05	.00	.12	.27	.23	.86
1951	.00	.00	.00	.00	.50	.33	.00	.00	.12	.00	.75	.92
1952	.11	.00	.00	.28	.00	.28	.00	.00	.10	.27	.67	.81
1953	.14	.00	.00	.22	.10	.08	.00	.00	.03	.23	.75	.38
1954	.00	.00	.00	.00	.00	.06	.04	.00	.11	.24	.71	.86
1955	.00	.00	.00	.29	.00	.00	.07	.00	.12	.21	.74	.45
1956	.00	.00	.00	.19	.08	.12	.00	.00	.00	.00	.46	.00
1957	.00	.00	.00	.00	.51	.56	.00	.00	.12	.27	.75	.47
1958	.00	.00	.00	.30	.30	.43	.00	.00	.12	.24	.66	.62
1959	.00	.00	.00	.16	.16	.32	.00	.00	.12	.25	.59	.64
1960	.00	.00	.00	.31	.41	.04	.00	.00	.00	.27	.75	.35
1961	.01	.00	.00	.23	.42	.48	.01	.00	.12	.27	.64	.70
1962	.11	.00	.00	.00	.61	.23	.01	.00	.00	.00	.75	.94
1963	.00	.00	.08	.00	.61	.44	.00	.00	.06	.27	.64	.77
1964	.00	.00	.00	.06	.37	.56	.00	.00	.00	.23	.63	.71
1965	.00	.00	.00	.08	.14	.74	.11	.00	.09	.27	.62	.51
1966	.00	.00	.00	.00	.00	.47	.00	.00	.12	.07	.66	.85
1967	.00	.00	.00	.29	.65	.00	.14	.00	.11	.26	.36	.91
1968	.17	.00	.00	.00	.46	.00	.00	.00	.10	.23	.75	.64
1969	.00	.00	.00	.21	.25	.57	.06	.00	.01	.19	.49	.74
1970	.00	.00	.00	.00	.39	.38	.00	.00	.11	.25	.71	.66
1971	.00	.00	.00	.00	.09	.04	.03	.00	.10	.27	.73	.93
1972	.11	.00	.00	.00	.00	.15	.00	.00	.12	.26	.11	.44
1973	.00	.00	.00	.00	.11	.24	.00	.00	.00	.11	.70	.88
1974	.12	.00	.00	.00	.00	.41	.00	.00	.11	.26	.74	.43
1975	.00	.00	.00	.07	.15	.01	.00	.00	.12	.27	.73	.83
1976	.00	.00	.00	.00	.16	.25	.06	.00	.12	.27	.67	.59
1977	.00	.00	.00	.00	.01	.47	.00	.00	.12	.27	.47	.50
1978	.00	.00	.00	.44	.56	.56	.00	.00	.08	.05	.31	.50
1979	.06	.00	.00	.00	.00	.62	.11	.00	.11	.27	.72	.58
1980	.14	.00	.00	.00	.00	.11	.01	.00	.02	.23	.52	.50
1981	.01	.00	.00	.00	.75	.48	.11	.00	.11	.22	.75	.86
1982	.00	.00	.00	.24	.72	.31	.00	.00	.05	.20	.51	.92
1983	.00	.00	.00	.00	.37	.04	.01	.00	.00	.00	.32	.80
1984	.00	.00	.00	.00	.00	.68	.20	.00	.08	.26	.75	.86
1985	.00	.00	.00	.00	.07	.21	.00	.00	.00	.27	.72	.81
1986	.01	.00	.00	.19	.22	.44	.08	.00	.01	.22	.34	.00
1987	.00	.00	.00	.00	.49	.32	.08	.00	.01	.13	.63	.77
1988	.00	.00	.00	.00	.00	.50	.00	.00	.00	.25	.71	.94
1989	.00	.00	.00	.07	.28	.00	.00	.00	.12	.27	.62	.94
1990	.00	.00	.00	.00	.00	.00	.22	.00	.00	.27	.72	.83
1991	.00	.00	.00	.44	.00	.64	.14	.00	.12	.27	.67	.92
1992	.04	.00	.00	.31	.00	.15	.00	.00	.12	.27	.72	.78
1993	.00	.00	.00	.00	.16	.00	.02	.00	.12	.27	.69	.85
1994	.00	.00	.00	.01	.44	.20	.00	.00	.11	.27	.71	.94

Third phase irrigation water use for 2030 – V375B.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	2.52	1.50	1.19	2.09	3.42	.74	1.66	.66	.00	1.13	1.76	.00
1926	2.99	1.54	.96	3.91	1.50	1.03	1.86	1.08	.90	.00	1.73	2.76
1927	1.41	2.81	.23	2.99	3.01	2.68	1.25	1.06	.90	1.13	1.17	1.98
1928	2.26	2.47	.00	3.74	3.92	.00	1.46	1.10	.00	.66	1.73	.43
1929	.49	.96	1.00	.49	3.23	3.28	1.57	1.09	.89	.47	1.20	2.36
1930	3.13	2.46	.00	.28	3.37	4.25	.25	1.12	.90	.78	1.76	3.28
1931	3.13	1.96	2.20	3.86	.15	.95	1.36	.00	.33	1.11	1.76	3.00
1932	3.51	2.99	.00	3.36	3.83	3.55	1.18	1.12	.90	.44	1.76	2.99
1933	2.76	.00	.00	.18	3.55	2.07	1.17	.77	.89	.30	.81	3.00
1934	1.99	.78	.00	2.99	2.71	2.91	.37	.96	.86	1.13	1.63	2.95
1935	2.72	2.94	.12	.00	2.46	.61	1.46	.00	.89	1.12	1.75	1.73
1936	2.00	.00	2.53	.63	.95	3.35	1.78	1.12	.90	1.13	1.76	2.25
1937	3.09	2.27	.39	2.60	2.89	2.24	.00	1.11	.11	.63	1.59	2.61
1938	1.08	2.00	.00	1.39	.00	1.20	1.72	.57	.90	.01	1.46	2.73
1939	2.10	.14	1.83	3.90	2.38	3.89	1.12	.00	.00	1.13	1.74	2.20
1940	2.63	1.11	.55	3.33	1.84	3.42	.00	1.12	.90	1.08	1.76	2.38
1941	2.95	2.21	1.01	.00	1.95	.07	1.89	.68	.08	1.13	1.43	1.74
1942	2.14	.00	.28	2.58	1.99	.66	.00	.66	.86	.00	.00	2.76
1943	.23	.37	.00	.99	.87	2.92	2.02	1.09	.00	1.13	1.76	.92
1944	1.08	2.55	2.81	2.89	1.63	.00	1.37	.95	.90	1.13	1.76	2.97
1945	3.66	2.37	2.95	2.08	2.81	1.84	1.54	1.07	.90	1.11	1.74	2.43
1946	1.39	1.29	1.97	3.52	1.51	2.55	1.22	1.12	.04	.78	1.72	3.09
1947	2.50	.00	.00	3.48	.49	1.97	1.75	.93	.90	1.13	1.76	1.84
1948	1.47	1.79	2.05	.51	1.51	2.93	.00	1.12	.90	1.13	1.76	2.29
1949	.91	1.84	.01	3.29	3.42	2.70	.62	.70	.75	1.10	1.25	3.29
1950	2.26	1.47	.94	3.80	4.02	2.38	.34	.90	.85	1.13	.00	2.62
1951	1.58	3.09	.00	.71	3.99	2.55	.43	1.01	.87	.00	1.76	3.29
1952	3.49	.33	1.18	4.00	.00	3.38	.36	1.12	.75	1.13	1.14	2.86
1953	2.96	.42	2.10	3.71	.08	3.39	1.33	.68	.68	1.13	1.76	1.72
1954	.95	.01	1.92	.00	.03	2.86	1.37	1.10	.81	1.11	1.73	3.09
1955	.78	1.56	1.17	4.43	.14	1.38	1.73	.23	.90	1.13	1.76	2.05
1956	.96	.70	.00	2.49	3.09	1.61	.00	.92	.38	.00	1.38	.00
1957	.00	2.81	2.21	2.47	3.12	3.11	.00	1.09	.90	1.06	1.76	2.29
1958	1.57	.90	.10	2.63	2.49	3.55	1.22	.38	.90	1.08	1.63	2.33
1959	.95	.84	.90	4.38	2.16	2.85	.08	.71	.90	1.13	1.23	1.80
1960	1.44	.14	.00	4.19	1.32	2.68	.00	.72	.45	1.13	1.76	1.44
1961	2.43	.95	1.61	.84	2.21	3.43	1.43	1.04	.90	1.13	1.07	2.25
1962	2.07	.01	.00	1.56	4.83	2.20	1.04	1.04	.00	.00	1.76	3.27
1963	1.00	.69	2.56	.96	3.31	3.36	1.39	1.12	.42	1.13	1.43	2.87
1964	.00	1.72	.49	.65	3.05	4.03	1.37	1.07	.15	.86	1.12	2.38
1965	1.51	1.12	2.16	1.11	2.38	4.28	1.01	.90	.71	1.13	1.06	1.60
1966	2.31	2.19	.57	.00	1.79	2.14	1.47	1.04	.90	.95	1.72	3.07
1967	1.91	.16	.66	2.81	4.63	2.14	1.81	1.11	.90	1.11	.83	3.19
1968	3.27	1.04	.21	2.17	3.48	.92	.43	.92	.87	.86	1.76	2.37
1969	.13	2.08	.60	2.66	2.53	3.52	1.20	.90	.68	.89	.93	2.02
1970	1.08	1.68	1.59	1.38	4.11	3.52	.00	.42	.90	.90	1.39	2.60
1971	1.35	1.94	.01	1.82	1.33	2.08	1.58	.61	.68	1.10	1.73	3.20
1972	2.60	1.36	1.84	2.98	.73	2.90	.00	1.08	.90	1.12	.01	1.75
1973	2.89	1.26	1.20	1.66	2.70	2.20	.23	.88	.47	.57	1.67	3.16
1974	2.68	.08	.00	.90	.88	2.89	.00	.99	.90	1.06	1.75	.36
1975	3.10	.62	.00	1.46	2.30	1.03	.23	.40	.90	1.13	1.72	2.68
1976	.36	1.63	.00	.63	3.39	1.86	1.60	1.11	.90	1.13	1.70	1.72
1977	1.67	1.13	.43	.00	1.73	3.66	.17	1.03	.89	1.10	.86	1.64
1978	.46	.80	1.50	2.29	2.70	3.72	.97	.92	.71	.61	.19	1.19
1979	2.72	1.54	1.29	.25	2.10	3.75	1.73	1.06	.90	1.13	1.72	1.72
1980	3.01	.51	.00	.01	2.05	2.14	1.07	.87	.51	1.05	1.01	1.16
1981	2.83	2.28	1.75	1.36	3.84	2.21	1.69	1.08	.84	1.01	1.76	2.59
1982	1.01	2.75	1.51	2.58	4.56	2.43	.91	.33	.81	.94	1.05	3.22
1983	1.60	.00	.00	.00	3.08	1.69	.85	1.08	.41	.37	.55	2.30
1984	1.84	2.19	1.99	2.25	.00	3.83	1.99	1.04	.90	1.08	1.76	2.71
1985	.00	1.18	.32	.45	1.55	1.85	.92	1.12	.42	1.13	1.67	2.80
1986	2.51	1.54	.00	1.15	3.19	1.99	1.01	1.11	.67	1.13	.39	.00
1987	.90	.46	.53	1.04	3.95	3.04	1.17	1.04	.15	.53	1.50	2.71
1988	1.00	1.41	.00	2.55	.70	3.01	1.36	.95	.30	1.13	1.66	3.22
1989	1.46	.00	.54	3.28	2.76	1.99	.00	1.08	.89	1.08	1.37	3.29
1990	2.69	2.79	.69	.49	.27	2.43	2.01	.78	.46	1.09	1.72	2.70
1991	.34	2.36	.00	2.81	2.25	3.84	1.45	1.12	.90	1.12	1.46	3.09
1992	2.92	1.68	.37	3.39	1.42	2.95	1.47	1.12	.90	1.13	1.46	2.75
1993	.00	1.69	1.17	1.67	1.74	2.02	1.17	1.11	.90	1.01	1.39	3.14
1994	1.61	2.62	.45	2.00	4.25	2.21	1.05	.92	.90	1.13	1.76	3.29

Third phase irrigation water use for 2030 – V3_RORK.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.63	.43	.36	.91	1.00	.65	.50	.34	.00	.34	.56	.19
1926	.57	.31	.27	.75	.06	.24	.53	.43	.26	.08	.49	.98
1927	.39	.80	.00	.70	1.05	.66	.46	.42	.26	.34	.42	.54
1928	.64	.72	.20	.55	1.07	.00	.40	.44	.00	.17	.54	.05
1929	.59	.03	.27	.39	.93	.89	.11	.44	.26	.22	.43	.66
1930	.75	.80	.00	.01	.68	.97	.36	.44	.26	.25	.56	1.03
1931	.81	.63	.80	.80	.00	.18	.47	.05	.22	.34	.56	.88
1932	.93	.54	.00	1.19	.91	.62	.28	.44	.25	.07	.54	.99
1933	.81	.00	.00	.01	.83	.47	.34	.22	.26	.06	.21	.97
1934	.75	.08	.00	.81	.69	.66	.06	.37	.22	.34	.52	.82
1935	.91	.74	.04	.00	.16	.04	.51	.00	.26	.34	.56	.88
1936	.57	.00	.69	.01	.29	.69	.34	.44	.25	.34	.56	.77
1937	.95	.70	.01	.43	.49	.74	.10	.44	.00	.09	.48	.88
1938	.04	.68	.00	.45	.23	.54	.51	.16	.26	.12	.49	.70
1939	.72	.00	.05	.80	.73	.94	.05	.00	.00	.33	.54	.55
1940	.51	.22	.01	.55	.48	.59	.00	.44	.26	.32	.56	.79
1941	.79	.54	.12	.00	.33	.51	.52	.34	.12	.34	.41	.42
1942	.49	.00	.01	.09	.99	.86	.00	.11	.23	.00	.00	.92
1943	.00	.05	.00	.54	.03	.86	.52	.44	.00	.34	.56	.04
1944	.50	.80	.40	.95	.80	.00	.20	.41	.26	.34	.56	.97
1945	1.08	.84	.82	.46	1.08	.36	.45	.43	.26	.34	.55	.95
1946	.22	.12	.37	1.06	.06	.68	.32	.44	.01	.32	.52	.80
1947	.65	.00	.00	.35	.41	.48	.29	.37	.26	.32	.56	.70
1948	.27	.46	.33	.02	.51	.48	.04	.44	.25	.33	.56	.72
1949	.32	.50	.00	.87	.90	.71	.03	.18	.24	.34	.39	.97
1950	.63	.40	.02	.94	.96	.53	.29	.33	.26	.30	.09	.78
1951	.58	.90	.00	.47	1.28	.77	.14	.37	.25	.09	.55	.98
1952	1.00	.13	.23	.37	.00	.78	.04	.44	.22	.34	.22	.93
1953	.99	.15	.50	.95	.01	.60	.33	.07	.22	.34	.55	.44
1954	.22	.00	.63	.00	.06	.74	.34	.41	.25	.34	.54	.98
1955	.48	.29	.31	1.09	.00	.59	.55	.09	.26	.34	.55	.65
1956	.45	.01	.00	.36	.72	.33	.00	.42	.15	.00	.29	.00
1957	.00	.74	.49	.33	.85	.56	.00	.44	.26	.34	.56	.77
1958	.53	.28	.05	.90	.55	1.06	.26	.17	.26	.20	.53	.82
1959	.45	.17	.18	.87	.54	.76	.00	.41	.26	.34	.44	.63
1960	.52	.08	.00	1.21	.77	.46	.00	.20	.20	.34	.56	.62
1961	.74	.20	.50	.29	.61	.86	.20	.39	.26	.34	.42	.81
1962	.89	.17	.00	.39	1.44	.35	.26	.36	.00	.00	.56	1.03
1963	.31	.03	.68	.04	.96	.86	.18	.43	.02	.33	.45	.51
1964	.00	.28	.06	.08	.76	1.24	.31	.42	.00	.24	.38	.74
1965	.52	.40	.51	.03	.75	1.28	.17	.28	.25	.34	.37	.79
1966	.79	.43	.01	.06	.38	.63	.08	.41	.26	.32	.55	.94
1967	.65	.19	.02	.94	1.26	.62	.44	.38	.26	.33	.24	.96
1968	1.06	.32	.00	.66	.65	.03	.02	.32	.23	.28	.55	.84
1969	.12	.67	.02	.19	.39	1.01	.25	.34	.22	.26	.03	.55
1970	.16	.39	.55	.25	1.17	.92	.00	.12	.26	.18	.39	.90
1971	.24	.53	.00	.57	.37	.10	.46	.23	.19	.33	.53	.99
1972	.53	.21	.45	.59	.24	.86	.00	.42	.26	.34	.01	.59
1973	1.02	.04	.61	.04	.55	.88	.01	.39	.09	.25	.47	1.00
1974	.97	.00	.00	.31	.06	.83	.00	.38	.26	.34	.53	.01
1975	.94	.18	.00	.23	.44	.38	.06	.10	.26	.34	.55	.82
1976	.02	.58	.00	.22	1.13	.33	.41	.43	.26	.34	.54	.35
1977	.35	.41	.27	.01	.35	.81	.16	.42	.25	.34	.32	.54
1978	.07	.29	.36	.48	.49	1.08	.29	.37	.25	.12	.08	.38
1979	.98	.57	.13	.04	.75	.97	.39	.43	.26	.34	.53	.36
1980	.83	.33	.00	.06	.58	1.01	.27	.39	.05	.34	.30	.43
1981	.87	.49	.59	.58	1.08	.39	.50	.42	.26	.30	.56	.66
1982	.03	.75	.21	.70	1.18	.64	.38	.25	.22	.25	.35	.99
1983	.51	.00	.00	.00	.83	.05	.29	.43	.17	.22	.17	.77
1984	.24	.58	.59	.33	.00	1.10	.57	.44	.26	.29	.55	.74
1985	.04	.16	.14	.14	.48	.56	.22	.44	.11	.34	.52	.84
1986	.70	.58	.00	.54	.66	.38	.29	.42	.19	.34	.17	.00
1987	.40	.33	.26	.13	.72	.55	.36	.41	.11	.21	.52	.72
1988	.28	.44	.00	.72	.02	.85	.48	.40	.15	.34	.54	1.02
1989	.61	.00	.23	1.02	.77	.62	.00	.41	.26	.33	.37	1.03
1990	.72	.77	.01	.33	.01	.74	.49	.27	.05	.32	.55	.78
1991	.08	.53	.00	.76	.63	.90	.32	.44	.26	.34	.44	.99
1992	.91	.37	.04	1.00	.25	.47	.39	.44	.26	.34	.40	.88
1993	.00	.32	.02	.47	.71	.48	.24	.43	.26	.27	.44	.87
1994	.67	.75	.04	.59	1.18	.43	.38	.33	.26	.34	.55	1.03

Third phase irrigation water use for 2030 – WAG75.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.11	.19	.26	.11	.10	.18	.14	.12	.03	.11	.16	.00
1926	.06	.14	.00	.08	.11	.08	.14	.15	.11	.11	.08	.19
1927	.05	.27	.02	.00	.21	.05	.17	.11	.11	.11	.13	.13
1928	.08	.24	.08	.04	.08	.00	.13	.14	.00	.00	.14	.02
1929	.12	.04	.19	.00	.09	.00	.14	.15	.08	.10	.14	.16
1930	.14	.23	.19	.08	.18	.14	.06	.15	.11	.02	.16	.20
1931	.16	.25	.17	.03	.00	.09	.16	.06	.11	.11	.16	.11
1932	.20	.04	.08	.23	.02	.09	.14	.15	.11	.03	.16	.20
1933	.19	.00	.08	.00	.15	.08	.07	.05	.11	.03	.04	.16
1934	.13	.00	.00	.27	.00	.08	.14	.11	.07	.11	.14	.18
1935	.24	.23	.17	.00	.00	.09	.16	.00	.11	.11	.16	.16
1936	.14	.04	.18	.16	.05	.16	.17	.15	.08	.11	.16	.18
1937	.22	.18	.05	.08	.13	.15	.00	.14	.07	.02	.11	.16
1938	.03	.21	.07	.17	.00	.10	.16	.08	.11	.08	.13	.09
1939	.11	.07	.07	.13	.11	.08	.14	.00	.01	.11	.15	.09
1940	.21	.14	.00	.11	.00	.00	.08	.15	.11	.10	.16	.18
1941	.13	.25	.16	.00	.00	.00	.08	.10	.10	.09	.09	.15
1942	.14	.01	.04	.00	.14	.09	.00	.01	.10	.00	.00	.18
1943	.00	.04	.16	.14	.00	.17	.19	.12	.04	.11	.16	.00
1944	.18	.16	.26	.18	.11	.00	.13	.11	.11	.11	.16	.20
1945	.23	.26	.21	.06	.06	.08	.14	.14	.11	.11	.16	.20
1946	.11	.09	.17	.20	.00	.03	.13	.15	.00	.11	.16	.13
1947	.10	.06	.04	.02	.08	.02	.07	.13	.11	.11	.15	.17
1948	.16	.20	.11	.04	.07	.01	.11	.12	.11	.11	.15	.11
1949	.20	.08	.08	.17	.14	.00	.11	.08	.11	.08	.05	.16
1950	.21	.21	.01	.08	.12	.03	.12	.14	.11	.11	.02	.11
1951	.16	.28	.08	.00	.10	.01	.16	.12	.11	.04	.12	.16
1952	.12	.14	.00	.16	.00	.16	.11	.15	.11	.11	.05	.18
1953	.13	.11	.08	.19	.00	.11	.11	.05	.11	.11	.15	.08
1954	.09	.04	.08	.00	.00	.04	.08	.10	.10	.11	.16	.17
1955	.20	.24	.03	.25	.00	.00	.16	.14	.11	.11	.14	.14
1956	.19	.10	.00	.00	.09	.01	.07	.12	.11	.04	.04	.00
1957	.00	.23	.14	.02	.04	.14	.04	.14	.11	.11	.16	.15
1958	.17	.12	.15	.11	.00	.16	.07	.00	.11	.08	.13	.19
1959	.10	.11	.08	.15	.01	.01	.04	.14	.11	.11	.12	.14
1960	.14	.11	.00	.24	.07	.02	.07	.14	.11	.11	.12	.11
1961	.23	.16	.12	.00	.00	.01	.03	.13	.11	.11	.11	.19
1962	.18	.04	.10	.08	.18	.00	.13	.14	.08	.07	.16	.19
1963	.12	.07	.19	.05	.18	.06	.12	.14	.05	.11	.15	.01
1964	.00	.12	.14	.15	.17	.22	.11	.11	.00	.07	.03	.12
1965	.21	.19	.16	.00	.14	.23	.12	.08	.09	.11	.09	.16
1966	.16	.04	.11	.00	.00	.00	.00	.12	.11	.10	.15	.19
1967	.16	.09	.14	.15	.16	.11	.14	.14	.11	.11	.11	.17
1968	.21	.16	.12	.14	.08	.00	.09	.04	.10	.11	.15	.11
1969	.08	.24	.08	.12	.02	.19	.18	.14	.09	.11	.00	.04
1970	.13	.21	.19	.04	.16	.16	.13	.04	.11	.04	.08	.19
1971	.11	.16	.15	.08	.08	.00	.13	.08	.11	.10	.14	.19
1972	.12	.05	.25	.08	.04	.08	.05	.14	.11	.10	.01	.04
1973	.23	.10	.10	.00	.04	.00	.04	.14	.06	.08	.14	.20
1974	.21	.11	.06	.00	.00	.14	.11	.14	.11	.11	.14	.00
1975	.20	.06	.00	.00	.00	.00	.13	.06	.11	.11	.15	.14
1976	.07	.20	.16	.02	.21	.05	.04	.15	.11	.11	.14	.09
1977	.05	.17	.11	.00	.14	.06	.04	.15	.11	.11	.11	.08
1978	.08	.15	.00	.10	.08	.10	.14	.02	.11	.06	.02	.16
1979	.19	.22	.14	.08	.14	.14	.15	.14	.11	.11	.14	.05
1980	.23	.11	.00	.00	.00	.16	.14	.14	.06	.11	.03	.15
1981	.23	.11	.19	.08	.21	.02	.13	.15	.10	.11	.14	.04
1982	.07	.26	.19	.10	.21	.08	.10	.11	.11	.05	.11	.18
1983	.11	.05	.09	.11	.18	.02	.08	.14	.08	.09	.06	.19
1984	.11	.20	.16	.01	.00	.16	.19	.14	.09	.11	.16	.17
1985	.01	.04	.15	.08	.11	.14	.13	.15	.07	.11	.06	.19
1986	.08	.16	.14	.11	.03	.02	.17	.15	.09	.11	.00	.00
1987	.16	.21	.20	.04	.00	.00	.13	.10	.00	.08	.14	.16
1988	.19	.17	.04	.11	.01	.14	.16	.13	.09	.11	.16	.20
1989	.16	.05	.16	.16	.15	.10	.11	.15	.10	.11	.04	.18
1990	.17	.23	.00	.00	.08	.18	.19	.14	.08	.11	.16	.15
1991	.00	.18	.00	.20	.04	.14	.12	.15	.11	.11	.14	.19
1992	.19	.17	.00	.09	.00	.08	.14	.13	.11	.11	.16	.13
1993	.00	.16	.08	.09	.04	.02	.11	.13	.11	.09	.11	.20
1994	.16	.30	.07	.08	.21	.05	.16	.14	.11	.11	.15	.19

Third phase irrigation water use for 2030 – ZAAID75.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1925	.08	.00	.08	.31	1.06	.63	.57	.00	.00	.81	2.24	1.39
1926	.47	.00	.00	.52	.00	.81	.19	.00	.35	.08	2.23	2.76
1927	.00	.00	.00	1.14	1.10	.31	.00	.00	.35	.81	1.99	1.80
1928	.17	.00	.00	.40	1.53	.00	.16	.00	.00	.50	2.03	.67
1929	.00	.00	.00	.00	1.76	1.57	.02	.00	.30	.52	1.98	2.59
1930	.80	.00	.00	.00	.54	1.25	.00	.00	.35	.41	2.24	2.80
1931	.56	.00	.00	.93	.00	.22	.24	.00	.14	.79	2.24	2.51
1932	.29	.00	.00	1.75	.04	1.10	.00	.00	.23	.46	2.24	2.60
1933	.45	.00	.00	.00	1.37	.88	.11	.00	.30	.14	1.49	2.74
1934	.08	.00	.00	.58	.59	.35	.23	.00	.22	.82	2.22	2.44
1935	.38	.00	.00	.00	1.34	.25	.35	.00	.32	.81	2.24	2.41
1936	.02	.00	.00	.00	.00	1.97	.50	.00	.35	.82	2.24	2.20
1937	.32	.00	.00	.98	1.87	1.42	.00	.00	.00	.59	1.88	2.52
1938	.00	.00	.00	.02	.00	.86	.58	.00	.34	.00	1.66	2.41
1939	.41	.00	.00	.23	1.15	1.41	.05	.00	.00	.80	2.24	2.25
1940	.47	.00	.00	.33	.63	.72	.00	.00	.35	.77	2.22	2.53
1941	.47	.00	.00	.00	1.01	.54	.00	.00	.06	.82	1.82	1.70
1942	.00	.00	.00	.03	.71	.13	.00	.00	.35	.00	.75	2.43
1943	.00	.00	.00	1.10	.00	1.13	.61	.00	.00	.82	2.24	.99
1944	.00	.00	.00	1.32	.70	.00	.34	.00	.35	.82	2.20	2.77
1945	1.07	.00	.20	.00	.66	.00	.50	.00	.35	.81	2.22	2.78
1946	.00	.00	.00	.90	.03	.77	.00	.00	.00	.34	2.22	2.50
1947	.64	.00	.00	.00	1.44	.70	.15	.00	.35	.82	2.24	1.76
1948	.14	.00	.11	.00	.91	.83	.00	.00	.34	.82	2.24	2.12
1949	.00	.00	.00	.70	1.15	.61	.00	.00	.22	.80	1.62	2.58
1950	.04	.00	.00	.94	.70	1.89	.08	.00	.28	.68	1.17	2.57
1951	.00	.00	.00	.00	1.94	1.61	.00	.00	.35	.00	2.24	2.77
1952	.60	.00	.00	.47	.00	.95	.00	.00	.31	.82	1.96	2.51
1953	.73	.00	.00	.94	.19	.31	.13	.00	.18	.77	2.24	1.54
1954	.00	.00	.00	.00	.00	.86	.23	.00	.31	.79	2.19	2.67
1955	.00	.00	.00	1.35	.21	.00	.33	.00	.33	.74	2.24	1.98
1956	.00	.00	.00	.67	.75	.26	.00	.00	.06	.00	1.46	.50
1957	.00	.00	.00	.00	1.48	1.18	.00	.00	.34	.82	2.24	1.85
1958	.10	.00	.00	1.34	1.31	1.42	.00	.00	.35	.72	2.15	2.22
1959	.00	.00	.00	1.09	.75	1.06	.00	.00	.35	.78	1.82	2.17
1960	.00	.00	.00	1.42	1.32	.44	.00	.00	.00	.82	2.24	1.42
1961	.28	.00	.00	.46	1.06	1.61	.19	.00	.35	.82	1.88	2.14
1962	.52	.00	.00	.00	2.05	1.11	.08	.00	.00	.00	2.24	2.84
1963	.00	.00	.12	.00	1.37	1.33	.00	.00	.12	.82	1.93	2.21
1964	.00	.00	.00	.14	1.27	1.98	.00	.00	.00	.67	1.83	2.47
1965	.04	.00	.01	.54	1.18	2.33	.34	.00	.28	.82	1.80	1.66
1966	.04	.00	.00	.00	.43	1.75	.00	.00	.35	.50	2.08	2.58
1967	.00	.00	.00	.88	2.24	.05	.33	.00	.34	.81	1.42	2.74
1968	.70	.00	.00	.00	1.54	.00	.00	.00	.24	.63	2.24	2.18
1969	.00	.00	.00	.56	1.19	1.96	.21	.00	.15	.55	1.47	2.26
1970	.00	.00	.00	.27	1.58	1.16	.00	.00	.34	.71	2.00	2.14
1971	.00	.00	.00	.00	.52	.13	.21	.00	.31	.82	2.16	2.81
1972	.33	.00	.00	.34	.00	.79	.00	.00	.35	.79	.58	1.64
1973	.00	.00	.00	.23	.53	1.01	.00	.00	.10	.48	2.09	2.38
1974	.54	.00	.00	.00	.06	1.57	.00	.00	.35	.81	2.21	1.25
1975	.28	.00	.00	.57	.56	.30	.00	.00	.35	.82	2.21	2.52
1976	.00	.00	.00	.00	.94	.83	.24	.00	.35	.82	2.07	.63
1977	.00	.00	.00	.00	.76	1.56	.00	.00	.35	.80	1.42	1.80
1978	.00	.00	.00	1.61	1.78	1.67	.11	.00	.31	.26	1.01	1.68
1979	.44	.00	.00	.00	.37	2.16	.44	.00	.34	.82	2.18	1.84
1980	.37	.00	.00	.00	.00	1.46	.04	.00	.08	.76	1.60	1.61
1981	.30	.00	.00	.00	2.40	1.70	.47	.00	.33	.67	2.24	2.50
1982	.00	.00	.00	1.22	2.13	1.49	.13	.00	.25	.63	1.64	2.79
1983	.00	.00	.00	.00	1.16	.24	.11	.00	.00	.00	1.07	2.60
1984	.00	.00	.00	.23	.00	1.96	.63	.00	.23	.80	2.24	2.60
1985	.00	.00	.00	.03	.31	.70	.03	.00	.01	.82	2.14	2.51
1986	.11	.00	.00	.74	1.07	1.66	.28	.00	.11	.67	1.20	.04
1987	.00	.00	.00	.00	1.54	.58	.35	.00	.03	.33	2.12	2.29
1988	.00	.00	.00	.00	.00	1.60	.03	.00	.00	.80	2.14	2.83
1989	.00	.00	.00	.47	1.05	.43	.00	.00	.35	.82	1.87	2.78
1990	.19	.00	.00	.00	.16	.16	.65	.00	.00	.82	2.18	2.41
1991	.00	.00	.00	1.52	.23	2.06	.48	.00	.35	.82	1.95	2.76
1992	.38	.00	.00	1.06	.11	.79	.00	.00	.35	.82	2.20	2.35
1993	.00	.00	.00	.00	.94	.00	.06	.00	.35	.82	2.01	2.55
1994	.00	.00	.00	.34	1.39	.73	.00	.00	.31	.77	2.18	2.77

Third phase irrigation water use for 1995 – CHELDPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.15	.06	.13	.19	.23	.17	.13	.08	.00	.10	.16	.01	1.40
1926	.20	.08	.04	.14	.04	.05	.14	.09	.07	.03	.13	.29	1.31
1927	.08	.19	.00	.15	.20	.11	.10	.09	.07	.10	.12	.14	1.35
1928	.20	.19	.03	.15	.31	.00	.15	.09	.00	.02	.15	.00	1.28
1929	.17	.00	.02	.01	.26	.28	.02	.09	.07	.06	.12	.20	1.30
1930	.24	.23	.00	.00	.14	.23	.09	.10	.07	.07	.16	.30	1.64
1931	.23	.13	.12	.14	.04	.08	.12	.01	.07	.09	.16	.24	1.43
1932	.25	.11	.00	.33	.28	.11	.04	.10	.07	.05	.16	.29	1.78
1933	.27	.00	.00	.00	.27	.11	.06	.04	.07	.02	.06	.29	1.20
1934	.18	.02	.00	.16	.05	.07	.04	.08	.06	.10	.15	.22	1.12
1935	.24	.22	.10	.00	.09	.00	.13	.00	.07	.10	.16	.26	1.37
1936	.16	.00	.19	.00	.05	.25	.05	.10	.07	.10	.16	.21	1.34
1937	.27	.20	.00	.16	.20	.27	.01	.08	.00	.05	.11	.25	1.61
1938	.00	.17	.00	.12	.01	.13	.16	.02	.07	.03	.13	.22	1.05
1939	.21	.00	.00	.13	.10	.33	.06	.00	.00	.10	.16	.12	1.22
1940	.25	.03	.00	.14	.08	.09	.00	.10	.07	.09	.16	.24	1.25
1941	.22	.16	.03	.00	.03	.16	.04	.05	.03	.10	.11	.09	1.02
1942	.13	.00	.00	.00	.27	.04	.00	.05	.07	.00	.00	.27	.84
1943	.00	.02	.00	.12	.00	.24	.16	.10	.00	.10	.16	.00	.90
1944	.05	.19	.17	.27	.22	.01	.04	.09	.07	.10	.16	.28	1.65
1945	.33	.25	.24	.03	.17	.01	.14	.09	.07	.10	.16	.28	1.89
1946	.09	.03	.09	.26	.00	.15	.05	.10	.00	.09	.16	.24	1.26
1947	.22	.00	.00	.02	.19	.12	.11	.07	.07	.10	.16	.17	1.24
1948	.08	.12	.11	.00	.05	.13	.00	.09	.07	.10	.16	.20	1.11
1949	.08	.06	.00	.16	.19	.21	.00	.04	.07	.09	.11	.26	1.28
1950	.15	.15	.00	.23	.12	.20	.02	.08	.07	.04	.02	.26	1.33
1951	.11	.24	.00	.04	.35	.23	.05	.08	.07	.00	.16	.28	1.62
1952	.24	.00	.06	.00	.00	.21	.01	.10	.06	.10	.01	.25	1.05
1953	.23	.04	.10	.23	.00	.07	.12	.02	.05	.10	.16	.14	1.25
1954	.06	.00	.15	.02	.02	.17	.07	.09	.07	.10	.16	.28	1.17
1955	.09	.13	.06	.23	.06	.04	.15	.02	.07	.10	.16	.18	1.28
1956	.14	.00	.00	.12	.11	.03	.00	.09	.03	.00	.08	.02	.62
1957	.01	.21	.11	.03	.08	.05	.00	.09	.07	.10	.16	.15	1.06
1958	.11	.07	.00	.21	.04	.22	.05	.03	.07	.07	.16	.22	1.27
1959	.07	.00	.03	.23	.10	.23	.00	.08	.07	.10	.10	.22	1.25
1960	.12	.06	.00	.35	.27	.04	.00	.06	.07	.10	.16	.17	1.39
1961	.23	.05	.07	.05	.06	.24	.08	.10	.07	.10	.10	.22	1.36
1962	.27	.09	.08	.02	.41	.14	.10	.08	.00	.00	.16	.30	1.64
1963	.12	.03	.15	.05	.25	.21	.01	.09	.00	.09	.12	.17	1.30
1964	.00	.06	.00	.05	.11	.36	.05	.09	.00	.07	.11	.22	1.13
1965	.10	.10	.11	.00	.23	.37	.03	.06	.07	.10	.10	.18	1.47
1966	.18	.06	.00	.00	.12	.19	.01	.09	.07	.10	.16	.27	1.25
1967	.22	.04	.02	.26	.39	.13	.08	.08	.07	.10	.06	.28	1.72
1968	.31	.07	.01	.08	.19	.01	.00	.06	.06	.07	.16	.23	1.26
1969	.01	.18	.03	.16	.08	.32	.05	.06	.06	.07	.04	.19	1.25
1970	.05	.13	.15	.00	.24	.20	.00	.00	.07	.06	.10	.22	1.22
1971	.14	.14	.00	.14	.04	.00	.11	.06	.07	.10	.15	.30	1.26
1972	.14	.07	.15	.20	.11	.24	.00	.09	.07	.10	.00	.12	1.29
1973	.25	.01	.06	.05	.03	.20	.00	.09	.03	.07	.14	.27	1.19
1974	.26	.00	.00	.06	.00	.27	.01	.09	.07	.10	.16	.00	1.01
1975	.26	.03	.00	.00	.09	.00	.01	.01	.07	.10	.16	.24	.96
1976	.02	.16	.00	.02	.31	.10	.10	.09	.07	.10	.16	.19	1.32
1977	.14	.21	.00	.00	.11	.11	.02	.10	.07	.10	.07	.14	1.07
1978	.08	.12	.00	.17	.11	.32	.09	.08	.07	.03	.03	.12	1.23
1979	.27	.13	.02	.00	.03	.26	.11	.09	.07	.10	.16	.09	1.32
1980	.21	.12	.01	.13	.09	.34	.09	.09	.03	.10	.08	.12	1.41
1981	.20	.17	.15	.08	.35	.16	.14	.08	.07	.08	.16	.24	1.89
1982	.01	.24	.11	.18	.34	.19	.08	.04	.06	.08	.11	.28	1.73
1983	.06	.00	.00	.01	.25	.01	.07	.09	.04	.06	.03	.25	.88
1984	.00	.15	.08	.00	.00	.33	.17	.09	.07	.09	.16	.23	1.37
1985	.01	.03	.00	.01	.04	.16	.03	.10	.04	.10	.15	.26	.93
1986	.13	.11	.00	.08	.04	.23	.06	.09	.06	.10	.04	.00	.95
1987	.03	.02	.00	.13	.13	.06	.11	.08	.03	.08	.16	.24	1.09
1988	.05	.16	.00	.11	.00	.23	.15	.09	.04	.10	.16	.29	1.39
1989	.14	.00	.00	.26	.17	.03	.04	.09	.07	.09	.13	.30	1.34
1990	.26	.26	.00	.04	.01	.18	.17	.08	.00	.10	.16	.20	1.46
1991	.00	.11	.00	.23	.00	.26	.10	.10	.07	.10	.06	.29	1.33
1992	.23	.12	.08	.31	.00	.25	.10	.10	.07	.10	.12	.24	1.72
1993	.00	.11	.01	.00	.10	.14	.07	.09	.07	.07	.11	.26	1.04
1994	.13	.20	.00	.04	.25	.06	.05	.08	.07	.10	.16	.30	1.45

Third phase irrigation water use for 1995 – KLIPPDA.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.20	.32	.28	.02	.33	.24	.29	.15	.14	.22	.22	.01	
1926	.15	.16	.25	.30	.16	.07	.29	.20	.19	.19	.15	.30	
1927	.14	.36	.19	.35	.31	.17	.28	.18	.19	.22	.19	.14	
1928	.25	.31	.03	.21	.24	.06	.20	.18	.03	.08	.19	.00	
1929	.20	.00	.26	.08	.28	.01	.18	.20	.17	.19	.19	.12	
1930	.31	.28	.10	.13	.27	.27	.22	.20	.19	.15	.22	.31	
1931	.24	.37	.17	.28	.00	.16	.27	.05	.19	.21	.22	.19	
1932	.29	.26	.23	.55	.27	.22	.16	.20	.19	.09	.22	.31	
1933	.36	.00	.00	.03	.28	.09	.01	.09	.19	.19	.03	.30	
1934	.26	.01	.00	.56	.20	.15	.28	.17	.15	.23	.19	.28	
1935	.39	.21	.39	.34	.10	.22	.30	.00	.19	.23	.22	.28	
1936	.25	.00	.21	.26	.01	.30	.23	.20	.19	.22	.22	.28	
1937	.32	.31	.17	.20	.32	.28	.04	.20	.09	.11	.15	.27	
1938	.23	.26	.23	.31	.01	.11	.30	.08	.19	.15	.19	.21	
1939	.24	.05	.24	.43	.29	.14	.21	.06	.01	.23	.21	.17	
1940	.32	.28	.27	.22	.24	.15	.11	.20	.19	.22	.22	.26	
1941	.25	.37	.37	.33	.10	.06	.11	.19	.18	.21	.14	.20	
1942	.32	.00	.09	.06	.38	.12	.00	.00	.19	.06	.00	.29	
1943	.00	.06	.14	.29	.09	.16	.31	.16	.11	.23	.22	.00	
1944	.29	.20	.48	.41	.28	.00	.27	.19	.18	.23	.22	.31	
1945	.41	.35	.40	.35	.11	.17	.22	.19	.19	.22	.21	.31	
1946	.11	.08	.35	.48	.05	.06	.22	.20	.08	.22	.22	.22	
1947	.17	.18	.14	.01	.28	.08	.10	.17	.19	.23	.22	.25	
1948	.23	.31	.18	.28	.15	.12	.15	.20	.19	.23	.17	.25	
1949	.31	.16	.33	.44	.36	.02	.21	.08	.19	.21	.14	.18	
1950	.28	.27	.01	.44	.32	.21	.19	.19	.18	.23	.04	.22	
1951	.27	.43	.26	.00	.26	.13	.22	.18	.19	.09	.18	.25	
1952	.23	.23	.19	.34	.01	.37	.15	.20	.19	.23	.17	.30	
1953	.32	.21	.13	.45	.00	.28	.24	.10	.18	.23	.22	.13	
1954	.14	.00	.26	.02	.07	.27	.24	.15	.19	.23	.22	.30	
1955	.34	.30	.16	.57	.12	.04	.27	.19	.19	.23	.22	.21	
1956	.36	.14	.00	.17	.41	.02	.13	.20	.18	.10	.08	.00	
1957	.00	.30	.34	.23	.17	.30	.01	.20	.19	.23	.22	.19	
1958	.30	.09	.21	.35	.22	.39	.16	.00	.19	.20	.22	.31	
1959	.11	.18	.29	.44	.13	.02	.05	.19	.19	.21	.18	.27	
1960	.26	.19	.15	.51	.31	.15	.11	.14	.18	.23	.20	.18	
1961	.37	.22	.29	.06	.25	.25	.13	.16	.19	.23	.18	.27	
1962	.39	.07	.18	.03	.42	.15	.20	.19	.10	.15	.22	.31	
1963	.19	.15	.48	.17	.41	.12	.14	.20	.11	.22	.18	.12	
1964	.03	.23	.31	.38	.31	.41	.21	.19	.01	.18	.05	.14	
1965	.36	.25	.31	.01	.27	.43	.26	.15	.15	.23	.17	.29	
1966	.32	.17	.10	.00	.12	.05	.00	.12	.19	.21	.21	.30	
1967	.34	.33	.35	.45	.38	.27	.26	.20	.19	.21	.14	.30	
1968	.36	.33	.32	.39	.36	.07	.19	.07	.19	.22	.22	.28	
1969	.07	.34	.22	.32	.21	.39	.28	.15	.16	.22	.01	.10	
1970	.24	.30	.41	.07	.30	.31	.22	.10	.19	.13	.15	.29	
1971	.20	.27	.17	.23	.25	.02	.24	.13	.19	.22	.18	.31	
1972	.25	.15	.42	.39	.16	.28	.05	.20	.19	.22	.01	.15	
1973	.38	.08	.15	.18	.01	.05	.12	.16	.15	.21	.18	.30	
1974	.35	.12	.07	.21	.03	.18	.18	.19	.19	.23	.21	.01	
1975	.37	.05	.05	.05	.10	.00	.14	.06	.19	.23	.20	.19	
1976	.14	.18	.27	.17	.43	.19	.17	.20	.19	.23	.21	.09	
1977	.08	.17	.26	.00	.27	.07	.17	.20	.19	.23	.14	.14	
1978	.06	.28	.00	.47	.00	.25	.21	.14	.19	.14	.01	.24	
1979	.29	.25	.26	.30	.11	.25	.21	.17	.19	.23	.20	.04	
1980	.33	.03	.00	.09	.00	.38	.25	.19	.10	.23	.09	.19	
1981	.34	.18	.33	.18	.43	.20	.29	.20	.19	.20	.21	.23	
1982	.10	.36	.25	.17	.43	.26	.25	.14	.17	.18	.18	.31	
1983	.14	.10	.20	.32	.43	.12	.15	.20	.17	.21	.06	.28	
1984	.23	.39	.42	.08	.01	.40	.32	.19	.18	.22	.22	.28	
1985	.00	.09	.20	.19	.31	.15	.16	.20	.12	.23	.13	.30	
1986	.01	.20	.00	.33	.00	.00	.28	.20	.14	.22	.00	.00	
1987	.30	.21	.23	.32	.05	.05	.23	.19	.08	.11	.22	.25	
1988	.19	.19	.05	.34	.00	.28	.26	.15	.15	.22	.22	.31	
1989	.26	.00	.13	.47	.29	.22	.13	.19	.19	.23	.08	.29	
1990	.30	.43	.10	.03	.13	.25	.31	.20	.15	.23	.22	.26	
1991	.00	.21	.08	.45	.01	.26	.27	.20	.19	.23	.16	.31	
1992	.34	.28	.25	.42	.20	.12	.19	.20	.19	.23	.22	.24	
1993	.00	.19	.07	.21	.05	.14	.19	.19	.19	.19	.17	.31	
1994	.30	.42	.29	.32	.26	.11	.25	.16	.19	.23	.22	.23	

Third phase irrigation water use for 1995 – KLIPPDB.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.92	1.47	1.30	.09	1.50	1.11	1.33	.70	.62	1.02	1.00	.02	
1926	.70	.71	1.15	1.38	.72	.33	1.31	.92	.89	.87	.68	1.37	
1927	.62	1.64	.88	1.61	1.40	.75	1.25	.83	.89	1.00	.87	.65	
1928	1.13	1.43	.15	.94	1.07	.30	.90	.84	.12	.35	.87	.02	
1929	.91	.01	1.20	.37	1.28	.05	.80	.92	.80	.89	.87	.52	
1930	1.42	1.27	.44	.57	1.25	1.23	1.00	.93	.88	.66	1.00	1.43	
1931	1.11	1.67	.77	1.29	.00	.72	1.24	.25	.85	.98	.98	.87	
1932	1.32	1.21	1.02	2.53	1.22	1.00	.74	.92	.89	.39	1.00	1.39	
1933	1.63	.00	.02	.13	1.29	.42	.06	.40	.88	.88	.13	1.38	
1934	1.16	.05	.00	2.54	.89	.67	1.27	.77	.66	1.02	.89	1.29	
1935	1.78	.93	1.78	1.56	.44	1.00	1.39	.00	.89	1.02	1.00	1.30	
1936	1.16	.00	.95	1.17	.05	1.34	1.06	.93	.86	.98	1.00	1.26	
1937	1.44	1.41	.76	.90	1.44	1.29	.17	.93	.39	.52	.69	1.24	
1938	1.06	1.17	1.07	1.41	.03	.50	1.37	.37	.89	.70	.87	.95	
1939	1.08	.21	1.09	1.94	1.32	.66	.95	.28	.03	1.02	.94	.79	
1940	1.46	1.29	1.24	1.00	1.11	.71	.52	.93	.89	1.02	1.00	1.17	
1941	1.14	1.66	1.70	1.51	.43	.29	.50	.88	.81	.98	.62	.90	
1942	1.45	.00	.39	.25	1.74	.52	.00	.02	.86	.26	.00	1.33	
1943	.00	.30	.62	1.32	.42	.75	1.43	.71	.51	1.02	1.00	.02	
1944	1.33	.90	2.21	1.89	1.25	.00	1.21	.87	.80	1.02	1.00	1.43	
1945	1.85	1.61	1.81	1.58	.52	.77	1.02	.88	.89	1.02	.98	1.43	
1946	.49	.36	1.58	2.17	.20	.25	.99	.93	.36	1.01	1.00	1.02	
1947	.75	.84	.66	.05	1.30	.39	.46	.75	.89	1.02	1.00	1.16	
1948	1.05	1.39	.82	1.25	.70	.57	.67	.92	.89	1.02	.75	1.16	
1949	1.41	.73	1.49	2.01	1.66	.09	.97	.35	.89	.97	.65	.81	
1950	1.28	1.23	.05	1.98	1.47	.97	.87	.85	.81	1.02	.16	1.01	
1951	1.22	1.94	1.20	.00	1.21	.59	.99	.82	.85	.43	.83	1.15	
1952	1.02	1.03	.87	1.54	.02	1.66	.70	.91	.89	1.02	.75	1.37	
1953	1.45	.93	.58	2.05	.00	1.27	1.10	.43	.81	1.02	1.00	.61	
1954	.64	.00	1.19	.09	.30	1.25	1.08	.68	.89	1.02	1.00	1.39	
1955	1.54	1.38	.72	2.58	.56	.16	1.25	.85	.89	1.02	1.00	.94	
1956	1.64	.62	.00	.76	1.85	.10	.61	.93	.82	.48	.34	.00	
1957	.02	1.37	1.55	1.06	.76	1.39	.05	.91	.89	1.02	1.00	.86	
1958	1.35	.42	.93	1.62	.99	1.78	.74	.00	.89	.93	1.00	1.40	
1959	.51	.84	1.31	2.02	.58	.08	.21	.88	.89	.98	.83	1.23	
1960	1.17	.89	.66	2.32	1.40	.71	.50	.65	.84	1.02	.93	.83	
1961	1.69	1.01	1.31	.26	1.13	1.13	.57	.74	.89	1.02	.81	1.21	
1962	1.78	.31	.80	.11	1.90	.66	.90	.88	.47	.67	1.00	1.43	
1963	.89	.71	2.19	.75	1.87	.53	.66	.92	.50	.99	.83	.55	
1964	.11	1.07	1.42	1.74	1.43	1.85	.97	.84	.06	.84	.22	.62	
1965	1.62	1.16	1.41	.03	1.21	1.95	1.16	.67	.69	1.02	.80	1.33	
1966	1.46	.75	.43	.00	.53	.21	.02	.54	.89	.93	.98	1.38	
1967	1.54	1.51	1.61	2.03	1.73	1.24	1.21	.90	.89	.96	.66	1.35	
1968	1.64	1.52	1.48	1.76	1.65	.34	.84	.30	.85	1.00	.98	1.25	
1969	.33	1.53	.99	1.45	.95	1.78	1.30	.70	.71	.99	.06	.46	
1970	1.09	1.36	1.86	.30	1.39	1.39	1.02	.48	.89	.60	.70	1.34	
1971	.93	1.21	.79	1.07	1.16	.09	1.08	.57	.85	1.01	.80	1.42	
1972	1.12	.68	1.90	1.79	.73	1.27	.23	.90	.89	1.01	.02	.68	
1973	1.71	.38	.70	.80	.04	.25	.55	.74	.66	.96	.82	1.39	
1974	1.62	.57	.33	.94	.14	.83	.80	.88	.89	1.02	.96	.02	
1975	1.67	.25	.25	.21	.46	.00	.64	.30	.89	1.02	.93	.84	
1976	.63	.83	1.23	.80	1.96	.89	.78	.92	.88	1.02	.97	.39	
1977	.34	.77	1.17	.01	1.24	.31	.80	.89	.89	1.02	.62	.62	
1978	.25	1.28	.02	2.14	.00	1.12	.98	.62	.88	.66	.04	1.11	
1979	1.32	1.12	1.21	1.34	.51	1.14	.98	.78	.89	1.02	.92	.18	
1980	1.49	.11	.01	.40	.00	1.71	1.15	.86	.45	1.02	.42	.86	
1981	1.56	.84	1.48	.82	1.98	.93	1.31	.89	.86	.90	.94	1.05	
1982	.46	1.62	1.14	.76	1.95	1.16	1.13	.66	.79	.83	.83	1.39	
1983	.64	.46	.91	1.48	1.97	.52	.68	.91	.77	.95	.27	1.26	
1984	1.05	1.80	1.90	.34	.03	1.82	1.44	.85	.81	1.02	1.00	1.25	
1985	.02	.42	.91	.89	1.39	.71	.71	.93	.52	1.02	.61	1.36	
1986	.04	.93	.02	1.50	.00	.00	1.28	.93	.63	1.01	.02	.00	
1987	1.35	.93	1.05	1.47	.24	.22	1.02	.89	.35	.52	1.00	1.12	
1988	.84	.84	.24	1.54	.00	1.25	1.16	.66	.71	1.02	.98	1.43	
1989	1.18	.00	.58	2.15	1.33	.98	.60	.85	.89	1.02	.36	1.30	
1990	1.36	1.94	.44	.15	.60	1.13	1.43	.90	.67	1.02	1.00	1.17	
1991	.00	.95	.38	2.03	.05	1.16	1.25	.93	.89	1.02	.71	1.42	
1992	1.56	1.29	1.12	1.93	.92	.53	.87	.89	.89	1.02	.98	1.12	
1993	.01	.88	.32	.94	.24	.65	.88	.88	.89	.88	.78	1.42	
1994	1.39	1.93	1.34	1.46	1.17	.49	1.15	.75	.88	1.02	1.00	1.02	

Third phase irrigation water use for 1995 – LOCHSPD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.68	1.28	1.49	.48	.87	.71	.81	.65	.24	.59	.80	.07	8.66
1926	.44	.92	.47	.56	.75	.52	.92	.77	.56	.54	.42	1.00	7.87
1927	.43	1.45	.31	.46	1.23	.52	.95	.64	.56	.58	.62	.42	8.19
1928	.84	1.33	.78	.35	.67	.32	.78	.66	.18	.00	.69	.04	6.65
1929	.88	.75	1.26	.44	.72	.07	.55	.77	.49	.53	.68	.72	7.85
1930	.94	1.20	1.15	.63	1.09	.84	.54	.76	.56	.36	.80	1.05	9.91
1931	.80	1.45	.94	.64	.17	.66	.76	.30	.51	.59	.80	.72	8.34
1932	1.16	.33	.58	1.30	.16	.25	.68	.77	.53	.25	.79	1.01	7.82
1933	.96	.00	.76	.00	.81	.68	.51	.36	.56	.32	.37	.89	6.21
1934	.71	.13	.36	1.38	.28	.60	.54	.63	.43	.58	.74	.98	7.36
1935	1.24	1.22	1.00	.02	.00	.78	.94	.01	.56	.59	.78	.80	7.96
1936	.90	.43	1.01	1.10	.40	.95	.92	.77	.52	.59	.79	.92	9.29
1937	1.16	.93	.61	.71	.63	1.00	.10	.75	.31	.12	.64	.87	7.83
1938	.58	1.24	.80	.99	.00	.66	.68	.40	.56	.40	.57	.57	7.46
1939	.61	.38	.64	1.00	.56	.52	.83	.00	.11	.57	.78	.54	6.54
1940	1.20	.85	.32	.78	.00	.00	.41	.77	.56	.53	.80	.98	7.19
1941	.78	1.36	1.04	.30	.29	.22	.59	.56	.53	.49	.54	.77	7.46
1942	.93	.22	.51	.00	.81	.48	.00	.22	.51	.00	.00	1.00	4.67
1943	.00	.59	.97	.98	.15	.97	.91	.65	.29	.59	.79	.16	7.06
1944	1.06	1.02	1.43	1.10	.64	.05	.80	.57	.53	.59	.79	1.04	9.61
1945	1.26	1.40	1.15	.61	.64	.57	.78	.71	.56	.58	.78	1.00	10.07
1946	.60	.76	1.08	.99	.00	.39	.69	.77	.04	.55	.80	.65	7.32
1947	.63	.40	.40	.48	.55	.43	.48	.71	.56	.59	.78	.90	6.90
1948	1.04	1.04	.73	.46	.40	.04	.60	.62	.55	.57	.79	.69	7.53
1949	1.00	.70	.60	1.23	.97	.36	.65	.56	.53	.42	.43	.93	8.37
1950	1.05	1.25	.51	.51	.74	.47	.61	.71	.52	.58	.11	.58	7.63
1951	.96	1.55	.47	.00	.68	.48	.87	.68	.56	.28	.66	.88	8.06
1952	.62	.94	.12	1.24	.12	.92	.65	.75	.55	.55	.36	.97	7.81
1953	.90	.57	.80	1.11	.45	.76	.54	.34	.53	.59	.78	.38	7.75
1954	.59	.50	.65	.00	.52	.18	.62	.58	.55	.59	.80	.95	6.50
1955	1.10	1.32	.42	1.40	.26	.00	.90	.73	.56	.56	.74	.69	8.68
1956	1.13	.81	.00	.11	.52	.27	.52	.65	.54	.26	.31	.00	5.11
1957	.08	1.29	.89	.50	.51	.86	.31	.73	.56	.56	.80	.83	7.90
1958	.94	.83	1.09	.80	.18	1.02	.48	.00	.56	.42	.71	.98	8.02
1959	.43	.75	.78	1.03	.46	.27	.45	.73	.56	.54	.64	.75	7.39
1960	.81	.56	.13	1.21	.60	.40	.53	.67	.53	.59	.63	.66	7.32
1961	1.19	1.00	.84	.00	.35	.29	.22	.69	.56	.59	.60	.96	7.28
1962	.96	.39	.76	.63	.99	.22	.67	.72	.41	.32	.79	1.00	7.85
1963	.68	.49	1.12	.37	.96	.53	.68	.73	.31	.55	.77	.25	7.44
1964	.23	.85	1.07	1.12	1.01	1.09	.70	.59	.05	.33	.25	.67	7.96
1965	1.09	1.06	.79	.00	.82	1.23	.61	.53	.50	.59	.55	.89	8.67
1966	.98	.53	.84	.00	.00	.20	.15	.63	.56	.47	.77	1.00	6.12
1967	.97	.62	.82	.89	1.06	.75	.78	.74	.56	.56	.61	.94	9.30
1968	1.14	1.10	.70	1.10	.58	.05	.64	.28	.54	.56	.76	.68	8.11
1969	.54	1.37	.68	.72	.17	1.14	.98	.67	.46	.58	.12	.34	7.78
1970	.81	1.11	1.07	.42	.96	1.03	.67	.34	.55	.29	.47	1.00	8.71
1971	.79	.93	.96	.53	.76	.00	.76	.47	.55	.53	.70	.99	7.97
1972	.81	.45	1.37	.73	.37	.47	.39	.72	.56	.52	.09	.46	6.94
1973	1.27	.68	.69	.00	.73	.57	.30	.72	.32	.47	.66	1.03	7.46
1974	1.16	.74	.33	.07	.09	.81	.55	.63	.56	.59	.75	.00	6.28
1975	1.21	.34	.16	.26	.13	.00	.75	.44	.56	.54	.79	.74	5.93
1976	.60	1.01	.95	.22	1.19	.53	.48	.75	.55	.57	.75	.60	8.19
1977	.20	1.02	.71	.39	.98	.42	.31	.77	.56	.59	.59	.43	6.94
1978	.59	1.06	.09	.56	.72	.70	.71	.41	.56	.37	.28	.87	6.93
1979	1.06	1.29	.91	.77	.96	.93	.80	.71	.56	.59	.75	.47	9.78
1980	1.21	.75	.00	.00	.34	.97	.82	.74	.33	.59	.34	.83	6.92
1981	1.17	.48	1.29	.55	1.07	.55	.83	.75	.50	.55	.76	.80	9.30
1982	.43	1.38	1.07	.82	1.20	.67	.62	.55	.54	.34	.66	.95	9.23
1983	.80	.45	.75	.95	1.17	.52	.35	.76	.40	.52	.31	.95	7.93
1984	.74	1.15	.90	.35	.33	.78	1.01	.73	.50	.59	.79	.93	8.80
1985	.39	.51	.79	.77	.63	.84	.78	.77	.34	.59	.47	.97	7.84
1986	.55	.95	.88	.73	.36	.19	.96	.76	.47	.57	.11	.00	6.51
1987	.88	1.12	1.04	.41	.00	.37	.73	.58	.15	.41	.71	.84	7.25
1988	1.08	1.15	.49	.81	.25	.97	.88	.70	.49	.56	.79	1.04	9.21
1989	.94	.38	.85	1.08	1.04	.73	.55	.75	.51	.59	.44	1.02	8.87
1990	.97	1.49	.18	.00	.78	1.09	.97	.75	.42	.59	.79	.87	8.89
1991	.00	1.02	.00	.99	.43	.60	.58	.77	.56	.58	.69	1.02	7.24
1992	1.04	1.05	.28	.69	.25	.60	.80	.66	.56	.59	.80	.73	8.04
1993	.00	1.02	.65	.67	.45	.34	.66	.66	.56	.49	.61	1.05	7.17
1994	.94	1.56	.61	.67	1.13	.45	.84	.69	.53	.56	.78	.97	9.75

Third phase irrigation water use for 1995 – MANDPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.32	.51	.37	.86	1.05	.00	.59	.13	.11	.33	.43	.34	5.03
1926	.33	.20	.00	.77	1.00	.00	.48	.31	.25	.23	.27	.65	4.49
1927	.45	.49	.00	.15	1.00	.83	.32	.31	.25	.32	.30	.38	4.79
1928	.59	.55	.42	.57	1.08	.00	.50	.31	.00	.20	.38	.27	4.86
1929	.35	.19	.52	.16	1.43	.99	.42	.32	.25	.30	.26	.38	5.57
1930	.57	.20	.00	.68	1.05	1.02	.38	.32	.24	.27	.41	.59	5.73
1931	.64	.25	.00	.62	.00	.16	.30	.04	.18	.31	.41	.55	3.47
1932	.61	.23	.00	.68	1.11	.92	.42	.33	.24	.21	.41	.67	5.84
1933	.64	.00	.00	.00	1.09	.45	.19	.18	.20	.23	.23	.66	3.89
1934	.67	.11	.00	.59	1.01	.84	.28	.15	.00	.31	.38	.68	5.02
1935	.62	.42	.24	.24	.35	.41	.40	.03	.22	.28	.43	.43	4.05
1936	.52	.00	.55	.73	.78	1.01	.47	.33	.19	.29	.38	.58	5.82
1937	.59	.38	.00	.13	.81	1.23	.00	.31	.15	.08	.36	.62	4.66
1938	.37	.28	.00	.52	.65	.60	.36	.18	.24	.17	.35	.30	4.01
1939	.59	.00	.00	.76	1.21	.97	.34	.00	.00	.32	.41	.40	5.01
1940	.70	.00	.00	.94	1.15	1.00	.04	.33	.23	.30	.36	.49	5.55
1941	.66	.29	.36	.52	1.07	.51	.35	.25	.19	.30	.25	.33	5.09
1942	.49	.00	.00	.76	1.02	.85	.00	.26	.18	.01	.07	.66	4.30
1943	.04	.00	.00	1.13	.75	.43	.47	.31	.00	.29	.38	.03	3.84
1944	.52	.27	.28	.75	1.02	.00	.52	.24	.24	.32	.40	.67	5.25
1945	.48	.64	.17	.18	1.12	.96	.43	.29	.25	.32	.42	.61	5.87
1946	.45	.11	.00	.36	.88	.42	.18	.29	.03	.29	.39	.55	3.94
1947	.50	.00	.00	.41	1.04	.52	.25	.28	.24	.32	.39	.64	4.61
1948	.57	.26	.04	.38	.99	.74	.00	.29	.19	.29	.40	.52	4.68
1949	.36	.00	.00	.54	1.10	.49	.38	.28	.23	.32	.28	.62	4.60
1950	.57	.52	.00	.70	1.25	.92	.44	.30	.21	.31	.00	.53	5.76
1951	.36	.65	.00	.38	1.12	.76	.37	.22	.22	.21	.39	.69	5.38
1952	.64	.00	.00	.51	.91	.99	.40	.30	.21	.32	.29	.48	5.07
1953	.61	.05	.00	.34	1.00	.81	.14	.12	.19	.30	.38	.22	4.16
1954	.00	.14	.41	.00	1.03	.47	.16	.27	.20	.32	.41	.50	3.91
1955	.31	.00	.00	1.30	.39	.73	.45	.26	.19	.28	.33	.46	4.71
1956	.59	.05	.00	.48	.94	.69	.06	.28	.21	.24	.36	.00	3.91
1957	.16	.30	.00	.17	.93	1.10	.00	.30	.21	.31	.40	.40	4.28
1958	.70	.05	.03	.42	.98	1.26	.44	.01	.24	.32	.29	.50	5.23
1959	.31	.28	.03	.89	.96	.83	.00	.27	.22	.30	.34	.46	4.89
1960	.52	.00	.00	.32	1.12	.92	.00	.30	.06	.30	.39	.39	4.31
1961	.52	.15	.09	.69	1.14	.65	.33	.29	.25	.32	.20	.66	5.29
1962	.45	.00	.00	.44	1.16	.43	.28	.33	.00	.03	.41	.66	4.19
1963	.55	.14	.39	.00	1.23	1.24	.14	.31	.19	.28	.36	.48	5.31
1964	.27	.42	.03	.95	1.13	1.26	.34	.23	.00	.22	.23	.44	5.53
1965	.47	.29	.02	.19	1.16	1.34	.21	.21	.19	.31	.31	.51	5.21
1966	.59	.26	.00	.00	.91	.25	.09	.31	.21	.22	.41	.63	3.87
1967	.42	.11	.34	.38	1.13	.65	.42	.31	.22	.32	.17	.44	4.89
1968	.59	.30	.00	.89	1.17	.01	.14	.16	.20	.27	.40	.37	4.50
1969	.21	.26	.00	.91	1.11	1.15	.38	.15	.17	.31	.33	.26	5.23
1970	.14	.20	.20	.44	1.05	.72	.21	.00	.25	.15	.25	.42	4.02
1971	.44	.21	.00	.63	.54	.60	.39	.07	.12	.21	.39	.62	4.21
1972	.57	.22	.02	.43	.74	.74	.19	.31	.23	.29	.11	.00	3.84
1973	.49	.16	.00	.00	.70	.95	.30	.22	.18	.27	.40	.70	4.35
1974	.79	.08	.00	.00	.70	1.02	.24	.26	.20	.30	.37	.00	3.96
1975	.65	.20	.00	.00	.87	.00	.06	.19	.25	.28	.33	.51	3.34
1976	.36	.20	.23	.12	.59	.65	.39	.30	.22	.32	.28	.37	4.04
1977	.30	.28	.14	.34	1.06	.52	.06	.32	.19	.29	.26	.39	4.16
1978	.16	.25	.00	.58	1.15	1.01	.37	.25	.23	.22	.27	.49	4.98
1979	.55	.41	.01	.87	1.33	1.16	.41	.29	.24	.31	.33	.00	5.93
1980	.69	.07	.24	.00	.92	1.21	.39	.10	.18	.27	.19	.34	4.60
1981	.64	.00	.39	.22	1.16	.37	.25	.27	.24	.30	.42	.53	4.80
1982	.12	.45	.35	.74	1.29	1.07	.45	.27	.23	.20	.23	.70	6.09
1983	.49	.00	.00	.00	.49	.67	.08	.25	.18	.04	.23	.66	3.11
1984	.43	.23	.19	.19	.30	1.12	.55	.32	.20	.31	.41	.61	4.86
1985	.00	.23	.00	.57	1.17	.63	.29	.33	.15	.31	.35	.56	4.60
1986	.35	.27	.00	.00	1.00	.43	.43	.20	.00	.28	.14	.00	3.10
1987	.48	.05	.00	.64	.30	.37	.50	.22	.13	.24	.26	.51	3.69
1988	.49	.07	.00	.91	.63	1.18	.37	.24	.18	.31	.39	.56	5.34
1989	.45	.00	.00	.97	1.06	.45	.15	.27	.22	.32	.23	.64	4.75
1990	.37	.28	.00	.00	.49	.36	.53	.25	.18	.27	.39	.40	3.53
1991	.39	.59	.19	1.00	1.07	1.18	.28	.33	.24	.32	.38	.61	6.58
1992	.65	.16	.22	.97	1.02	.88	.41	.31	.25	.32	.34	.41	5.93
1993	.00	.40	.00	.29	1.30	.53	.53	.33	.24	.20	.00	.66	4.46
1994	.62	.40	.16	.67	1.31	.56	.15	.11	.01	.27	.38	.64	5.28

Third phase irrigation water use for 1995 – MHLPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.40	.36	.00	.64	1.28	.38	.50	.19	.06	.31	.39	.14	4.65
1926	.00	.00	.26	.65	.80	.40	.55	.25	.24	.18	.30	.61	4.23
1927	.49	.47	.00	.00	1.13	.90	.50	.31	.24	.31	.35	.55	5.25
1928	.57	.48	.47	.45	1.12	.38	.41	.27	.07	.20	.40	.33	5.14
1929	.39	.00	.02	.00	1.05	.90	.18	.32	.23	.30	.32	.38	4.10
1930	.61	.13	.00	.04	1.12	1.04	.31	.32	.24	.29	.41	.69	5.21
1931	.49	.25	.10	.74	.08	.34	.45	.05	.18	.30	.41	.46	3.85
1932	.73	.00	.00	.97	1.03	1.06	.45	.32	.24	.19	.41	.68	6.07
1933	.64	.00	.00	.00	1.16	.57	.01	.19	.22	.22	.20	.66	3.86
1934	.31	.03	.00	.75	.97	.71	.32	.24	.13	.31	.41	.67	4.85
1935	.68	.30	.31	.09	.54	.72	.33	.07	.24	.31	.41	.50	4.49
1936	.49	.00	.40	.63	.68	.82	.49	.32	.22	.31	.40	.61	5.38
1937	.67	.33	.00	.00	.60	.92	.00	.31	.09	.08	.39	.63	4.03
1938	.45	.37	.00	.31	.28	.55	.45	.18	.24	.22	.32	.31	3.68
1939	.54	.00	.00	.61	1.12	.85	.30	.00	.00	.31	.40	.22	4.35
1940	.71	.00	.00	.70	.94	.77	.00	.32	.23	.29	.40	.53	4.90
1941	.55	.42	.00	.23	.73	.52	.36	.27	.19	.30	.29	.44	4.30
1942	.35	.00	.00	.29	.87	.91	.00	.18	.18	.01	.00	.67	3.47
1943	.00	.00	.00	.87	.75	.80	.47	.31	.05	.29	.40	.12	4.07
1944	.40	.34	.00	.49	1.03	.11	.45	.24	.24	.31	.40	.66	4.67
1945	.68	.68	.00	.06	1.20	.71	.43	.29	.24	.31	.41	.60	5.62
1946	.17	.09	.00	.26	.86	.70	.29	.27	.01	.29	.40	.45	3.80
1947	.55	.00	.00	.58	.86	.31	.25	.28	.23	.31	.40	.60	4.38
1948	.44	.27	.00	.00	.71	.54	.07	.30	.22	.26	.40	.58	3.79
1949	.35	.00	.00	.42	1.10	.41	.29	.27	.23	.30	.30	.64	4.32
1950	.55	.37	.00	.60	1.15	.82	.43	.29	.21	.31	.00	.50	5.23
1951	.34	.65	.00	.05	1.02	.73	.33	.24	.21	.19	.39	.70	4.85
1952	.54	.00	.00	.31	.48	.88	.34	.30	.14	.31	.23	.53	4.06
1953	.61	.00	.00	.52	1.00	.83	.23	.09	.20	.30	.38	.27	4.43
1954	.00	.00	.42	.00	.89	.45	.11	.29	.22	.31	.41	.61	3.71
1955	.35	.00	.00	1.27	.27	.87	.46	.26	.22	.30	.35	.45	4.81
1956	.40	.00	.00	.39	1.01	.83	.06	.30	.21	.17	.33	.00	3.69
1957	.00	.24	.12	.33	.84	.98	.00	.31	.23	.31	.40	.54	4.30
1958	.59	.00	.00	.00	.59	1.08	.32	.11	.24	.30	.31	.60	4.16
1959	.31	.29	.00	.52	.83	.66	.01	.30	.24	.29	.37	.48	4.30
1960	.45	.01	.00	.24	.99	.82	.07	.27	.19	.31	.41	.39	4.13
1961	.58	.00	.00	.44	1.14	.48	.26	.28	.24	.30	.24	.69	4.66
1962	.40	.00	.00	.32	1.26	.08	.22	.31	.13	.00	.40	.68	3.80
1963	.53	.00	.51	.00	1.15	1.17	.25	.28	.16	.29	.38	.43	5.16
1964	.30	.34	.00	.90	1.07	1.25	.29	.21	.01	.25	.26	.45	5.35
1965	.50	.12	.00	.00	1.02	1.28	.19	.26	.23	.31	.33	.59	4.83
1966	.55	.00	.00	.00	.59	.27	.14	.29	.22	.23	.40	.60	3.30
1967	.44	.02	.25	.35	1.06	.57	.38	.31	.24	.31	.29	.50	4.70
1968	.62	.30	.00	.59	1.13	.08	.12	.23	.21	.26	.39	.49	4.41
1969	.23	.39	.00	.80	1.03	1.01	.35	.18	.20	.31	.23	.27	5.01
1970	.24	.09	.13	.58	1.07	.86	.10	.00	.24	.17	.21	.61	4.29
1971	.43	.26	.00	.35	.87	.62	.39	.12	.18	.25	.38	.66	4.52
1972	.48	.26	.15	.27	.33	.65	.18	.31	.23	.30	.15	.19	3.50
1973	.60	.17	.00	.00	.99	.70	.32	.25	.13	.28	.39	.69	4.51
1974	.77	.00	.00	.11	.83	1.09	.12	.24	.23	.31	.36	.00	4.08
1975	.69	.00	.00	.00	.71	.20	.25	.22	.24	.31	.35	.57	3.54
1976	.24	.17	.00	.00	.71	.59	.43	.27	.24	.31	.33	.38	3.66
1977	.17	.09	.00	.00	.97	.73	.17	.30	.24	.30	.28	.41	3.66
1978	.06	.30	.00	.39	.93	.99	.28	.27	.24	.24	.25	.40	4.36
1979	.62	.44	.00	.79	1.25	1.16	.38	.28	.24	.31	.36	.35	6.18
1980	.59	.13	.12	.22	1.11	1.19	.44	.22	.16	.30	.30	.39	5.18
1981	.57	.00	.37	.36	1.03	.22	.23	.28	.24	.29	.40	.58	4.57
1982	.01	.28	.13	.66	1.29	.95	.30	.28	.24	.23	.32	.70	5.38
1983	.42	.00	.00	.00	.80	.63	.12	.26	.18	.12	.27	.58	3.38
1984	.38	.24	.28	.24	.39	1.02	.55	.30	.23	.28	.38	.61	4.90
1985	.11	.32	.00	.56	1.05	.62	.27	.30	.17	.31	.37	.58	4.66
1986	.36	.25	.00	.00	1.03	.48	.42	.27	.03	.28	.21	.00	3.33
1987	.47	.07	.00	.53	.72	.59	.41	.29	.16	.18	.32	.46	4.19
1988	.35	.00	.00	.72	.60	1.12	.46	.24	.15	.31	.38	.62	4.93
1989	.54	.00	.00	.82	.99	.62	.23	.28	.24	.31	.21	.62	4.85
1990	.40	.28	.00	.00	.75	.44	.51	.25	.19	.29	.40	.37	3.87
1991	.28	.47	.00	.74	.94	1.03	.38	.32	.24	.30	.37	.64	5.72
1992	.62	.25	.08	.82	1.01	.79	.43	.29	.24	.31	.32	.51	5.68
1993	.00	.42	.00	.49	1.22	.53	.47	.29	.24	.25	.21	.65	4.78
1994	.48	.51	.00	.50	1.31	.71	.30	.14	.01	.29	.37	.67	5.29

Third phase irrigation water use for 1995 – MNGWENPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	1.01	1.95	2.19	.64	1.37	.93	1.19	.96	.37	.84	1.14	.13	12.71
1926	.66	1.38	.83	.83	1.14	.78	1.38	1.10	.81	.78	.60	1.45	11.73
1927	.66	2.09	.47	.81	1.82	.83	1.39	.96	.80	.84	.88	.50	12.06
1928	1.36	1.94	1.24	.51	1.05	.56	1.17	.94	.34	.00	.99	.00	10.10
1929	1.34	1.26	1.90	.81	1.12	.14	.70	1.10	.73	.76	.96	.97	11.80
1930	1.42	1.70	1.69	.98	1.62	1.24	.86	1.09	.80	.60	1.14	1.50	14.64
1931	1.13	2.15	1.35	1.08	.32	1.02	1.04	.41	.73	.84	1.14	1.09	12.31
1932	1.70	.47	.86	1.91	.22	.25	.95	1.10	.76	.37	1.14	1.45	11.20
1933	1.37	.00	1.20	.00	1.16	1.05	.78	.54	.81	.53	.58	1.28	9.29
1934	1.02	.21	.67	1.98	.51	.92	.69	.93	.65	.84	1.08	1.42	10.93
1935	1.79	1.75	1.46	.03	.00	1.22	1.40	.03	.81	.84	1.11	1.15	11.58
1936	1.34	.68	1.46	1.67	.59	1.39	1.33	1.10	.78	.84	1.14	1.31	13.64
1937	1.66	1.31	.98	1.12	.87	1.51	.16	1.09	.44	.17	.94	1.25	11.49
1938	.98	1.83	1.29	1.45	.00	1.00	.91	.58	.81	.57	.79	.86	11.08
1939	.87	.52	1.00	1.54	.79	.77	1.22	.00	.17	.83	1.13	.80	9.64
1940	1.76	1.26	.55	1.17	.00	.00	.59	1.10	.80	.78	1.14	1.42	10.57
1941	1.15	1.98	1.57	.52	.51	.38	.92	.81	.76	.72	.81	1.09	11.21
1942	1.41	.33	.82	.00	1.18	.68	.00	.34	.74	.00	.00	1.47	6.96
1943	.00	.98	1.44	1.49	.27	1.43	1.28	.93	.43	.84	1.13	.30	10.53
1944	1.55	1.52	2.07	1.64	.94	.09	1.19	.81	.76	.84	1.14	1.49	14.04
1945	1.84	2.02	1.66	.97	1.04	.88	1.15	1.03	.81	.84	1.11	1.42	14.78
1946	.84	1.17	1.62	1.39	.00	.63	1.00	1.10	.06	.78	1.14	.93	10.66
1947	.94	.58	.60	.80	.83	.72	.71	1.04	.81	.84	1.11	1.29	10.27
1948	1.55	1.47	1.09	.72	.57	.02	.87	.89	.80	.82	1.14	1.02	10.97
1949	1.40	1.11	.91	1.89	1.50	.66	.96	.85	.75	.61	.67	1.36	12.67
1950	1.48	1.85	.87	.72	1.09	.78	.86	1.02	.75	.82	.14	.83	11.21
1951	1.42	2.25	.64	.00	1.02	.83	1.25	.99	.81	.41	.96	1.29	11.87
1952	.88	1.41	.20	1.93	.23	1.35	.95	1.07	.79	.79	.54	1.41	11.56
1953	1.36	.81	1.26	1.63	.81	1.16	.76	.50	.77	.84	1.12	.53	11.55
1954	.87	.79	1.00	.00	.94	.22	.96	.86	.81	.84	1.14	1.37	9.81
1955	1.60	1.91	.67	2.05	.48	.00	1.31	1.04	.81	.79	1.08	.99	12.73
1956	1.66	1.27	.00	.19	.74	.43	.80	.94	.78	.37	.48	.00	7.65
1957	.10	1.89	1.31	.84	.82	1.26	.46	1.06	.81	.80	1.14	1.20	11.70
1958	1.35	1.25	1.68	1.24	.34	1.53	.72	.00	.80	.62	1.03	1.41	11.98
1959	.56	1.13	1.23	1.57	.78	.44	.72	1.05	.81	.78	.93	1.08	11.08
1960	1.19	.80	.25	1.71	.95	.66	.82	.95	.76	.84	.91	.97	10.80
1961	1.72	1.49	1.27	.00	.61	.47	.32	.99	.81	.84	.88	1.37	10.78
1962	1.38	.60	1.15	.96	1.43	.39	.96	1.04	.59	.44	1.14	1.43	11.53
1963	.97	.74	1.65	.54	1.39	.82	.99	1.04	.46	.79	1.10	.40	10.89
1964	.43	1.28	1.67	1.73	1.49	1.56	1.06	.85	.09	.46	.38	.98	11.97
1965	1.56	1.52	1.10	.01	1.19	1.79	.86	.79	.73	.84	.82	1.30	12.52
1966	1.45	.86	1.28	.00	.00	.37	.27	.91	.80	.67	1.11	1.44	9.15
1967	1.45	.92	1.18	1.29	1.60	1.14	1.15	1.06	.81	.80	.89	1.36	13.65
1968	1.64	1.65	1.01	1.72	.86	.09	.97	.40	.79	.80	1.09	1.00	12.03
1969	.82	2.02	1.04	1.05	.24	1.69	1.42	.95	.65	.84	.21	.53	11.49
1970	1.22	1.58	1.55	.64	1.42	1.54	.96	.52	.79	.42	.69	1.44	12.77
1971	1.20	1.37	1.43	.78	1.20	.00	1.11	.69	.79	.76	1.00	1.43	11.75
1972	1.23	.68	1.99	1.14	.54	.67	.59	1.05	.81	.76	.12	.73	10.31
1973	1.86	1.03	1.04	.00	1.25	1.04	.44	1.03	.46	.69	.93	1.48	11.26
1974	1.69	1.11	.43	.14	.16	1.19	.79	.86	.80	.84	1.08	.00	9.10
1975	1.79	.47	.30	.49	.25	.00	1.11	.68	.81	.76	1.14	1.08	8.86
1976	.93	1.42	1.38	.32	1.74	.84	.79	1.07	.79	.82	1.10	.90	12.09
1977	.22	1.50	1.05	.72	1.50	.62	.47	1.10	.80	.84	.85	.61	10.27
1978	.92	1.61	.17	.81	1.13	1.07	.99	.70	.81	.54	.46	1.27	10.47
1979	1.55	1.90	1.34	1.21	1.46	1.40	1.16	1.02	.81	.84	1.09	.74	14.51
1980	1.76	1.13	.00	.00	.63	1.44	1.21	1.07	.48	.84	.56	1.20	10.32
1981	1.68	.63	1.96	.84	1.53	.94	1.25	1.07	.72	.78	1.10	1.36	13.86
1982	.62	1.98	1.55	1.28	1.77	1.06	.92	.78	.76	.52	.98	1.37	13.60
1983	1.21	.68	1.16	1.50	1.76	.89	.46	1.10	.56	.76	.44	1.36	11.87
1984	1.11	1.68	1.30	.59	.62	1.09	1.46	1.05	.74	.84	1.14	1.35	12.97
1985	.66	.81	1.12	1.23	.92	1.24	1.15	1.10	.48	.84	.73	1.39	11.69
1986	.84	1.38	1.31	1.09	.58	.27	1.39	1.08	.68	.82	.20	.00	9.62
1987	1.27	1.60	1.48	.63	.00	.66	1.07	.86	.25	.60	1.02	1.22	10.67
1988	1.58	1.74	.79	1.22	.40	1.47	1.28	1.02	.72	.80	1.14	1.49	13.64
1989	1.39	.55	1.20	1.64	1.59	1.12	.79	1.08	.73	.84	.70	1.49	13.12
1990	1.40	2.25	.34	.00	1.25	1.61	1.38	1.08	.60	.84	1.14	1.28	13.19
1991	.00	1.48	.00	1.39	.68	.81	.80	1.10	.81	.83	1.00	1.46	10.37
1992	1.51	1.55	.51	1.05	.44	.90	1.16	.96	.81	.84	1.14	1.06	11.92
1993	.00	1.50	1.00	1.03	.71	.56	.97	.95	.80	.71	.89	1.50	10.62
1994	1.38	2.24	.95	1.03	1.64	.71	1.22	.99	.77	.80	1.12	1.39	14.25

Third phase irrigation water use for 1995 – MUNGUPDB.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.17	.24	.46	.03	.29	.19	.30	.17	.08	.17	.24	.02	
1926	.20	.21	.30	.29	.03	.10	.32	.22	.17	.12	.15	.33	
1927	.19	.35	.16	.18	.25	.12	.29	.17	.17	.17	.22	.22	
1928	.27	.40	.31	.22	.25	.05	.25	.20	.05	.09	.23	.05	
1929	.33	.08	.25	.08	.15	.21	.25	.22	.16	.15	.18	.24	
1930	.30	.40	.19	.03	.17	.21	.28	.22	.17	.13	.24	.34	
1931	.29	.33	.30	.21	.00	.17	.32	.05	.14	.17	.24	.26	
1932	.37	.30	.25	.41	.19	.15	.27	.22	.17	.09	.24	.33	
1933	.38	.02	.16	.01	.23	.16	.27	.11	.14	.08	.10	.33	
1934	.23	.24	.06	.30	.20	.14	.16	.21	.14	.17	.24	.29	
1935	.37	.40	.36	.11	.01	.09	.32	.00	.17	.17	.24	.30	
1936	.24	.03	.40	.15	.04	.20	.30	.22	.16	.17	.24	.27	
1937	.37	.36	.12	.20	.12	.26	.21	.22	.02	.07	.21	.27	
1938	.07	.32	.08	.24	.02	.26	.30	.08	.17	.08	.21	.19	
1939	.31	.00	.21	.23	.24	.22	.26	.00	.08	.17	.24	.19	
1940	.30	.19	.13	.26	.13	.22	.05	.22	.17	.15	.24	.30	
1941	.31	.38	.17	.11	.08	.11	.24	.18	.14	.17	.17	.22	
1942	.27	.01	.21	.00	.21	.21	.02	.02	.17	.00	.00	.32	
1943	.00	.07	.21	.30	.01	.30	.33	.22	.02	.17	.24	.02	
1944	.31	.36	.33	.33	.23	.01	.27	.20	.17	.17	.24	.33	
1945	.40	.43	.46	.21	.30	.14	.31	.21	.17	.17	.24	.31	
1946	.13	.05	.36	.37	.01	.18	.27	.22	.04	.17	.24	.25	
1947	.27	.10	.26	.17	.29	.16	.24	.20	.17	.17	.24	.27	
1948	.19	.28	.33	.07	.13	.21	.15	.21	.16	.17	.24	.26	
1949	.22	.30	.13	.33	.21	.21	.20	.13	.16	.17	.17	.33	
1950	.27	.27	.19	.36	.29	.20	.22	.19	.16	.14	.02	.27	
1951	.29	.46	.13	.05	.31	.18	.20	.15	.17	.05	.24	.33	
1952	.30	.19	.37	.17	.00	.24	.17	.22	.15	.17	.07	.31	
1953	.36	.08	.36	.33	.00	.16	.27	.07	.15	.17	.24	.17	
1954	.08	.00	.35	.00	.08	.25	.26	.22	.17	.17	.24	.33	
1955	.21	.25	.31	.42	.13	.13	.34	.11	.17	.17	.24	.23	
1956	.27	.09	.01	.08	.22	.17	.22	.22	.11	.00	.13	.00	
1957	.06	.37	.39	.20	.14	.15	.02	.22	.17	.17	.24	.24	
1958	.26	.17	.21	.32	.08	.30	.23	.06	.17	.14	.23	.30	
1959	.17	.21	.36	.20	.18	.19	.12	.21	.17	.17	.17	.27	
1960	.24	.15	.13	.41	.21	.07	.14	.13	.15	.17	.24	.22	
1961	.33	.21	.35	.03	.11	.28	.19	.21	.17	.17	.16	.27	
1962	.36	.21	.17	.19	.35	.04	.25	.20	.07	.00	.24	.34	
1963	.24	.24	.40	.08	.28	.21	.21	.22	.07	.17	.22	.17	
1964	.08	.25	.27	.11	.20	.36	.26	.21	.02	.13	.18	.24	
1965	.27	.28	.37	.01	.27	.38	.18	.16	.16	.17	.17	.29	
1966	.32	.27	.23	.01	.16	.01	.14	.21	.17	.17	.24	.31	
1967	.32	.20	.31	.40	.31	.18	.30	.21	.17	.17	.12	.33	
1968	.37	.27	.27	.26	.11	.00	.17	.17	.16	.13	.24	.31	
1969	.11	.40	.26	.21	.08	.32	.26	.17	.14	.15	.05	.22	
1970	.21	.27	.43	.08	.29	.17	.19	.05	.17	.10	.14	.31	
1971	.19	.31	.14	.04	.09	.05	.31	.16	.14	.17	.21	.32	
1972	.27	.23	.41	.25	.00	.29	.11	.22	.17	.17	.04	.17	
1973	.35	.05	.36	.00	.12	.22	.14	.21	.10	.15	.21	.34	
1974	.36	.15	.17	.15	.02	.25	.16	.20	.17	.17	.23	.00	
1975	.36	.16	.19	.02	.04	.02	.18	.11	.17	.17	.22	.27	
1976	.10	.30	.24	.09	.30	.04	.21	.20	.17	.17	.24	.17	
1977	.12	.30	.29	.00	.17	.14	.20	.22	.17	.17	.16	.15	
1978	.04	.27	.34	.24	.02	.31	.28	.18	.17	.03	.08	.14	
1979	.34	.29	.30	.15	.14	.19	.28	.21	.17	.17	.24	.11	
1980	.27	.20	.15	.06	.05	.33	.24	.21	.05	.17	.14	.18	
1981	.33	.26	.40	.22	.36	.11	.31	.21	.16	.14	.24	.21	
1982	.02	.34	.38	.21	.34	.21	.27	.15	.15	.14	.17	.33	
1983	.21	.06	.15	.01	.28	.09	.17	.22	.12	.14	.09	.27	
1984	.15	.36	.30	.02	.00	.34	.34	.21	.17	.17	.24	.28	
1985	.02	.15	.19	.05	.10	.17	.22	.22	.08	.17	.22	.31	
1986	.28	.34	.14	.23	.07	.01	.27	.22	.15	.17	.07	.00	
1987	.21	.20	.29	.16	.04	.16	.24	.22	.08	.05	.24	.23	
1988	.15	.29	.12	.21	.00	.24	.28	.21	.13	.17	.24	.34	
1989	.27	.00	.21	.33	.24	.23	.14	.21	.17	.17	.14	.34	
1990	.28	.39	.12	.13	.02	.24	.33	.19	.11	.17	.24	.27	
1991	.07	.31	.10	.30	.09	.25	.19	.22	.17	.17	.20	.33	
1992	.36	.27	.33	.30	.11	.14	.27	.22	.17	.17	.20	.27	
1993	.00	.21	.15	.17	.14	.09	.25	.22	.17	.14	.14	.32	
1994	.33	.39	.28	.20	.33	.17	.27	.14	.17	.17	.24	.32	

Third phase irrigation water use for 1995 – NONPD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.14	.24	.33	.11	.43	.30	.27	.12	.10	.26	.41	.10	2.81
1926	.10	.13	.11	.41	.16	.20	.29	.18	.19	.21	.31	.50	2.79
1927	.13	.28	.09	.36	.40	.23	.26	.16	.19	.25	.38	.34	3.05
1928	.21	.31	.14	.30	.32	.07	.18	.16	.01	.10	.38	.09	2.27
1929	.29	.05	.17	.13	.28	.16	.18	.18	.17	.23	.34	.36	2.53
1930	.28	.30	.07	.10	.33	.33	.22	.18	.18	.20	.41	.52	3.12
1931	.23	.31	.12	.36	.00	.23	.24	.05	.16	.25	.41	.39	2.74
1932	.38	.20	.16	.66	.32	.27	.17	.18	.18	.13	.41	.51	3.58
1933	.38	.03	.05	.01	.30	.25	.15	.09	.16	.15	.20	.51	2.28
1934	.19	.11	.01	.59	.30	.21	.11	.16	.15	.26	.40	.48	2.95
1935	.39	.31	.35	.21	.07	.26	.27	.00	.19	.25	.41	.48	3.19
1936	.24	.02	.22	.30	.16	.32	.24	.18	.18	.25	.41	.47	2.99
1937	.36	.30	.04	.36	.22	.38	.10	.18	.01	.11	.36	.42	2.84
1938	.11	.26	.11	.41	.15	.35	.27	.07	.19	.15	.36	.37	2.82
1939	.28	.01	.16	.47	.46	.33	.22	.02	.04	.26	.41	.29	2.94
1940	.29	.19	.05	.41	.23	.19	.03	.18	.19	.23	.41	.48	2.88
1941	.31	.32	.16	.26	.07	.06	.14	.16	.16	.25	.31	.41	2.61
1942	.23	.02	.04	.10	.25	.26	.00	.01	.18	.02	.00	.49	1.62
1943	.00	.03	.05	.42	.08	.41	.31	.17	.04	.26	.41	.09	2.27
1944	.33	.22	.32	.53	.37	.02	.26	.16	.18	.26	.41	.51	3.56
1945	.43	.31	.33	.36	.35	.27	.26	.16	.19	.25	.41	.49	3.80
1946	.04	.06	.28	.61	.12	.14	.18	.18	.01	.25	.41	.37	2.64
1947	.23	.04	.08	.17	.40	.19	.11	.17	.19	.26	.41	.45	2.69
1948	.19	.21	.17	.18	.23	.18	.04	.16	.18	.24	.41	.41	2.60
1949	.25	.18	.12	.63	.41	.28	.07	.12	.18	.24	.33	.49	3.30
1950	.24	.17	.03	.52	.36	.26	.14	.17	.16	.25	.07	.40	2.77
1951	.24	.36	.09	.01	.43	.16	.17	.14	.18	.10	.38	.49	2.73
1952	.24	.18	.16	.38	.08	.33	.14	.18	.17	.26	.24	.50	2.86
1953	.33	.14	.21	.49	.07	.24	.16	.05	.17	.25	.41	.30	2.82
1954	.03	.01	.18	.04	.10	.37	.21	.16	.19	.26	.41	.50	2.45
1955	.24	.22	.12	.68	.13	.10	.29	.14	.19	.25	.41	.39	3.14
1956	.33	.08	.00	.10	.41	.23	.07	.18	.16	.04	.28	.00	1.90
1957	.01	.26	.32	.32	.30	.25	.00	.18	.19	.25	.41	.39	2.90
1958	.25	.13	.09	.43	.12	.46	.14	.02	.19	.21	.40	.50	2.94
1959	.05	.18	.25	.40	.23	.22	.01	.18	.19	.25	.35	.45	2.74
1960	.17	.17	.05	.59	.29	.15	.01	.13	.17	.25	.40	.36	2.73
1961	.36	.19	.22	.09	.14	.33	.09	.17	.19	.26	.32	.46	2.80
1962	.36	.13	.00	.27	.42	.02	.18	.17	.09	.07	.41	.52	2.64
1963	.20	.12	.37	.25	.49	.25	.10	.18	.07	.25	.38	.33	2.97
1964	.07	.20	.20	.27	.24	.51	.19	.16	.01	.19	.27	.35	2.66
1965	.28	.19	.31	.05	.36	.56	.14	.12	.16	.26	.31	.46	3.20
1966	.29	.14	.10	.06	.29	.05	.03	.13	.18	.23	.41	.51	2.42
1967	.31	.22	.20	.53	.45	.34	.26	.18	.19	.25	.29	.49	3.71
1968	.41	.25	.27	.38	.30	.00	.09	.09	.17	.23	.40	.47	3.05
1969	.05	.34	.06	.46	.24	.49	.24	.15	.15	.24	.15	.29	2.86
1970	.21	.22	.32	.19	.42	.37	.15	.06	.18	.15	.32	.47	3.05
1971	.13	.19	.06	.27	.32	.10	.23	.12	.17	.25	.35	.52	2.70
1972	.23	.08	.34	.41	.13	.43	.02	.18	.19	.25	.10	.32	2.68
1973	.38	.10	.23	.25	.16	.10	.13	.18	.12	.23	.38	.52	2.79
1974	.39	.15	.00	.19	.17	.40	.09	.18	.19	.25	.40	.07	2.47
1975	.40	.09	.12	.16	.12	.01	.13	.08	.19	.26	.40	.41	2.35
1976	.14	.19	.13	.21	.42	.20	.14	.18	.18	.25	.40	.29	2.74
1977	.07	.17	.23	.02	.44	.11	.10	.18	.19	.26	.32	.29	2.36
1978	.04	.20	.10	.46	.08	.38	.19	.13	.18	.14	.18	.36	2.44
1979	.29	.24	.19	.37	.35	.39	.18	.16	.19	.26	.41	.20	3.23
1980	.33	.12	.03	.13	.17	.48	.20	.18	.11	.25	.27	.38	2.63
1981	.37	.18	.28	.25	.52	.32	.28	.18	.16	.21	.41	.40	3.59
1982	.02	.27	.13	.27	.56	.30	.21	.13	.17	.19	.34	.50	3.10
1983	.22	.14	.00	.30	.52	.22	.05	.18	.16	.23	.27	.45	2.74
1984	.14	.32	.32	.07	.09	.48	.31	.16	.15	.26	.41	.48	3.19
1985	.02	.21	.16	.17	.37	.16	.13	.18	.07	.26	.35	.50	2.57
1986	.06	.24	.02	.25	.05	.05	.27	.18	.12	.26	.07	.00	1.57
1987	.26	.22	.10	.21	.17	.16	.15	.17	.06	.07	.41	.40	2.40
1988	.09	.27	.03	.46	.06	.40	.27	.14	.15	.25	.40	.52	3.03
1989	.25	.01	.03	.50	.38	.27	.07	.17	.18	.26	.23	.52	2.89
1990	.28	.34	.02	.11	.18	.40	.29	.16	.12	.26	.41	.39	2.95
1991	.01	.22	.05	.40	.16	.34	.24	.18	.19	.26	.35	.49	2.89
1992	.38	.19	.09	.50	.20	.14	.20	.18	.19	.26	.39	.38	3.09
1993	.00	.17	.02	.21	.31	.08	.19	.16	.19	.22	.31	.51	2.37
1994	.33	.30	.25	.07	.44	.14	.24	.16	.18	.26	.40	.40	3.17

Third phase irrigation water use for 1995 – RORKPDB.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.57	.40	.33	.86	.93	.62	.46	.32	.00	.32	.51	.18	
1926	.51	.28	.25	.66	.03	.22	.49	.40	.24	.08	.45	.92	
1927	.36	.73	.00	.64	.98	.60	.44	.40	.24	.32	.40	.49	
1928	.58	.66	.20	.46	.98	.00	.36	.41	.00	.15	.50	.04	
1929	.58	.01	.25	.38	.86	.81	.08	.41	.23	.21	.40	.61	
1930	.68	.74	.00	.00	.61	.88	.35	.42	.24	.23	.51	.96	
1931	.74	.58	.75	.71	.00	.16	.44	.05	.21	.31	.51	.81	
1932	.85	.47	.00	1.11	.83	.54	.26	.42	.23	.06	.50	.92	
1933	.74	.00	.00	.01	.75	.43	.31	.20	.24	.06	.20	.90	
1934	.70	.06	.00	.75	.63	.60	.05	.35	.21	.31	.48	.75	
1935	.84	.67	.04	.00	.11	.03	.47	.00	.24	.31	.51	.83	
1936	.53	.00	.63	.00	.27	.62	.30	.42	.23	.32	.51	.72	
1937	.88	.65	.00	.37	.43	.68	.10	.42	.00	.08	.44	.83	
1938	.01	.64	.00	.42	.23	.51	.47	.14	.24	.12	.45	.64	
1939	.67	.00	.02	.71	.68	.85	.03	.00	.00	.31	.50	.50	
1940	.45	.19	.00	.48	.43	.51	.00	.42	.24	.30	.51	.73	
1941	.72	.49	.10	.00	.29	.50	.47	.32	.12	.32	.38	.38	
1942	.45	.00	.00	.04	.94	.84	.00	.10	.21	.00	.00	.85	
1943	.00	.05	.00	.52	.01	.79	.47	.41	.00	.32	.51	.02	
1944	.48	.74	.34	.88	.76	.00	.17	.38	.24	.32	.51	.90	
1945	.99	.79	.75	.41	1.01	.32	.41	.41	.24	.32	.51	.90	
1946	.20	.09	.32	.97	.03	.62	.29	.42	.01	.30	.48	.73	
1947	.60	.00	.00	.28	.40	.44	.26	.35	.24	.30	.51	.66	
1948	.24	.42	.29	.01	.47	.41	.04	.41	.23	.31	.51	.66	
1949	.30	.45	.00	.79	.82	.66	.01	.16	.22	.31	.36	.90	
1950	.57	.36	.00	.86	.86	.47	.28	.31	.23	.28	.08	.72	
1951	.54	.83	.00	.45	1.18	.71	.13	.35	.23	.10	.51	.90	
1952	.92	.12	.21	.29	.00	.70	.03	.41	.20	.32	.20	.86	
1953	.92	.14	.45	.86	.01	.53	.30	.06	.20	.32	.51	.40	
1954	.20	.00	.58	.00	.06	.68	.31	.38	.24	.32	.50	.91	
1955	.46	.25	.29	.99	.00	.56	.51	.08	.24	.32	.51	.61	
1956	.42	.00	.00	.30	.66	.29	.00	.40	.14	.00	.25	.00	
1957	.00	.68	.44	.27	.78	.49	.00	.41	.24	.32	.51	.71	
1958	.49	.27	.05	.84	.49	.97	.23	.16	.24	.18	.49	.77	
1959	.43	.15	.16	.78	.49	.70	.00	.40	.24	.31	.42	.59	
1960	.49	.08	.00	1.11	.73	.40	.00	.18	.19	.32	.51	.58	
1961	.69	.18	.47	.27	.56	.78	.17	.36	.24	.32	.40	.76	
1962	.84	.17	.00	.35	1.33	.31	.23	.34	.00	.00	.51	.96	
1963	.29	.01	.62	.02	.88	.79	.15	.40	.01	.31	.42	.44	
1964	.00	.24	.05	.06	.69	1.14	.28	.40	.00	.22	.36	.69	
1965	.48	.38	.47	.01	.69	1.18	.16	.26	.23	.32	.34	.75	
1966	.74	.38	.00	.06	.34	.58	.05	.38	.24	.31	.51	.87	
1967	.61	.18	.01	.88	1.15	.57	.40	.35	.24	.31	.23	.89	
1968	.98	.30	.00	.61	.57	.01	.01	.29	.21	.26	.51	.79	
1969	.12	.62	.01	.14	.34	.93	.22	.32	.21	.24	.01	.51	
1970	.14	.35	.51	.21	1.08	.84	.00	.11	.24	.16	.36	.84	
1971	.21	.49	.00	.53	.34	.06	.42	.21	.17	.31	.49	.92	
1972	.47	.18	.42	.52	.22	.80	.00	.40	.24	.32	.01	.55	
1973	.95	.02	.58	.01	.49	.83	.00	.37	.08	.23	.43	.93	
1974	.91	.00	.00	.29	.04	.76	.00	.36	.24	.32	.49	.01	
1975	.87	.16	.00	.20	.39	.36	.05	.08	.24	.32	.51	.76	
1976	.01	.54	.00	.20	1.05	.29	.37	.40	.24	.32	.50	.31	
1977	.31	.39	.27	.01	.31	.73	.16	.39	.23	.31	.29	.51	
1978	.05	.27	.32	.43	.43	.99	.27	.35	.23	.10	.08	.35	
1979	.91	.53	.10	.03	.70	.89	.36	.40	.24	.32	.49	.32	
1980	.76	.32	.00	.06	.53	.96	.25	.37	.05	.31	.27	.40	
1981	.80	.44	.55	.55	.99	.34	.47	.40	.24	.28	.51	.60	
1982	.01	.69	.18	.64	1.09	.59	.36	.25	.21	.23	.32	.92	
1983	.47	.00	.00	.00	.75	.01	.28	.41	.16	.21	.15	.71	
1984	.21	.53	.55	.28	.00	1.01	.52	.41	.24	.26	.51	.68	
1985	.04	.14	.13	.13	.44	.51	.20	.42	.10	.32	.48	.78	
1986	.64	.55	.00	.51	.59	.33	.27	.39	.18	.32	.16	.00	
1987	.38	.31	.24	.11	.64	.48	.33	.38	.10	.20	.49	.66	
1988	.26	.41	.00	.67	.01	.78	.45	.38	.14	.32	.51	.94	
1989	.58	.00	.22	.95	.71	.57	.00	.39	.24	.31	.34	.95	
1990	.66	.71	.00	.32	.00	.68	.45	.25	.04	.30	.51	.72	
1991	.07	.47	.00	.70	.58	.82	.29	.42	.24	.32	.41	.92	
1992	.84	.33	.03	.93	.22	.41	.36	.42	.24	.32	.37	.81	
1993	.00	.29	.00	.43	.68	.44	.22	.40	.24	.24	.41	.80	
1994	.63	.70	.03	.55	1.09	.38	.35	.31	.23	.31	.51	.95	

Third phase irrigation water use for 1995 – THDRIEPD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.13	.00	.00	.03	.10	.01	.12	.10	.06	.22	.41	.04	1.22
1926	.01	.00	.00	.00	.08	.00	.04	.12	.14	.16	.34	.43	1.32
1927	.00	.03	.00	.04	.11	.00	.12	.08	.16	.22	.38	.38	1.52
1928	.16	.00	.00	.05	.02	.00	.02	.07	.00	.05	.40	.00	.76
1929	.14	.00	.00	.05	.11	.00	.11	.08	.08	.15	.31	.32	1.35
1930	.17	.06	.00	.00	.14	.00	.00	.12	.15	.07	.42	.44	1.58
1931	.16	.03	.00	.12	.00	.00	.11	.07	.12	.21	.41	.38	1.61
1932	.19	.00	.00	.11	.17	.11	.03	.12	.15	.11	.41	.44	1.84
1933	.21	.00	.00	.00	.09	.00	.00	.03	.15	.12	.20	.40	1.19
1934	.00	.00	.00	.19	.00	.00	.14	.11	.09	.21	.39	.39	1.52
1935	.24	.00	.00	.03	.06	.00	.12	.00	.15	.22	.42	.39	1.62
1936	.05	.00	.00	.00	.00	.09	.12	.13	.15	.22	.41	.40	1.56
1937	.16	.00	.00	.00	.14	.14	.00	.13	.06	.08	.30	.36	1.38
1938	.00	.00	.00	.00	.00	.00	.17	.05	.16	.09	.36	.32	1.15
1939	.00	.00	.00	.10	.09	.00	.08	.00	.02	.22	.40	.24	1.14
1940	.22	.00	.00	.00	.02	.11	.00	.13	.16	.20	.41	.39	1.64
1941	.10	.03	.00	.03	.05	.00	.00	.11	.11	.23	.27	.32	1.23
1942	.04	.00	.00	.00	.16	.00	.00	.01	.15	.00	.01	.43	.81
1943	.00	.00	.00	.02	.00	.07	.16	.10	.00	.23	.41	.07	1.07
1944	.13	.00	.00	.12	.15	.00	.06	.12	.14	.23	.41	.44	1.79
1945	.25	.01	.00	.00	.03	.00	.10	.12	.16	.23	.41	.45	1.76
1946	.00	.00	.00	.17	.00	.00	.07	.12	.08	.22	.40	.34	1.39
1947	.00	.00	.00	.00	.10	.00	.00	.10	.16	.23	.41	.39	1.39
1948	.12	.00	.00	.04	.09	.00	.00	.10	.14	.23	.36	.33	1.41
1949	.16	.00	.00	.10	.09	.00	.08	.06	.13	.19	.29	.37	1.46
1950	.13	.00	.00	.17	.07	.05	.06	.12	.13	.22	.24	.30	1.50
1951	.11	.06	.00	.00	.01	.00	.08	.12	.15	.05	.37	.37	1.31
1952	.04	.00	.00	.06	.00	.13	.01	.12	.16	.23	.37	.42	1.54
1953	.13	.00	.00	.07	.00	.00	.12	.03	.13	.23	.41	.25	1.38
1954	.07	.00	.00	.00	.00	.00	.07	.09	.14	.23	.42	.42	1.43
1955	.18	.00	.00	.20	.00	.00	.15	.10	.16	.22	.41	.34	1.77
1956	.17	.00	.00	.00	.09	.00	.00	.11	.13	.09	.24	.00	.84
1957	.00	.00	.00	.00	.09	.02	.00	.12	.16	.23	.42	.29	1.32
1958	.16	.00	.00	.08	.07	.12	.00	.00	.15	.18	.41	.44	1.60
1959	.00	.00	.00	.10	.02	.00	.00	.12	.16	.21	.37	.37	1.35
1960	.13	.00	.00	.14	.17	.00	.00	.09	.15	.22	.41	.30	1.61
1961	.23	.00	.00	.00	.07	.06	.00	.10	.16	.23	.37	.39	1.60
1962	.24	.00	.00	.00	.16	.00	.07	.12	.04	.15	.42	.45	1.66
1963	.02	.00	.01	.00	.18	.00	.04	.12	.06	.22	.37	.23	1.25
1964	.00	.00	.00	.10	.19	.23	.01	.11	.00	.19	.18	.29	1.31
1965	.19	.00	.00	.00	.11	.25	.12	.10	.13	.23	.36	.39	1.89
1966	.14	.00	.00	.00	.02	.00	.00	.11	.15	.21	.41	.43	1.47
1967	.16	.00	.00	.13	.19	.05	.10	.11	.15	.22	.31	.41	1.83
1968	.22	.00	.00	.13	.09	.00	.00	.06	.12	.21	.41	.35	1.58
1969	.00	.00	.00	.08	.08	.12	.12	.11	.12	.22	.21	.20	1.27
1970	.09	.00	.00	.00	.08	.02	.03	.06	.14	.11	.31	.43	1.26
1971	.04	.00	.00	.05	.05	.00	.08	.07	.15	.23	.37	.43	1.44
1972	.08	.00	.00	.13	.00	.04	.00	.12	.16	.21	.19	.23	1.16
1973	.20	.00	.00	.00	.00	.00	.00	.10	.06	.19	.38	.44	1.38
1974	.21	.00	.00	.00	.00	.00	.02	.12	.16	.23	.41	.02	1.16
1975	.19	.00	.00	.00	.00	.00	.00	.04	.16	.23	.40	.27	1.29
1976	.00	.00	.00	.04	.12	.00	.00	.12	.16	.23	.40	.21	1.27
1977	.00	.00	.00	.00	.03	.00	.00	.12	.15	.23	.31	.29	1.12
1978	.00	.00	.00	.12	.00	.00	.08	.07	.16	.14	.13	.38	1.08
1979	.09	.00	.00	.02	.00	.00	.09	.11	.16	.23	.38	.15	1.22
1980	.21	.00	.00	.00	.00	.20	.10	.11	.08	.23	.19	.33	1.44
1981	.21	.00	.00	.04	.16	.00	.00	.12	.15	.19	.41	.34	1.64
1982	.01	.00	.00	.06	.18	.13	.09	.10	.15	.06	.37	.41	1.54
1983	.00	.00	.00	.06	.11	.00	.00	.12	.12	.20	.25	.40	1.27
1984	.09	.03	.00	.00	.00	.19	.17	.12	.15	.23	.41	.40	1.79
1985	.00	.00	.00	.00	.13	.00	.00	.13	.11	.23	.29	.41	1.29
1986	.00	.00	.00	.11	.00	.00	.15	.13	.13	.22	.15	.00	.88
1987	.13	.00	.00	.07	.00	.00	.07	.10	.03	.14	.38	.36	1.30
1988	.07	.00	.00	.03	.00	.00	.05	.09	.11	.22	.41	.45	1.43
1989	.13	.00	.00	.11	.12	.03	.01	.11	.15	.22	.30	.44	1.61
1990	.14	.05	.00	.00	.04	.00	.19	.12	.11	.23	.41	.38	1.68
1991	.00	.00	.00	.14	.00	.00	.10	.13	.16	.23	.35	.43	1.52
1992	.15	.00	.00	.09	.00	.00	.05	.12	.16	.23	.39	.38	1.56
1993	.00	.00	.00	.00	.00	.00	.01	.13	.15	.20	.37	.44	1.30
1994	.13	.06	.00	.03	.12	.00	.03	.11	.15	.22	.41	.34	1.60

Third phase irrigation water use for 1995 – THLTUGPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	2.37	1.82	1.78	.47	1.85	1.39	2.41	1.55	1.19	2.29	2.45	.48	20.05
1926	1.65	.83	1.33	1.56	1.07	.45	2.14	1.95	1.84	1.94	1.77	3.16	19.68
1927	1.36	2.47	.99	2.01	1.77	.94	2.40	1.52	1.90	2.23	2.19	2.30	22.09
1928	2.69	1.85	.22	1.35	1.25	.46	1.82	1.41	.39	.85	2.25	.14	14.68
1929	2.45	.22	1.54	.80	1.68	.00	1.98	1.71	1.65	2.05	2.04	1.97	18.09
1930	2.78	2.12	.86	.77	1.72	1.41	1.61	1.97	1.86	1.18	2.47	3.29	22.05
1931	2.65	2.41	1.39	1.86	.00	.78	2.43	.92	1.79	2.20	2.42	2.34	21.19
1932	2.86	1.44	1.38	3.10	1.74	1.49	1.59	1.94	1.86	1.12	2.46	3.23	24.21
1933	3.25	.00	.00	.24	1.63	.48	.01	.77	1.88	1.74	.75	2.97	13.73
1934	2.24	.00	.00	3.30	.98	.86	2.50	1.60	1.41	2.24	2.22	2.94	20.27
1935	3.69	1.31	2.19	1.96	.74	1.18	2.44	.00	1.84	2.27	2.47	3.00	23.10
1936	2.22	.00	1.40	1.38	.03	1.75	2.02	2.00	1.81	2.24	2.46	2.94	20.26
1937	3.01	1.94	1.05	1.14	1.94	1.80	.18	1.99	1.05	1.21	1.67	2.84	19.82
1938	1.42	1.51	1.35	1.66	.00	.58	2.63	.88	1.90	1.46	2.11	2.33	17.84
1939	1.97	.31	1.36	2.49	1.63	.84	1.75	.32	.41	2.27	2.31	1.96	17.63
1940	3.16	1.61	1.69	1.23	1.33	1.26	1.10	2.00	1.90	2.22	2.45	2.84	22.79
1941	2.57	2.44	2.31	1.90	.70	.36	.92	1.84	1.71	2.21	1.60	2.17	20.73
1942	2.61	.00	.54	.52	2.27	.65	.00	.08	1.87	.48	.08	3.15	12.25
1943	.00	.36	.97	1.68	.55	1.05	2.76	1.57	.77	2.30	2.46	.46	14.92
1944	2.74	1.26	2.87	2.44	1.71	.00	2.10	1.83	1.71	2.29	2.45	3.28	24.68
1945	3.68	2.24	2.43	1.92	.67	.85	1.94	1.86	1.90	2.28	2.43	3.32	25.54
1946	1.44	.54	2.19	2.82	.28	.33	1.84	1.93	1.05	2.28	2.36	2.56	19.63
1947	1.63	1.13	.88	.10	1.62	.42	1.04	1.59	1.90	2.29	2.46	2.83	17.89
1948	2.56	1.83	1.23	1.73	1.03	.71	1.26	1.82	1.86	2.29	2.01	2.58	20.90
1949	3.03	.98	1.97	2.51	1.99	.00	1.90	.80	1.82	2.08	1.54	2.30	20.95
1950	2.83	1.67	.00	2.65	1.78	1.30	1.75	1.85	1.74	2.28	.96	2.42	21.23
1951	2.60	2.89	1.68	.08	1.33	.84	1.95	1.80	1.82	1.13	2.08	2.67	20.86
1952	2.23	1.40	.96	2.00	.00	2.11	1.44	1.93	1.87	2.30	1.88	3.12	21.25
1953	2.69	1.24	.96	2.54	.00	1.57	2.17	.81	1.78	2.29	2.47	1.82	20.33
1954	1.81	.04	1.60	.20	.40	1.49	1.86	1.30	1.77	2.28	2.47	3.14	18.36
1955	3.23	1.78	.91	3.33	.65	.24	2.32	1.82	1.90	2.27	2.38	2.46	23.29
1956	3.19	.80	.00	1.09	2.21	.16	1.03	1.84	1.73	1.36	1.08	.00	14.49
1957	.47	1.85	2.03	1.16	1.06	1.75	.30	1.89	1.88	2.30	2.47	2.25	19.42
1958	2.89	.57	1.26	2.11	1.33	2.19	1.41	.03	1.88	1.93	2.38	3.26	21.23
1959	1.49	1.09	1.72	2.61	.74	.00	.55	1.90	1.90	2.21	2.12	2.77	19.09
1960	2.64	1.18	.96	2.94	1.91	.87	.86	1.53	1.82	2.28	2.37	2.19	21.55
1961	3.50	1.32	1.73	.46	1.48	1.43	1.01	1.56	1.90	2.29	2.05	2.95	21.69
1962	3.51	.42	1.15	.18	2.40	.89	1.82	1.90	1.07	1.72	2.47	3.30	20.83
1963	1.68	.86	2.86	.92	2.40	.64	1.34	1.97	1.16	2.25	2.17	1.39	19.65
1964	.15	1.30	1.77	2.38	2.07	2.70	1.52	1.76	.13	1.96	.72	1.92	18.39
1965	3.25	1.48	1.90	.14	1.58	2.82	2.24	1.52	1.60	2.30	2.03	2.95	23.80
1966	2.86	1.01	.58	.00	.62	.35	.05	1.41	1.87	2.14	2.41	3.17	16.46
1967	3.07	1.97	2.17	2.61	2.27	1.53	2.11	1.82	1.88	2.20	1.79	3.02	26.41
1968	3.39	1.88	1.82	2.42	2.03	.44	1.47	.81	1.75	2.21	2.38	2.60	23.19
1969	.97	1.96	1.26	1.93	1.24	2.20	2.36	1.68	1.63	2.25	.56	1.27	19.31
1970	2.26	1.76	2.47	.54	1.66	1.69	1.70	.99	1.86	1.43	1.66	3.11	21.12
1971	1.99	1.59	1.18	1.50	1.41	.17	1.86	1.12	1.84	2.25	2.14	3.18	20.23
1972	2.36	1.00	2.51	2.41	.91	1.55	.62	1.92	1.88	2.20	.72	1.64	19.72
1973	3.35	.53	.92	.87	.12	.35	.64	1.74	1.26	2.07	2.15	3.25	17.25
1974	3.19	.63	.51	1.20	.22	.90	1.47	1.91	1.89	2.29	2.38	.25	16.86
1975	3.25	.37	.31	.38	.55	.00	1.14	.67	1.90	2.29	2.36	1.98	15.19
1976	1.17	1.12	1.66	1.22	2.38	1.11	1.24	1.95	1.89	2.29	2.31	1.38	19.72
1977	.84	1.04	1.52	.04	1.38	.52	1.24	1.92	1.86	2.30	1.71	1.99	16.35
1978	.63	1.75	.00	2.73	.00	1.34	1.88	1.12	1.89	1.61	.54	2.71	16.20
1979	2.53	1.37	1.53	1.70	.60	1.36	1.68	1.73	1.90	2.29	2.19	.93	19.82
1980	3.16	.36	.05	.49	.00	2.32	2.08	1.79	1.17	2.30	.93	2.32	16.96
1981	3.26	.96	1.87	1.22	2.47	1.16	1.77	1.91	1.79	2.05	2.38	2.40	23.24
1982	1.43	2.18	1.73	1.22	2.46	1.59	1.92	1.48	1.76	1.31	2.10	3.08	22.26
1983	1.24	.56	1.28	1.94	2.34	.56	1.40	1.93	1.62	2.09	1.09	3.01	19.06
1984	2.35	2.38	2.49	.57	.00	2.47	2.72	1.90	1.79	2.29	2.45	2.93	24.34
1985	.00	.50	1.14	1.17	1.81	.97	1.13	1.99	1.35	2.30	1.41	3.07	16.85
1986	.44	1.15	.12	2.09	.00	.08	2.51	1.99	1.47	2.23	.41	.00	12.48
1987	2.66	1.10	1.50	1.98	.30	.26	1.75	1.65	.78	1.39	2.32	2.67	18.37
1988	2.09	1.02	.42	1.93	.00	1.53	1.96	1.43	1.51	2.26	2.46	3.31	19.91
1989	2.55	.00	.97	2.71	1.72	1.29	1.23	1.82	1.83	2.28	1.31	3.12	20.83
1990	2.75	2.70	.63	.25	.85	1.36	2.79	1.94	1.50	2.29	2.43	2.75	22.25
1991	.06	1.25	.66	2.67	.02	1.39	2.25	1.99	1.90	2.30	1.96	3.22	19.69
1992	2.96	1.71	1.51	2.45	1.02	.71	1.72	1.91	1.90	2.29	2.35	2.78	23.30
1993	.45	1.18	.58	1.25	.31	.88	1.75	1.94	1.88	2.03	2.00	3.25	17.50
1994	2.74	2.91	1.87	1.92	1.53	.61	1.88	1.65	1.86	2.28	2.46	2.46	24.18

Third phase irrigation water use for 1995 – THSKDSPD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.22	.39	.31	.01	.37	.28	.31	.16	.13	.15	.14	.00	2.46
1926	.18	.25	.29	.23	.24	.14	.30	.20	.18	.12	.09	.22	2.45
1927	.17	.41	.25	.27	.36	.22	.29	.18	.18	.15	.12	.09	2.69
1928	.26	.37	.11	.15	.30	.15	.23	.18	.04	.03	.12	.00	1.95
1929	.21	.12	.30	.06	.34	.01	.21	.20	.16	.13	.12	.07	1.92
1930	.31	.34	.17	.10	.33	.30	.25	.20	.18	.09	.14	.23	2.63
1931	.25	.42	.22	.22	.00	.21	.29	.08	.17	.14	.14	.13	2.28
1932	.28	.34	.27	.43	.33	.27	.20	.20	.18	.04	.14	.22	2.88
1933	.34	.00	.05	.02	.34	.16	.02	.11	.18	.13	.00	.22	1.56
1934	.26	.00	.00	.44	.26	.20	.31	.17	.14	.15	.12	.20	2.25
1935	.37	.28	.40	.27	.20	.27	.32	.00	.18	.15	.14	.20	2.77
1936	.26	.11	.25	.21	.11	.33	.26	.20	.17	.14	.14	.20	2.36
1937	.31	.37	.23	.14	.37	.31	.10	.20	.10	.06	.08	.20	2.47
1938	.25	.33	.29	.23	.00	.17	.31	.10	.18	.10	.12	.15	2.23
1939	.25	.17	.28	.33	.34	.20	.24	.09	.02	.15	.13	.12	2.32
1940	.32	.36	.32	.16	.31	.21	.17	.20	.18	.15	.14	.18	2.68
1941	.25	.41	.40	.26	.19	.14	.16	.19	.16	.14	.08	.13	2.52
1942	.32	.00	.16	.04	.42	.18	.00	.00	.17	.02	.00	.21	1.52
1943	.00	.18	.20	.22	.19	.21	.32	.16	.12	.15	.14	.00	1.88
1944	.29	.28	.48	.32	.33	.01	.29	.19	.16	.15	.14	.23	2.86
1945	.38	.40	.40	.28	.19	.23	.25	.19	.18	.15	.14	.23	3.01
1946	.15	.19	.37	.36	.15	.13	.25	.20	.09	.15	.14	.16	2.34
1947	.19	.28	.20	.00	.33	.15	.15	.17	.18	.15	.14	.18	2.12
1948	.24	.37	.22	.22	.23	.19	.20	.20	.18	.15	.09	.18	2.48
1949	.31	.25	.36	.34	.40	.00	.25	.10	.18	.14	.08	.11	2.52
1950	.28	.34	.02	.33	.37	.26	.23	.19	.16	.15	.00	.16	2.49
1951	.27	.47	.30	.00	.32	.19	.25	.18	.17	.05	.11	.18	2.49
1952	.24	.31	.23	.26	.06	.38	.20	.20	.18	.15	.10	.22	2.52
1953	.31	.29	.18	.35	.08	.32	.27	.12	.16	.15	.14	.09	2.45
1954	.18	.11	.30	.01	.17	.30	.26	.15	.18	.15	.14	.22	2.17
1955	.33	.37	.21	.44	.21	.12	.29	.19	.18	.15	.14	.14	2.78
1956	.35	.24	.00	.13	.44	.10	.18	.20	.16	.06	.02	.00	1.88
1957	.06	.36	.36	.18	.24	.34	.09	.19	.18	.15	.14	.13	2.41
1958	.30	.20	.26	.27	.29	.40	.20	.00	.18	.13	.14	.22	2.59
1959	.15	.27	.31	.35	.21	.07	.11	.19	.18	.14	.11	.19	2.30
1960	.27	.28	.21	.39	.36	.22	.17	.15	.17	.15	.13	.12	2.62
1961	.35	.30	.32	.04	.32	.28	.18	.16	.18	.15	.11	.19	2.59
1962	.37	.17	.23	.01	.44	.21	.23	.19	.10	.10	.14	.23	2.43
1963	.21	.24	.47	.12	.44	.18	.19	.20	.11	.14	.11	.07	2.48
1964	.08	.30	.34	.31	.37	.41	.25	.19	.03	.12	.00	.08	2.48
1965	.34	.32	.33	.00	.32	.42	.29	.15	.14	.15	.11	.21	2.79
1966	.31	.25	.17	.00	.19	.13	.08	.13	.18	.13	.14	.22	1.92
1967	.33	.39	.38	.34	.41	.30	.28	.19	.18	.14	.08	.21	3.24
1968	.34	.39	.34	.31	.41	.15	.23	.09	.17	.15	.14	.20	2.91
1969	.12	.39	.27	.24	.27	.39	.30	.16	.15	.15	.00	.06	2.49
1970	.25	.36	.42	.05	.35	.33	.26	.12	.18	.08	.09	.21	2.69
1971	.22	.34	.23	.18	.32	.11	.26	.14	.17	.15	.11	.23	2.44
1972	.25	.25	.42	.31	.25	.30	.12	.19	.18	.15	.00	.10	2.51
1973	.36	.19	.21	.13	.12	.13	.17	.16	.14	.14	.11	.22	2.07
1974	.34	.22	.14	.16	.14	.22	.22	.19	.18	.15	.13	.00	2.09
1975	.35	.17	.13	.03	.20	.06	.19	.09	.18	.15	.13	.12	1.78
1976	.17	.27	.31	.13	.46	.25	.22	.20	.18	.15	.13	.05	2.51
1977	.12	.26	.29	.00	.32	.15	.22	.19	.18	.15	.08	.09	2.03
1978	.11	.35	.02	.36	.05	.28	.25	.15	.18	.09	.00	.18	2.01
1979	.29	.32	.30	.23	.19	.28	.24	.17	.18	.15	.13	.01	2.49
1980	.32	.14	.05	.06	.00	.39	.28	.19	.10	.15	.04	.13	1.83
1981	.33	.27	.35	.13	.45	.25	.30	.19	.17	.13	.13	.16	2.87
1982	.14	.41	.29	.13	.45	.29	.27	.15	.16	.12	.11	.22	2.74
1983	.17	.20	.26	.25	.45	.18	.20	.20	.16	.14	.02	.20	2.41
1984	.24	.44	.42	.06	.03	.40	.33	.19	.17	.15	.14	.20	2.75
1985	.05	.19	.25	.15	.35	.21	.20	.20	.12	.15	.07	.22	2.15
1986	.07	.28	.08	.26	.06	.03	.30	.20	.13	.15	.00	.00	1.55
1987	.29	.28	.28	.25	.15	.13	.26	.19	.08	.06	.14	.18	2.30
1988	.21	.27	.13	.26	.00	.31	.28	.15	.14	.15	.14	.23	2.26
1989	.26	.03	.19	.37	.34	.26	.18	.19	.18	.15	.03	.20	2.38
1990	.30	.47	.17	.02	.22	.28	.33	.19	.14	.15	.14	.18	2.58
1991	.06	.29	.15	.35	.07	.29	.29	.20	.18	.15	.09	.23	2.34
1992	.33	.35	.29	.33	.28	.18	.23	.19	.18	.15	.14	.18	2.81
1993	.06	.28	.14	.16	.15	.21	.23	.19	.18	.12	.10	.22	2.04
1994	.30	.46	.32	.26	.31	.18	.27	.17	.17	.15	.14	.16	2.89

Third phase irrigation water use for 1995 – THSKOPPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	2.12	2.46	4.62	.00	4.36	2.45	3.40	2.21	1.68	2.32	2.32	.38	28.31
1926	3.00	2.69	3.82	2.45	1.27	.08	2.90	2.53	2.33	1.43	1.72	3.11	27.33
1927	.00	5.07	2.37	3.27	3.96	.07	3.30	2.62	2.33	2.31	2.07	2.04	29.39
1928	3.23	4.83	2.89	2.82	.56	.00	.92	1.90	.81	1.05	2.14	.00	21.14
1929	2.26	.81	.00	.39	4.00	3.16	1.49	2.01	2.28	1.94	1.97	2.34	22.66
1930	3.79	4.59	4.34	.00	3.58	2.61	2.22	2.62	2.33	1.39	2.35	3.12	32.93
1931	2.70	4.53	5.49	4.49	.12	.97	3.10	.92	1.89	1.92	2.33	2.66	31.14
1932	4.03	2.56	3.10	4.45	4.45	3.13	2.14	2.56	2.27	1.45	2.35	3.13	35.61
1933	4.05	.00	1.79	.00	3.37	2.44	1.25	.61	2.33	.97	.13	3.00	19.94
1934	1.22	2.00	.00	4.45	3.06	2.48	3.02	2.43	1.83	2.32	2.02	2.71	27.55
1935	3.70	4.81	3.84	3.69	1.53	1.21	3.33	.00	2.26	2.32	2.35	2.43	31.47
1936	2.18	.00	4.59	.00	1.12	3.80	2.94	2.62	2.33	2.26	2.34	2.59	26.76
1937	3.20	4.63	2.22	1.01	3.40	4.34	.27	2.60	.78	.86	1.55	2.13	27.00
1938	.54	3.67	2.26	1.12	.00	.63	3.18	1.58	1.84	1.34	1.73	1.79	19.67
1939	1.41	.02	2.11	3.77	4.20	3.36	2.79	.00	.87	2.32	2.15	1.08	24.06
1940	4.04	2.25	2.26	.03	1.79	3.62	1.30	2.62	2.24	1.93	2.35	2.90	27.33
1941	2.38	4.25	4.81	2.51	1.14	1.28	.83	2.30	1.72	2.32	.85	2.31	26.69
1942	1.41	.00	1.25	2.25	4.85	1.39	.00	1.15	1.58	.33	.00	2.67	16.89
1943	.00	.28	1.83	1.87	.00	3.48	3.61	1.99	.00	2.32	2.33	.00	17.70
1944	1.28	2.64	5.49	4.04	2.55	.00	3.07	2.45	2.24	2.32	2.32	3.01	31.41
1945	3.87	4.76	6.08	1.81	2.02	.74	3.05	2.17	2.33	2.27	2.35	3.19	34.63
1946	.39	1.06	4.76	4.86	.88	.71	2.46	2.62	1.59	2.15	2.31	1.53	25.34
1947	1.40	1.00	2.53	1.00	3.24	.00	2.08	2.15	2.33	2.31	2.29	2.43	22.76
1948	2.18	3.88	4.31	2.61	2.91	1.55	1.78	2.02	2.13	2.31	2.34	1.11	29.13
1949	2.55	2.24	2.98	2.51	2.88	.00	2.61	1.29	2.09	2.02	1.30	2.75	25.22
1950	2.01	4.02	.06	4.02	3.30	2.33	2.07	2.22	1.96	2.22	.49	1.21	25.92
1951	2.24	5.28	3.07	.23	.71	2.20	2.50	2.38	2.32	.57	2.07	2.41	25.99
1952	1.95	3.43	2.50	2.10	.00	2.94	1.68	2.17	2.33	2.32	1.60	2.97	25.98
1953	2.96	2.34	3.67	3.66	.09	2.17	3.09	1.39	1.86	2.27	2.34	1.01	26.86
1954	1.45	1.05	4.31	.05	.62	2.73	3.18	2.03	2.33	2.32	2.33	3.03	25.42
1955	3.39	2.41	2.29	4.63	.75	.00	3.35	1.60	2.33	2.32	2.35	2.16	27.59
1956	3.23	2.00	.00	.87	2.42	1.12	2.19	2.43	2.05	.38	.70	.00	17.40
1957	.00	4.29	3.31	.00	3.53	1.99	1.00	2.49	2.33	2.32	2.35	.96	24.56
1958	2.96	1.49	1.33	2.72	1.75	3.07	2.05	.00	2.33	1.94	2.31	3.05	24.99
1959	.12	2.00	3.94	3.61	1.76	1.78	.86	2.54	2.33	2.18	1.70	2.40	25.21
1960	2.02	3.17	.75	4.35	4.48	.32	1.18	1.59	2.22	2.29	2.34	1.54	26.26
1961	3.88	2.13	3.37	.03	2.34	3.22	1.62	2.57	2.33	2.32	1.93	2.67	28.41
1962	3.89	2.37	2.56	.00	5.17	1.83	2.90	2.53	.97	1.53	2.35	3.15	29.25
1963	2.71	3.27	4.98	.18	4.51	1.97	2.51	2.62	.89	2.29	1.80	.93	28.66
1964	.03	2.68	1.13	2.63	4.22	4.77	1.66	2.28	.68	2.16	.02	1.56	23.81
1965	3.79	2.43	4.98	.11	2.85	4.79	3.37	2.28	2.08	2.32	1.77	2.61	33.37
1966	3.40	2.86	.00	.00	.75	2.48	1.38	2.42	2.33	2.32	2.35	3.11	23.38
1967	3.23	4.25	3.01	4.36	4.63	3.40	3.48	2.37	2.33	2.32	1.08	2.92	37.38
1968	3.79	3.96	4.25	3.87	2.35	1.04	2.33	1.05	2.02	2.27	2.28	2.52	31.73
1969	.26	4.39	3.33	2.22	3.04	4.32	3.60	2.44	1.77	2.24	.40	.87	28.88
1970	1.91	4.22	4.88	.16	2.39	2.48	2.00	.98	2.12	1.34	1.79	3.05	27.32
1971	1.88	3.43	2.33	3.69	1.77	.07	3.11	2.02	2.19	2.32	1.91	3.20	27.92
1972	2.50	2.94	5.58	3.93	.00	4.05	1.09	2.62	2.33	2.27	.00	.51	27.81
1973	4.19	2.05	2.40	2.23	.00	.91	1.46	2.62	1.27	2.22	2.07	3.18	24.60
1974	4.20	.44	3.14	1.34	.00	3.03	1.35	2.39	2.33	2.32	2.35	.01	22.89
1975	3.73	2.69	1.00	.11	2.36	.00	2.69	1.29	2.33	2.32	2.24	2.11	22.87
1976	.07	2.26	3.31	3.10	4.33	2.22	2.86	2.62	2.33	2.31	2.24	1.19	28.84
1977	.05	3.13	3.94	.00	2.50	1.91	2.42	2.60	2.32	2.26	1.51	1.49	24.13
1978	.06	3.72	1.51	3.39	2.36	2.40	2.72	1.90	2.33	1.15	.00	2.54	24.07
1979	1.12	1.86	4.06	2.43	.22	.62	3.51	2.34	2.33	2.32	2.28	.35	23.44
1980	4.04	2.10	1.40	.00	.00	3.53	2.98	2.48	1.85	2.27	.47	2.03	23.14
1981	3.95	2.70	2.89	1.75	5.88	2.33	1.67	2.51	2.26	2.13	2.32	2.96	33.34
1982	1.45	3.24	5.43	4.25	4.40	3.86	3.02	2.14	2.33	1.90	1.80	2.92	36.71
1983	.99	.16	2.96	1.97	4.32	.04	1.16	2.61	1.96	2.12	.67	2.42	21.39
1984	1.93	4.76	4.74	1.28	.00	4.21	3.73	2.62	2.33	2.32	2.35	2.82	33.09
1985	.06	1.23	2.13	.70	4.28	2.42	2.27	2.62	1.95	2.32	1.14	2.68	23.80
1986	.77	3.16	3.66	1.77	1.08	.75	3.57	2.62	2.19	2.22	.13	.00	21.92
1987	3.25	2.24	1.71	3.07	1.95	1.20	3.49	2.62	1.14	1.52	2.21	2.41	26.81
1988	1.87	2.82	1.26	1.57	.00	1.78	3.14	2.22	2.11	2.22	2.32	3.17	24.48
1989	2.86	.12	3.85	3.85	2.88	1.79	1.53	2.48	2.28	2.04	.70	3.20	27.60
1990	3.54	5.47	2.06	.00	2.46	3.54	3.77	2.59	1.94	2.32	2.35	2.60	32.63
1991	.00	1.82	3.69	3.99	3.28	1.74	3.20	2.62	2.33	2.32	1.54	3.20	29.71
1992	3.66	1.98	4.53	3.24	.00	1.02	3.09	2.62	2.33	2.32	2.04	2.76	29.58
1993	.00	2.89	2.51	1.08	.56	.81	1.66	2.62	2.33	2.09	1.98	3.16	21.68
1994	2.91	5.68	4.89	.87	3.89	1.06	2.25	2.48	2.25	2.32	2.25	2.63	33.49

Third phase irrigation water use for 1995 – THWOODPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.41	.00	.24	.00	.14	.00	.48	.38	.30	.44	.62	.12	3.13
1926	.52	.00	.17	.03	.00	.00	.39	.44	.39	.25	.50	.72	3.41
1927	.00	.17	.01	.11	.07	.00	.39	.38	.39	.44	.59	.57	3.13
1928	.38	.00	.13	.00	.14	.00	.24	.37	.00	.14	.57	.00	1.97
1929	.52	.00	.11	.00	.15	.00	.25	.41	.36	.43	.56	.60	3.38
1930	.47	.05	.08	.00	.09	.00	.16	.44	.39	.15	.62	.72	3.16
1931	.51	.00	.31	.14	.00	.00	.47	.24	.33	.44	.62	.57	3.64
1932	.54	.00	.16	.17	.06	.00	.34	.41	.35	.37	.62	.71	3.74
1933	.63	.00	.00	.00	.00	.00	.28	.17	.39	.08	.26	.72	2.53
1934	.21	.00	.00	.18	.00	.00	.29	.37	.35	.44	.59	.62	3.05
1935	.58	.00	.24	.18	.00	.00	.42	.02	.39	.44	.62	.65	3.55
1936	.33	.00	.16	.00	.00	.05	.46	.44	.39	.44	.61	.63	3.50
1937	.51	.09	.05	.09	.01	.15	.00	.43	.08	.23	.34	.60	2.60
1938	.11	.00	.00	.03	.00	.00	.43	.27	.39	.23	.45	.52	2.44
1939	.22	.00	.11	.25	.00	.02	.20	.06	.19	.43	.61	.31	2.40
1940	.63	.00	.03	.00	.00	.08	.24	.34	.39	.33	.61	.59	3.26
1941	.43	.12	.21	.03	.07	.00	.18	.36	.33	.44	.38	.48	3.02
1942	.20	.00	.00	.11	.12	.00	.00	.23	.39	.00	.10	.66	1.80
1943	.00	.00	.01	.01	.00	.10	.48	.30	.00	.44	.61	.06	2.02
1944	.24	.00	.27	.17	.00	.00	.30	.38	.38	.44	.61	.67	3.46
1945	.53	.07	.34	.00	.00	.00	.37	.32	.39	.43	.62	.71	3.79
1946	.00	.00	.23	.25	.01	.00	.26	.42	.36	.43	.56	.41	2.93
1947	.23	.00	.09	.00	.04	.00	.14	.36	.39	.44	.60	.60	2.89
1948	.31	.00	.25	.09	.04	.00	.15	.37	.36	.44	.61	.44	3.07
1949	.32	.00	.06	.01	.00	.00	.21	.27	.35	.36	.38	.65	2.61
1950	.31	.08	.00	.21	.04	.00	.26	.37	.33	.43	.33	.44	2.79
1951	.31	.19	.17	.00	.00	.00	.30	.40	.37	.24	.56	.58	3.12
1952	.37	.00	.02	.11	.00	.00	.18	.32	.35	.44	.49	.65	2.93
1953	.42	.00	.07	.12	.00	.00	.40	.23	.31	.44	.62	.41	3.01
1954	.29	.00	.12	.00	.00	.00	.30	.29	.36	.44	.62	.67	3.08
1955	.51	.00	.12	.16	.00	.00	.36	.23	.39	.44	.62	.54	3.36
1956	.37	.00	.00	.01	.00	.00	.22	.37	.32	.19	.32	.00	1.79
1957	.00	.00	.08	.00	.02	.00	.01	.39	.39	.44	.62	.41	2.35
1958	.47	.00	.02	.13	.00	.11	.12	.00	.38	.31	.61	.68	2.83
1959	.04	.00	.09	.14	.00	.00	.07	.42	.39	.40	.46	.55	2.56
1960	.30	.00	.00	.10	.11	.00	.04	.27	.35	.42	.61	.52	2.73
1961	.60	.00	.11	.02	.00	.00	.19	.43	.39	.44	.57	.61	3.36
1962	.50	.00	.14	.00	.15	.00	.29	.41	.17	.35	.62	.72	3.35
1963	.35	.00	.21	.00	.18	.00	.33	.45	.15	.44	.53	.47	3.09
1964	.00	.00	.10	.02	.18	.09	.11	.41	.11	.39	.20	.50	2.12
1965	.58	.00	.26	.00	.03	.23	.40	.38	.35	.44	.55	.58	3.81
1966	.44	.00	.01	.00	.00	.00	.03	.34	.38	.42	.60	.67	2.90
1967	.52	.00	.12	.20	.14	.00	.22	.34	.39	.44	.43	.63	3.43
1968	.60	.00	.07	.15	.02	.00	.23	.20	.26	.41	.59	.59	3.11
1969	.09	.00	.00	.10	.02	.03	.40	.38	.30	.38	.31	.41	2.42
1970	.30	.01	.26	.00	.00	.00	.16	.22	.35	.31	.49	.68	2.78
1971	.47	.00	.15	.00	.00	.00	.34	.31	.39	.44	.54	.70	3.34
1972	.42	.00	.30	.20	.00	.00	.24	.43	.39	.42	.17	.33	2.93
1973	.58	.00	.08	.00	.00	.00	.07	.44	.20	.43	.56	.71	3.07
1974	.53	.00	.14	.00	.00	.00	.19	.45	.39	.43	.60	.23	2.96
1975	.46	.00	.01	.00	.00	.00	.22	.20	.39	.44	.61	.51	2.84
1976	.05	.00	.09	.00	.00	.00	.10	.41	.39	.44	.59	.26	2.33
1977	.13	.00	.03	.00	.00	.00	.21	.45	.38	.44	.43	.44	2.51
1978	.03	.00	.00	.19	.00	.00	.36	.29	.39	.26	.14	.51	2.16
1979	.20	.00	.08	.03	.00	.00	.42	.41	.39	.44	.57	.27	2.81
1980	.58	.00	.10	.00	.00	.05	.30	.43	.31	.42	.28	.56	3.03
1981	.58	.00	.08	.16	.17	.00	.14	.43	.39	.40	.61	.61	3.56
1982	.18	.02	.30	.22	.17	.07	.39	.32	.38	.18	.55	.65	3.43
1983	.19	.00	.03	.15	.06	.00	.28	.42	.35	.42	.33	.66	2.88
1984	.37	.00	.30	.00	.00	.15	.43	.45	.39	.44	.61	.64	3.78
1985	.00	.00	.00	.00	.11	.00	.09	.44	.32	.44	.38	.61	2.40
1986	.15	.00	.09	.21	.00	.00	.35	.44	.36	.43	.18	.00	2.20
1987	.36	.00	.21	.05	.00	.00	.29	.35	.23	.33	.53	.48	2.84
1988	.24	.00	.02	.00	.00	.04	.19	.32	.28	.44	.62	.72	2.88
1989	.39	.00	.05	.12	.03	.00	.27	.38	.37	.43	.48	.71	3.23
1990	.45	.17	.06	.00	.00	.00	.48	.43	.33	.44	.61	.59	3.57
1991	.09	.00	.05	.25	.00	.00	.32	.45	.39	.44	.52	.68	3.19
1992	.46	.03	.28	.12	.00	.00	.34	.44	.39	.44	.58	.56	3.64
1993	.12	.00	.09	.00	.00	.00	.23	.45	.38	.42	.52	.68	2.89
1994	.48	.17	.25	.00	.10	.00	.19	.39	.28	.42	.61	.52	3.42

Third phase irrigation water use for 1995 – TM02PD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.20	.00	.00	.00	.00	.00	.23	.18	.15	.21	.30	.06	1.33
1926	.25	.00	.00	.00	.00	.00	.19	.21	.19	.12	.24	.35	1.55
1927	.00	.09	.00	.00	.00	.00	.19	.18	.19	.21	.28	.28	1.42
1928	.19	.00	.00	.00	.00	.00	.12	.18	.00	.07	.27	.00	.83
1929	.25	.00	.00	.00	.00	.00	.12	.20	.17	.20	.27	.29	1.51
1930	.23	.03	.00	.00	.00	.00	.08	.21	.19	.07	.30	.35	1.45
1931	.25	.00	.00	.00	.00	.00	.23	.12	.16	.21	.30	.28	1.54
1932	.26	.00	.00	.00	.00	.00	.17	.20	.17	.18	.30	.34	1.61
1933	.31	.00	.00	.00	.00	.00	.13	.09	.19	.04	.13	.35	1.23
1934	.10	.00	.00	.00	.00	.00	.14	.18	.17	.21	.28	.30	1.39
1935	.28	.00	.00	.00	.00	.00	.20	.01	.19	.21	.30	.31	1.51
1936	.16	.00	.00	.00	.00	.02	.22	.21	.19	.21	.29	.30	1.61
1937	.25	.05	.00	.00	.00	.07	.00	.21	.04	.11	.16	.29	1.19
1938	.06	.00	.00	.00	.00	.00	.21	.13	.19	.11	.22	.25	1.17
1939	.11	.00	.00	.00	.00	.01	.10	.03	.09	.21	.29	.15	1.00
1940	.31	.00	.00	.00	.00	.04	.12	.17	.19	.16	.29	.29	1.56
1941	.21	.06	.00	.00	.00	.00	.09	.17	.16	.21	.19	.23	1.32
1942	.10	.00	.00	.00	.00	.00	.00	.11	.19	.00	.05	.32	.77
1943	.00	.00	.00	.00	.00	.05	.23	.14	.00	.21	.29	.04	.97
1944	.12	.00	.00	.00	.00	.00	.15	.19	.18	.21	.29	.32	1.46
1945	.26	.04	.00	.00	.00	.00	.18	.16	.19	.21	.30	.34	1.66
1946	.00	.00	.00	.00	.00	.00	.13	.20	.17	.21	.27	.20	1.18
1947	.12	.00	.00	.00	.00	.00	.07	.17	.19	.21	.29	.29	1.34
1948	.15	.00	.00	.00	.00	.00	.07	.18	.17	.21	.29	.21	1.30
1949	.16	.00	.00	.00	.00	.00	.10	.13	.17	.17	.19	.31	1.23
1950	.15	.04	.00	.00	.00	.00	.13	.18	.16	.20	.16	.21	1.24
1951	.15	.09	.00	.00	.00	.00	.15	.19	.18	.12	.27	.28	1.43
1952	.18	.00	.00	.00	.00	.00	.09	.15	.17	.21	.24	.31	1.35
1953	.20	.00	.00	.00	.00	.00	.19	.11	.15	.21	.30	.20	1.37
1954	.14	.00	.00	.00	.00	.00	.14	.14	.17	.21	.30	.32	1.43
1955	.24	.00	.00	.00	.00	.00	.17	.11	.19	.21	.30	.26	1.48
1956	.18	.00	.00	.00	.00	.00	.11	.18	.15	.09	.15	.00	.87
1957	.00	.00	.00	.00	.00	.00	.00	.19	.19	.21	.30	.20	1.09
1958	.23	.00	.00	.00	.00	.06	.06	.00	.18	.15	.29	.33	1.30
1959	.02	.00	.00	.00	.00	.00	.04	.20	.19	.19	.22	.27	1.13
1960	.15	.00	.00	.00	.00	.00	.02	.13	.17	.20	.29	.25	1.22
1961	.29	.00	.00	.00	.00	.00	.09	.21	.19	.21	.28	.29	1.56
1962	.24	.00	.00	.00	.00	.00	.14	.20	.08	.17	.30	.34	1.47
1963	.17	.00	.00	.00	.00	.00	.16	.21	.07	.21	.25	.23	1.31
1964	.00	.00	.00	.00	.00	.04	.06	.20	.05	.19	.10	.24	.88
1965	.28	.00	.00	.00	.00	.11	.19	.18	.17	.21	.26	.28	1.69
1966	.21	.00	.00	.00	.00	.00	.02	.16	.18	.20	.29	.32	1.40
1967	.25	.00	.00	.00	.00	.00	.11	.16	.19	.21	.21	.30	1.43
1968	.29	.00	.00	.00	.00	.00	.11	.10	.13	.20	.28	.28	1.39
1969	.05	.00	.00	.00	.00	.02	.19	.18	.14	.18	.15	.20	1.12
1970	.15	.00	.00	.00	.00	.00	.08	.11	.17	.15	.24	.33	1.22
1971	.23	.00	.00	.00	.00	.00	.17	.15	.19	.21	.26	.34	1.54
1972	.21	.00	.00	.00	.00	.00	.12	.21	.19	.20	.09	.16	1.18
1973	.28	.00	.00	.00	.00	.00	.04	.21	.10	.21	.27	.34	1.44
1974	.26	.00	.00	.00	.00	.00	.09	.22	.19	.21	.29	.11	1.36
1975	.22	.00	.00	.00	.00	.00	.11	.10	.19	.21	.29	.25	1.37
1976	.03	.00	.00	.00	.00	.00	.05	.20	.19	.21	.28	.13	1.09
1977	.07	.00	.00	.00	.00	.00	.10	.21	.18	.21	.21	.21	1.20
1978	.02	.00	.00	.00	.00	.00	.17	.14	.19	.13	.07	.24	.96
1979	.10	.00	.00	.00	.00	.00	.20	.20	.19	.21	.27	.13	1.31
1980	.28	.00	.00	.00	.00	.03	.15	.20	.15	.20	.14	.27	1.42
1981	.28	.00	.00	.00	.00	.00	.07	.21	.19	.19	.29	.29	1.52
1982	.09	.01	.00	.00	.00	.04	.19	.15	.18	.09	.27	.31	1.33
1983	.10	.00	.00	.00	.00	.00	.13	.20	.17	.20	.16	.32	1.28
1984	.18	.00	.00	.00	.00	.07	.21	.22	.19	.21	.29	.31	1.68
1985	.00	.00	.00	.00	.00	.00	.05	.21	.15	.21	.18	.30	1.11
1986	.08	.00	.00	.00	.00	.00	.17	.21	.17	.20	.09	.00	.92
1987	.18	.00	.00	.00	.00	.00	.14	.17	.11	.16	.26	.23	1.25
1988	.12	.00	.00	.00	.00	.02	.09	.16	.14	.21	.30	.35	1.39
1989	.19	.00	.00	.00	.00	.00	.13	.18	.18	.21	.23	.34	1.47
1990	.22	.08	.00	.00	.00	.00	.23	.21	.16	.21	.29	.28	1.69
1991	.05	.00	.00	.00	.00	.00	.15	.22	.19	.21	.25	.33	1.40
1992	.23	.02	.00	.00	.00	.00	.16	.21	.19	.21	.28	.27	1.56
1993	.06	.00	.00	.00	.00	.00	.11	.22	.18	.20	.25	.33	1.36
1994	.23	.08	.00	.00	.00	.00	.09	.19	.14	.20	.29	.25	1.48

Third phase irrigation water use for 1995 – TM06PD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.55	.64	1.14	.00	1.08	.63	.82	.54	.41	.56	.56	.13	7.06
1926	.74	.69	.96	.65	.38	.08	.71	.61	.56	.36	.42	.75	6.92
1927	.00	1.23	.63	.84	.99	.07	.80	.63	.56	.56	.50	.51	7.31
1928	.80	1.18	.75	.73	.22	.00	.26	.47	.22	.27	.52	.00	5.41
1929	.58	.27	.00	.19	1.00	.79	.39	.49	.55	.47	.48	.58	5.78
1930	.92	1.13	1.08	.00	.90	.67	.55	.63	.56	.35	.56	.75	8.11
1931	.68	1.11	1.34	1.11	.12	.30	.75	.25	.46	.47	.56	.65	7.80
1932	.98	.66	.80	1.10	1.10	.78	.54	.62	.55	.36	.56	.75	8.81
1933	.98	.00	.50	.00	.86	.63	.34	.18	.56	.25	.06	.72	5.08
1934	.34	.54	.00	1.10	.79	.64	.74	.59	.45	.56	.49	.66	6.89
1935	.90	1.17	.97	.93	.44	.35	.81	.00	.55	.56	.56	.59	7.83
1936	.56	.00	1.14	.00	.35	.94	.72	.63	.56	.54	.56	.63	6.63
1937	.79	1.13	.60	.32	.86	1.06	.11	.63	.21	.23	.38	.53	6.86
1938	.19	.92	.61	.35	.00	.22	.77	.39	.45	.34	.42	.45	5.11
1939	.38	.02	.58	.95	1.04	.84	.68	.00	.23	.56	.52	.29	6.09
1940	.98	.60	.61	.03	.50	.90	.35	.63	.54	.47	.56	.70	6.86
1941	.60	1.05	1.19	.66	.35	.37	.24	.56	.42	.56	.23	.57	6.79
1942	.38	.00	.38	.61	1.19	.39	.00	.30	.39	.11	.00	.65	4.40
1943	.00	.15	.51	.52	.00	.87	.87	.49	.00	.56	.56	.00	4.52
1944	.36	.68	1.34	1.01	.67	.00	.75	.59	.54	.56	.56	.73	7.78
1945	.94	1.16	1.47	.51	.55	.24	.74	.53	.56	.55	.56	.77	8.59
1946	.15	.33	1.18	1.20	.29	.24	.61	.63	.39	.52	.56	.39	6.48
1947	.38	.31	.67	.32	.83	.00	.52	.52	.56	.56	.55	.60	5.82
1948	.56	.96	1.07	.69	.75	.43	.45	.49	.51	.56	.56	.30	7.34
1949	.64	.59	.77	.66	.74	.00	.64	.33	.51	.49	.33	.67	6.38
1950	.52	.99	.06	1.01	.84	.60	.52	.54	.48	.54	.14	.32	6.56
1951	.57	1.28	.79	.15	.25	.58	.62	.58	.56	.16	.50	.59	6.63
1952	.51	.86	.66	.57	.00	.74	.43	.53	.56	.56	.39	.72	6.53
1953	.74	.61	.93	.93	.09	.57	.75	.35	.45	.55	.56	.27	6.80
1954	.39	.32	1.07	.05	.23	.70	.77	.50	.56	.56	.56	.73	6.45
1955	.83	.63	.62	1.15	.26	.00	.81	.40	.56	.56	.56	.53	6.92
1956	.80	.54	.00	.29	.64	.33	.55	.59	.50	.12	.19	.00	4.54
1957	.00	1.06	.85	.00	.89	.53	.28	.60	.56	.56	.56	.26	6.15
1958	.74	.42	.40	.71	.49	.77	.52	.00	.56	.47	.56	.73	6.37
1959	.09	.54	.99	.91	.49	.48	.25	.61	.56	.53	.42	.59	6.45
1960	.52	.80	.27	1.08	1.11	.15	.32	.40	.54	.55	.56	.39	6.69
1961	.94	.57	.86	.03	.62	.81	.42	.62	.56	.56	.47	.65	7.11
1962	.95	.62	.68	.00	1.26	.49	.71	.61	.25	.38	.56	.76	7.27
1963	.68	.82	1.22	.14	1.11	.52	.62	.63	.23	.55	.44	.25	7.24
1964	.03	.69	.35	.69	1.05	1.16	.43	.55	.19	.52	.02	.40	6.08
1965	.92	.63	1.22	.11	.74	1.16	.81	.55	.50	.56	.43	.64	8.29
1966	.83	.73	.00	.00	.26	.64	.36	.58	.56	.56	.56	.75	5.85
1967	.80	1.05	.78	1.08	1.14	.85	.84	.57	.56	.56	.28	.71	9.21
1968	.92	.98	1.06	.97	.62	.31	.58	.27	.49	.55	.55	.62	7.93
1969	.12	1.08	.85	.60	.78	1.05	.87	.59	.43	.54	.12	.24	7.29
1970	.50	1.04	1.20	.13	.63	.64	.50	.26	.51	.34	.44	.74	6.93
1971	.49	.86	.62	.93	.49	.07	.76	.50	.53	.56	.47	.77	7.05
1972	.63	.75	1.36	.99	.00	.99	.30	.63	.56	.55	.00	.16	6.92
1973	1.01	.55	.64	.60	.00	.28	.38	.63	.32	.53	.50	.77	6.22
1974	1.02	.18	.81	.40	.00	.76	.36	.58	.56	.56	.56	.01	5.80
1975	.91	.69	.32	.11	.63	.00	.66	.33	.56	.56	.54	.52	5.84
1976	.07	.60	.85	.80	1.07	.58	.70	.63	.56	.56	.54	.31	7.26
1977	.05	.79	.99	.00	.66	.51	.60	.63	.56	.54	.37	.38	6.09
1978	.06	.93	.44	.86	.63	.62	.67	.47	.56	.29	.00	.62	6.14
1979	.32	.51	1.02	.65	.14	.22	.85	.57	.56	.56	.55	.12	6.05
1980	.98	.56	.41	.00	.00	.88	.73	.60	.45	.55	.14	.50	5.80
1981	.96	.70	.75	.49	1.43	.60	.43	.61	.54	.51	.56	.72	8.30
1982	.39	.82	1.33	1.06	1.09	.95	.74	.52	.56	.46	.44	.71	9.06
1983	.29	.12	.77	.54	1.07	.05	.32	.63	.48	.51	.18	.59	5.55
1984	.50	1.16	1.17	.39	.00	1.03	.90	.63	.56	.56	.56	.68	8.15
1985	.06	.36	.58	.25	1.06	.62	.57	.63	.47	.56	.29	.65	6.12
1986	.24	.80	.93	.50	.34	.25	.86	.63	.53	.54	.06	.00	5.66
1987	.80	.59	.48	.79	.53	.35	.84	.63	.29	.38	.53	.59	6.82
1988	.49	.72	.38	.45	.00	.48	.76	.54	.51	.54	.56	.76	6.20
1989	.71	.11	.97	.97	.75	.48	.40	.60	.55	.50	.19	.77	6.99
1990	.87	1.32	.56	.00	.65	.88	.91	.62	.47	.56	.56	.63	8.04
1991	.00	.50	.93	1.00	.83	.47	.78	.63	.56	.56	.38	.77	7.41
1992	.89	.53	1.12	.83	.00	.31	.75	.63	.56	.56	.50	.67	7.35
1993	.00	.74	.66	.34	.22	.26	.43	.63	.56	.51	.48	.76	5.59
1994	.72	1.37	1.20	.29	.97	.32	.56	.60	.54	.56	.54	.64	8.33

Third phase irrigation water use for 1995 – TM08PDA.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.43	.00	.00	.00	.00	.00	.30	.26	.17	.40	.51	.20	
1926	.29	.00	.00	.00	.00	.00	.23	.32	.29	.35	.39	.61	
1927	.22	.12	.00	.00	.00	.00	.32	.21	.31	.39	.47	.57	
1928	.47	.00	.00	.00	.00	.00	.27	.17	.08	.16	.49	.06	
1929	.48	.00	.00	.00	.00	.00	.34	.26	.28	.39	.43	.52	
1930	.39	.11	.00	.00	.00	.00	.16	.32	.30	.16	.51	.63	
1931	.46	.08	.00	.00	.00	.00	.35	.22	.29	.38	.50	.50	
1932	.46	.00	.00	.00	.00	.04	.25	.31	.30	.24	.51	.62	
1933	.48	.00	.00	.00	.00	.00	.00	.13	.30	.27	.26	.54	
1934	.35	.00	.00	.00	.00	.00	.33	.24	.23	.38	.47	.56	
1935	.58	.00	.00	.00	.00	.00	.29	.00	.29	.39	.51	.59	
1936	.31	.00	.00	.00	.00	.01	.25	.33	.29	.40	.51	.57	
1937	.48	.04	.00	.00	.00	.04	.00	.33	.19	.22	.37	.54	
1938	.06	.00	.00	.00	.00	.00	.35	.16	.31	.25	.44	.48	
1939	.29	.00	.00	.00	.00	.00	.21	.00	.12	.39	.48	.43	
1940	.50	.00	.00	.00	.00	.08	.17	.33	.31	.38	.51	.58	
1941	.46	.11	.00	.00	.00	.00	.11	.29	.28	.39	.38	.44	
1942	.34	.00	.00	.00	.00	.00	.00	.03	.31	.07	.03	.62	
1943	.00	.00	.00	.00	.00	.01	.38	.27	.08	.40	.51	.18	
1944	.42	.00	.00	.00	.00	.00	.25	.29	.27	.40	.51	.63	
1945	.55	.07	.00	.00	.00	.00	.25	.29	.31	.40	.51	.64	
1946	.29	.00	.00	.00	.00	.00	.22	.31	.21	.40	.48	.54	
1947	.27	.00	.00	.00	.00	.00	.16	.25	.31	.40	.51	.57	
1948	.47	.00	.00	.00	.00	.00	.14	.28	.30	.40	.46	.49	
1949	.49	.00	.00	.00	.00	.00	.24	.14	.29	.35	.33	.52	
1950	.48	.00	.00	.00	.00	.00	.24	.31	.29	.40	.30	.50	
1951	.41	.14	.00	.00	.00	.00	.26	.29	.29	.24	.44	.53	
1952	.38	.00	.00	.00	.00	.00	.20	.31	.30	.40	.38	.59	
1953	.36	.00	.00	.00	.00	.00	.29	.12	.30	.40	.51	.44	
1954	.34	.00	.00	.00	.00	.00	.20	.18	.26	.39	.51	.59	
1955	.50	.00	.00	.00	.00	.00	.29	.30	.31	.39	.48	.53	
1956	.46	.00	.00	.00	.00	.00	.09	.28	.27	.28	.30	.00	
1957	.17	.02	.00	.00	.00	.00	.07	.30	.30	.40	.51	.50	
1958	.46	.00	.00	.00	.00	.00	.19	.02	.30	.31	.48	.63	
1959	.32	.00	.00	.00	.00	.00	.07	.31	.31	.39	.46	.53	
1960	.43	.00	.00	.00	.00	.00	.07	.28	.30	.39	.51	.48	
1961	.55	.00	.00	.00	.00	.00	.10	.25	.31	.40	.43	.59	
1962	.50	.00	.00	.00	.00	.00	.25	.31	.19	.33	.51	.63	
1963	.23	.00	.00	.00	.00	.00	.17	.32	.20	.40	.48	.32	
1964	.00	.00	.00	.00	.00	.14	.12	.28	.02	.35	.23	.47	
1965	.48	.00	.00	.00	.00	.14	.28	.26	.28	.40	.43	.55	
1966	.42	.00	.00	.00	.00	.00	.00	.27	.30	.38	.50	.61	
1967	.46	.00	.00	.00	.00	.00	.24	.28	.30	.39	.42	.56	
1968	.53	.00	.00	.00	.00	.00	.15	.16	.28	.38	.49	.45	
1969	.21	.00	.00	.00	.00	.02	.28	.31	.28	.39	.22	.31	
1970	.34	.00	.00	.00	.00	.00	.16	.16	.30	.27	.35	.59	
1971	.32	.00	.00	.00	.00	.00	.19	.16	.31	.39	.48	.59	
1972	.38	.00	.00	.00	.00	.00	.09	.31	.30	.38	.30	.35	
1973	.49	.00	.00	.00	.00	.00	.00	.33	.18	.35	.48	.63	
1974	.47	.00	.00	.00	.00	.00	.17	.32	.31	.40	.50	.11	
1975	.47	.00	.00	.00	.00	.00	.13	.12	.31	.40	.50	.42	
1976	.17	.00	.00	.00	.00	.00	.09	.32	.31	.40	.47	.37	
1977	.14	.00	.00	.00	.00	.00	.09	.31	.29	.40	.40	.49	
1978	.13	.00	.00	.00	.00	.00	.24	.14	.31	.31	.22	.54	
1979	.36	.00	.00	.00	.00	.00	.16	.29	.31	.40	.45	.30	
1980	.50	.00	.00	.00	.00	.05	.24	.29	.22	.40	.22	.50	
1981	.51	.00	.00	.00	.00	.00	.11	.31	.28	.37	.50	.46	
1982	.29	.04	.00	.00	.00	.01	.19	.25	.29	.15	.45	.57	
1983	.19	.00	.00	.00	.00	.00	.20	.31	.26	.36	.31	.59	
1984	.39	.03	.00	.00	.00	.08	.36	.32	.29	.40	.50	.57	
1985	.00	.00	.00	.00	.00	.00	.10	.33	.25	.40	.30	.58	
1986	.11	.00	.00	.00	.00	.00	.35	.33	.25	.38	.17	.00	
1987	.38	.00	.00	.00	.00	.00	.16	.22	.12	.27	.47	.53	
1988	.38	.00	.00	.00	.00	.00	.22	.24	.25	.39	.51	.63	
1989	.41	.00	.00	.00	.00	.00	.16	.29	.29	.40	.35	.61	
1990	.41	.07	.00	.00	.00	.00	.38	.32	.25	.40	.50	.54	
1991	.00	.00	.00	.00	.00	.00	.27	.33	.31	.40	.46	.61	
1992	.42	.00	.00	.00	.00	.00	.23	.31	.31	.40	.48	.57	
1993	.16	.00	.00	.00	.00	.00	.26	.33	.30	.36	.43	.62	
1994	.40	.15	.00	.00	.00	.00	.20	.28	.30	.39	.51	.49	

Third phase irrigation water use for 1995 – TM08PDB.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	1.18	.00	.00	.00	.00	.00	.81	.69	.46	1.09	1.38	.53	
1926	.79	.00	.00	.00	.00	.00	.63	.85	.79	.93	1.05	1.64	
1927	.58	.31	.00	.00	.00	.00	.87	.57	.83	1.05	1.27	1.53	
1928	1.27	.00	.00	.00	.00	.00	.74	.46	.23	.44	1.31	.15	
1929	1.31	.00	.00	.00	.00	.00	.93	.70	.75	1.06	1.16	1.42	
1930	1.05	.31	.00	.00	.00	.00	.45	.86	.81	.44	1.39	1.69	
1931	1.26	.22	.00	.00	.00	.00	.94	.59	.78	1.04	1.37	1.34	
1932	1.26	.00	.00	.00	.00	.09	.66	.85	.81	.64	1.39	1.68	
1933	1.31	.00	.00	.00	.00	.00	.00	.35	.82	.72	.69	1.47	
1934	.93	.00	.00	.00	.00	.00	.89	.65	.63	1.04	1.28	1.52	
1935	1.56	.00	.00	.00	.00	.00	.77	.00	.77	1.07	1.39	1.58	
1936	.85	.00	.00	.00	.00	.03	.69	.88	.77	1.08	1.38	1.55	
1937	1.31	.09	.00	.00	.00	.11	.00	.88	.52	.61	1.00	1.47	
1938	.18	.00	.00	.00	.00	.00	.94	.44	.83	.66	1.20	1.29	
1939	.79	.00	.00	.00	.00	.00	.56	.00	.33	1.07	1.31	1.15	
1940	1.35	.00	.00	.00	.00	.22	.46	.88	.83	1.03	1.37	1.55	
1941	1.25	.29	.00	.00	.00	.00	.30	.80	.76	1.05	1.01	1.20	
1942	.92	.00	.00	.00	.00	.00	.00	.08	.83	.18	.09	1.68	
1943	.00	.00	.00	.00	.00	.03	1.03	.73	.22	1.09	1.38	.50	
1944	1.13	.00	.00	.00	.00	.00	.66	.79	.74	1.08	1.38	1.69	
1945	1.48	.18	.00	.00	.00	.00	.68	.79	.83	1.07	1.38	1.73	
1946	.80	.00	.00	.00	.00	.00	.59	.83	.55	1.07	1.29	1.45	
1947	.73	.00	.00	.00	.00	.00	.42	.69	.83	1.09	1.38	1.55	
1948	1.27	.00	.00	.00	.00	.00	.38	.75	.81	1.08	1.23	1.31	
1949	1.31	.00	.00	.00	.00	.00	.64	.38	.77	.96	.90	1.42	
1950	1.29	.00	.00	.00	.00	.00	.64	.82	.77	1.07	.80	1.36	
1951	1.12	.39	.00	.00	.00	.00	.70	.79	.80	.66	1.20	1.42	
1952	1.04	.00	.00	.00	.00	.00	.55	.85	.81	1.09	1.03	1.59	
1953	.97	.00	.00	.00	.00	.00	.79	.31	.81	1.09	1.39	1.20	
1954	.91	.00	.00	.00	.00	.00	.53	.49	.71	1.07	1.39	1.61	
1955	1.34	.00	.00	.00	.00	.00	.78	.80	.83	1.07	1.29	1.42	
1956	1.23	.00	.00	.00	.00	.00	.25	.75	.74	.77	.81	.01	
1957	.45	.04	.00	.00	.00	.00	.18	.81	.81	1.09	1.39	1.34	
1958	1.23	.00	.00	.00	.00	.00	.51	.04	.81	.85	1.29	1.69	
1959	.87	.00	.00	.00	.00	.00	.18	.85	.83	1.05	1.23	1.42	
1960	1.17	.00	.00	.00	.00	.00	.20	.76	.81	1.07	1.37	1.31	
1961	1.47	.00	.00	.00	.00	.00	.28	.69	.83	1.09	1.17	1.61	
1962	1.37	.00	.00	.00	.00	.00	.69	.85	.51	.88	1.39	1.72	
1963	.63	.00	.00	.00	.00	.00	.46	.86	.55	1.07	1.31	.86	
1964	.00	.00	.00	.00	.00	.39	.34	.76	.06	.96	.62	1.28	
1965	1.29	.00	.00	.00	.00	.39	.74	.70	.76	1.09	1.18	1.47	
1966	1.12	.00	.00	.00	.00	.00	.00	.74	.81	1.03	1.37	1.64	
1967	1.25	.00	.00	.00	.00	.00	.64	.76	.82	1.07	1.13	1.51	
1968	1.44	.00	.00	.00	.00	.00	.40	.44	.75	1.03	1.32	1.22	
1969	.56	.00	.00	.00	.00	.06	.76	.82	.77	1.07	.58	.84	
1970	.92	.00	.00	.00	.00	.00	.45	.42	.81	.72	.96	1.61	
1971	.86	.00	.00	.00	.00	.00	.52	.45	.82	1.05	1.29	1.61	
1972	1.01	.00	.00	.00	.00	.00	.24	.83	.81	1.01	.80	.93	
1973	1.31	.00	.00	.00	.00	.00	.00	.88	.48	.96	1.29	1.70	
1974	1.27	.00	.00	.00	.00	.00	.46	.85	.83	1.09	1.35	.28	
1975	1.27	.00	.00	.00	.00	.00	.34	.33	.83	1.07	1.37	1.12	
1976	.46	.00	.00	.00	.00	.00	.26	.85	.82	1.08	1.27	1.00	
1977	.38	.00	.00	.00	.00	.00	.26	.85	.80	1.09	1.08	1.33	
1978	.34	.00	.00	.00	.00	.00	.66	.37	.83	.82	.60	1.45	
1979	.97	.00	.00	.00	.00	.00	.44	.80	.83	1.09	1.22	.80	
1980	1.35	.00	.00	.00	.00	.14	.65	.77	.61	1.09	.59	1.37	
1981	1.37	.00	.00	.00	.00	.00	.29	.85	.75	.99	1.37	1.25	
1982	.77	.11	.00	.00	.00	.02	.52	.69	.80	.42	1.22	1.55	
1983	.51	.00	.00	.00	.00	.00	.55	.85	.70	.98	.85	1.61	
1984	1.07	.07	.00	.00	.00	.20	.96	.85	.78	1.09	1.37	1.55	
1985	.00	.00	.00	.00	.00	.00	.27	.88	.67	1.09	.81	1.57	
1986	.31	.00	.00	.00	.00	.00	.94	.88	.66	1.04	.45	.00	
1987	1.03	.00	.00	.00	.00	.00	.44	.61	.33	.73	1.27	1.44	
1988	1.01	.00	.00	.00	.00	.00	.58	.65	.66	1.05	1.39	1.72	
1989	1.10	.00	.00	.00	.00	.00	.44	.80	.78	1.09	.94	1.66	
1990	1.10	.20	.00	.00	.00	.00	1.04	.85	.66	1.09	1.35	1.45	
1991	.00	.00	.00	.00	.00	.00	.74	.88	.83	1.09	1.23	1.64	
1992	1.12	.01	.00	.00	.00	.00	.63	.85	.83	1.08	1.31	1.53	
1993	.44	.00	.00	.00	.00	.00	.72	.88	.82	.97	1.16	1.67	
1994	1.08	.41	.00	.00	.00	.00	.53	.75	.81	1.07	1.39	1.33	

Third phase irrigation water use for 1995 – TM11PDA.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.21	.19	.34	.00	.23	.19	.27	.17	.11	.17	.25	.01	
1926	.19	.16	.20	.16	.02	.01	.25	.21	.17	.11	.21	.32	
1927	.09	.32	.15	.19	.15	.03	.24	.17	.17	.17	.22	.22	
1928	.27	.35	.06	.20	.06	.00	.13	.18	.03	.05	.23	.00	
1929	.27	.03	.11	.02	.18	.19	.19	.19	.16	.15	.20	.26	
1930	.34	.33	.26	.00	.00	.20	.25	.21	.17	.11	.25	.33	
1931	.27	.31	.28	.25	.00	.14	.27	.10	.13	.14	.25	.26	
1932	.35	.24	.23	.29	.16	.20	.20	.21	.17	.10	.25	.33	
1933	.38	.00	.06	.00	.22	.17	.11	.09	.17	.07	.07	.33	
1934	.26	.14	.00	.31	.16	.09	.20	.20	.14	.17	.24	.28	
1935	.36	.36	.32	.18	.02	.06	.26	.00	.16	.17	.25	.29	
1936	.21	.01	.26	.00	.15	.25	.20	.21	.17	.17	.25	.28	
1937	.34	.34	.14	.21	.13	.24	.09	.21	.01	.04	.18	.23	
1938	.15	.22	.04	.14	.01	.06	.29	.10	.17	.06	.22	.23	
1939	.25	.00	.08	.30	.14	.25	.22	.03	.08	.17	.25	.14	
1940	.29	.17	.04	.03	.01	.21	.10	.21	.17	.15	.25	.31	
1941	.33	.33	.24	.11	.00	.05	.12	.17	.13	.17	.14	.23	
1942	.15	.00	.05	.00	.24	.06	.00	.13	.17	.00	.00	.32	
1943	.01	.20	.12	.14	.00	.23	.30	.20	.00	.17	.25	.00	
1944	.17	.31	.37	.32	.13	.00	.25	.20	.16	.17	.25	.30	
1945	.39	.41	.43	.00	.05	.00	.27	.20	.17	.17	.25	.33	
1946	.11	.06	.28	.28	.00	.10	.18	.21	.04	.16	.25	.23	
1947	.21	.05	.14	.05	.19	.05	.19	.19	.17	.17	.25	.28	
1948	.21	.27	.34	.06	.06	.06	.13	.18	.17	.16	.25	.22	
1949	.23	.15	.20	.21	.14	.04	.19	.14	.16	.16	.18	.28	
1950	.23	.35	.18	.24	.12	.17	.18	.19	.14	.16	.09	.24	
1951	.26	.38	.22	.00	.09	.10	.19	.18	.17	.04	.23	.31	
1952	.24	.22	.35	.07	.00	.17	.15	.20	.17	.17	.17	.32	
1953	.33	.18	.23	.24	.00	.11	.19	.09	.13	.17	.25	.14	
1954	.11	.00	.18	.00	.00	.22	.24	.19	.17	.17	.25	.31	
1955	.28	.18	.23	.35	.00	.00	.29	.09	.17	.17	.25	.24	
1956	.27	.07	.00	.08	.11	.05	.18	.21	.14	.00	.17	.00	
1957	.10	.32	.26	.04	.15	.11	.05	.21	.17	.17	.25	.15	
1958	.27	.17	.12	.15	.00	.27	.21	.00	.17	.16	.25	.32	
1959	.10	.20	.23	.18	.02	.16	.07	.21	.17	.16	.20	.28	
1960	.22	.21	.00	.36	.25	.00	.11	.14	.16	.17	.25	.21	
1961	.35	.14	.22	.00	.07	.28	.15	.20	.17	.17	.20	.27	
1962	.38	.16	.19	.00	.28	.17	.24	.20	.06	.09	.25	.33	
1963	.29	.21	.40	.09	.31	.15	.22	.20	.06	.17	.20	.22	
1964	.03	.26	.16	.11	.13	.32	.16	.19	.03	.15	.14	.20	
1965	.32	.25	.30	.00	.11	.33	.20	.14	.16	.17	.20	.28	
1966	.32	.23	.06	.00	.10	.00	.07	.19	.17	.16	.25	.32	
1967	.33	.32	.16	.31	.25	.24	.28	.21	.17	.17	.17	.31	
1968	.37	.32	.33	.19	.15	.00	.13	.09	.16	.15	.25	.30	
1969	.10	.38	.17	.14	.09	.31	.25	.17	.13	.15	.08	.18	
1970	.19	.28	.33	.00	.19	.23	.20	.07	.17	.07	.20	.30	
1971	.18	.25	.10	.08	.02	.04	.25	.17	.16	.17	.18	.33	
1972	.24	.17	.33	.23	.02	.30	.00	.21	.17	.17	.01	.12	
1973	.33	.11	.14	.10	.02	.13	.16	.15	.14	.16	.23	.32	
1974	.37	.11	.23	.01	.00	.11	.18	.20	.17	.17	.24	.00	
1975	.34	.06	.02	.00	.00	.00	.08	.09	.17	.17	.24	.27	
1976	.09	.17	.19	.08	.20	.04	.06	.21	.17	.17	.25	.11	
1977	.10	.25	.22	.00	.12	.05	.19	.21	.17	.17	.18	.15	
1978	.04	.20	.10	.29	.00	.23	.24	.10	.12	.06	.01	.19	
1979	.31	.27	.20	.07	.05	.22	.25	.17	.17	.17	.24	.09	
1980	.29	.16	.07	.05	.00	.33	.24	.20	.11	.17	.15	.18	
1981	.33	.18	.25	.12	.29	.15	.28	.20	.16	.15	.25	.27	
1982	.08	.33	.33	.19	.28	.20	.25	.18	.15	.15	.22	.33	
1983	.08	.07	.02	.06	.25	.05	.20	.21	.15	.15	.06	.27	
1984	.20	.36	.31	.00	.00	.31	.30	.21	.16	.17	.25	.29	
1985	.05	.03	.11	.04	.23	.09	.18	.21	.12	.17	.19	.32	
1986	.16	.23	.12	.19	.00	.00	.24	.21	.15	.16	.02	.00	
1987	.30	.17	.16	.29	.00	.07	.29	.21	.07	.11	.25	.27	
1988	.22	.17	.14	.10	.00	.15	.22	.17	.13	.17	.25	.33	
1989	.26	.00	.29	.30	.15	.13	.18	.20	.17	.17	.16	.33	
1990	.31	.41	.18	.00	.00	.15	.30	.21	.11	.17	.25	.30	
1991	.00	.25	.14	.27	.00	.28	.25	.21	.17	.17	.20	.33	
1992	.36	.28	.25	.18	.05	.09	.21	.21	.17	.17	.24	.23	
1993	.02	.22	.20	.10	.00	.12	.20	.21	.17	.15	.19	.32	
1994	.28	.41	.32	.20	.19	.14	.21	.17	.16	.17	.22	.27	

Third phase irrigation water use for 1995 – TM11PDB.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.41	.37	.66	.00	.44	.38	.51	.34	.21	.33	.50	.03	
1926	.37	.32	.39	.30	.03	.03	.48	.41	.32	.21	.41	.63	
1927	.17	.61	.29	.38	.29	.05	.47	.33	.32	.33	.43	.42	
1928	.53	.68	.13	.38	.13	.00	.25	.35	.06	.09	.46	.00	
1929	.53	.06	.21	.03	.36	.36	.38	.37	.31	.28	.40	.50	
1930	.65	.65	.50	.01	.01	.40	.50	.41	.32	.22	.50	.63	
1931	.52	.60	.54	.48	.00	.28	.53	.19	.26	.26	.50	.51	
1932	.67	.48	.46	.57	.32	.38	.38	.40	.32	.18	.50	.63	
1933	.74	.00	.13	.00	.42	.34	.21	.17	.32	.15	.15	.64	
1934	.50	.26	.01	.61	.32	.17	.39	.39	.27	.33	.46	.53	
1935	.69	.69	.62	.36	.05	.11	.51	.00	.32	.33	.50	.57	
1936	.41	.02	.50	.00	.30	.48	.39	.41	.32	.33	.50	.53	
1937	.65	.67	.26	.41	.24	.46	.18	.41	.01	.08	.35	.46	
1938	.29	.43	.08	.26	.03	.13	.55	.20	.32	.12	.43	.45	
1939	.49	.00	.16	.57	.26	.50	.43	.05	.16	.33	.48	.28	
1940	.57	.32	.07	.07	.03	.42	.19	.41	.32	.28	.50	.59	
1941	.63	.65	.47	.22	.00	.09	.23	.33	.26	.33	.28	.45	
1942	.30	.00	.11	.00	.46	.12	.00	.26	.32	.00	.00	.62	
1943	.01	.38	.24	.28	.00	.46	.58	.39	.00	.33	.49	.01	
1944	.33	.60	.73	.61	.25	.00	.48	.40	.30	.33	.49	.58	
1945	.75	.81	.84	.00	.11	.01	.52	.38	.32	.33	.50	.65	
1946	.20	.12	.55	.54	.00	.18	.36	.41	.08	.30	.49	.45	
1947	.42	.09	.27	.11	.37	.09	.36	.37	.32	.32	.49	.54	
1948	.42	.53	.67	.12	.12	.12	.25	.36	.32	.31	.50	.43	
1949	.46	.30	.38	.40	.27	.07	.37	.26	.32	.32	.35	.55	
1950	.44	.67	.34	.46	.22	.33	.36	.37	.27	.30	.17	.48	
1951	.50	.74	.44	.00	.17	.20	.38	.35	.32	.07	.46	.59	
1952	.48	.44	.69	.15	.00	.34	.29	.39	.32	.33	.32	.62	
1953	.63	.34	.46	.46	.00	.20	.37	.18	.25	.33	.50	.27	
1954	.21	.01	.36	.00	.00	.44	.48	.36	.32	.33	.49	.60	
1955	.53	.35	.46	.68	.00	.00	.56	.17	.32	.33	.50	.48	
1956	.51	.15	.00	.16	.20	.09	.34	.40	.28	.00	.33	.00	
1957	.18	.63	.51	.07	.29	.21	.11	.41	.32	.33	.50	.28	
1958	.51	.32	.22	.29	.00	.53	.42	.00	.32	.30	.49	.61	
1959	.18	.40	.45	.34	.03	.31	.13	.40	.32	.32	.40	.55	
1960	.42	.40	.01	.69	.48	.01	.22	.27	.32	.33	.50	.40	
1961	.69	.27	.42	.01	.15	.53	.29	.39	.32	.33	.39	.53	
1962	.75	.30	.38	.00	.53	.34	.48	.39	.13	.17	.50	.65	
1963	.56	.42	.79	.17	.59	.28	.44	.40	.13	.32	.40	.43	
1964	.07	.50	.30	.20	.24	.63	.30	.37	.06	.28	.27	.38	
1965	.63	.50	.59	.00	.22	.63	.40	.27	.32	.33	.38	.55	
1966	.63	.44	.13	.00	.20	.01	.13	.36	.32	.31	.49	.62	
1967	.64	.61	.30	.61	.50	.47	.54	.40	.32	.33	.33	.60	
1968	.72	.63	.63	.36	.30	.00	.24	.17	.31	.29	.50	.57	
1969	.18	.74	.32	.28	.18	.61	.49	.32	.24	.29	.15	.35	
1970	.36	.53	.64	.00	.37	.45	.40	.13	.32	.15	.39	.57	
1971	.36	.50	.20	.16	.03	.07	.50	.34	.31	.33	.36	.64	
1972	.47	.32	.63	.44	.05	.59	.00	.41	.32	.33	.01	.24	
1973	.65	.21	.26	.18	.03	.24	.31	.29	.27	.31	.45	.63	
1974	.72	.22	.45	.03	.00	.22	.36	.39	.32	.33	.48	.00	
1975	.67	.11	.04	.01	.01	.00	.15	.17	.32	.33	.47	.53	
1976	.17	.33	.36	.15	.39	.08	.12	.41	.32	.33	.49	.20	
1977	.20	.48	.44	.00	.24	.10	.36	.40	.32	.33	.34	.28	
1978	.09	.38	.19	.56	.00	.46	.46	.20	.23	.13	.01	.37	
1979	.61	.53	.40	.13	.09	.43	.50	.34	.32	.33	.48	.17	
1980	.57	.32	.13	.10	.00	.65	.48	.40	.21	.33	.29	.35	
1981	.64	.34	.50	.22	.57	.29	.54	.40	.32	.29	.50	.53	
1982	.15	.64	.65	.36	.55	.39	.48	.34	.29	.29	.44	.63	
1983	.15	.13	.04	.12	.50	.09	.38	.40	.29	.29	.12	.51	
1984	.39	.69	.59	.00	.00	.59	.57	.41	.31	.32	.50	.56	
1985	.09	.06	.21	.08	.46	.17	.35	.41	.23	.33	.37	.61	
1986	.31	.45	.23	.38	.00	.00	.47	.41	.28	.32	.05	.00	
1987	.57	.33	.31	.55	.00	.15	.55	.41	.14	.20	.49	.51	
1988	.43	.32	.28	.18	.00	.28	.43	.33	.25	.33	.48	.65	
1989	.50	.01	.57	.57	.28	.25	.35	.39	.32	.33	.31	.65	
1990	.61	.81	.35	.00	.00	.30	.59	.41	.20	.33	.50	.59	
1991	.00	.49	.27	.52	.01	.55	.50	.41	.32	.33	.40	.65	
1992	.70	.53	.49	.34	.09	.18	.42	.40	.32	.33	.48	.46	
1993	.03	.43	.39	.20	.00	.23	.39	.41	.32	.29	.38	.63	
1994	.55	.80	.62	.39	.38	.28	.41	.33	.30	.33	.44	.51	

Third phase irrigation water use for 1995 – TM12PD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.08	.14	.14	.08	.06	.09	.12	.06	.04	.10	.13	.01	1.05
1926	.06	.07	.08	.13	.02	.02	.13	.10	.08	.09	.09	.16	1.01
1927	.05	.15	.08	.15	.10	.04	.11	.09	.08	.10	.11	.09	1.15
1928	.10	.14	.07	.03	.05	.00	.09	.09	.00	.02	.11	.00	.70
1929	.10	.01	.15	.07	.06	.00	.07	.10	.07	.09	.11	.10	.91
1930	.13	.13	.04	.07	.09	.08	.08	.10	.08	.07	.13	.17	1.16
1931	.11	.17	.11	.12	.00	.04	.09	.02	.07	.10	.13	.11	1.07
1932	.14	.07	.08	.25	.07	.04	.06	.10	.08	.03	.13	.16	1.20
1933	.17	.00	.06	.01	.07	.06	.00	.04	.08	.07	.04	.15	.74
1934	.11	.00	.00	.24	.03	.01	.11	.08	.06	.10	.12	.15	1.03
1935	.17	.13	.21	.09	.01	.08	.09	.00	.08	.10	.13	.15	1.24
1936	.12	.00	.02	.15	.00	.11	.08	.10	.07	.09	.13	.15	1.03
1937	.15	.15	.05	.06	.09	.10	.01	.10	.02	.04	.10	.15	1.00
1938	.12	.14	.15	.14	.00	.06	.12	.05	.08	.07	.10	.12	1.15
1939	.13	.01	.16	.22	.11	.11	.08	.03	.00	.10	.12	.10	1.16
1940	.14	.13	.07	.12	.03	.00	.03	.10	.08	.10	.13	.15	1.06
1941	.10	.14	.19	.08	.00	.00	.03	.09	.07	.09	.09	.13	1.02
1942	.13	.00	.05	.10	.04	.05	.00	.01	.07	.03	.00	.15	.63
1943	.00	.00	.04	.17	.00	.06	.13	.08	.05	.10	.13	.02	.77
1944	.13	.10	.22	.22	.06	.00	.12	.08	.07	.10	.13	.17	1.41
1945	.18	.14	.13	.21	.00	.10	.08	.09	.08	.10	.13	.17	1.39
1946	.05	.03	.17	.21	.00	.00	.08	.10	.02	.10	.12	.10	.97
1947	.08	.04	.00	.00	.03	.00	.02	.09	.08	.10	.13	.14	.72
1948	.11	.11	.05	.17	.03	.01	.04	.09	.08	.10	.13	.11	1.02
1949	.14	.07	.16	.24	.12	.00	.06	.05	.07	.10	.09	.12	1.21
1950	.12	.00	.00	.15	.06	.02	.06	.09	.06	.10	.04	.10	.79
1951	.12	.17	.10	.00	.09	.01	.10	.09	.07	.04	.11	.13	1.06
1952	.09	.07	.03	.12	.00	.10	.06	.10	.08	.10	.09	.16	.99
1953	.12	.08	.07	.22	.00	.08	.07	.05	.07	.10	.13	.08	1.07
1954	.04	.00	.13	.04	.00	.09	.09	.07	.08	.10	.13	.16	.92
1955	.15	.14	.02	.26	.00	.00	.11	.10	.08	.10	.13	.12	1.19
1956	.18	.06	.00	.10	.11	.00	.02	.10	.07	.05	.06	.00	.74
1957	.01	.13	.11	.13	.00	.13	.00	.09	.08	.10	.13	.13	1.03
1958	.12	.05	.10	.17	.04	.15	.05	.01	.08	.08	.13	.16	1.13
1959	.02	.06	.13	.23	.00	.00	.00	.09	.08	.09	.12	.14	.97
1960	.11	.07	.06	.22	.03	.04	.00	.09	.07	.09	.11	.11	1.01
1961	.16	.09	.13	.05	.00	.04	.04	.09	.08	.10	.12	.15	1.04
1962	.17	.02	.00	.08	.04	.02	.06	.09	.05	.07	.13	.16	.89
1963	.10	.00	.18	.08	.15	.01	.05	.10	.04	.10	.12	.05	.97
1964	.01	.02	.16	.18	.10	.14	.09	.08	.00	.07	.04	.09	.98
1965	.15	.10	.13	.00	.06	.17	.11	.06	.05	.10	.09	.15	1.17
1966	.12	.01	.04	.05	.00	.03	.00	.04	.07	.09	.13	.16	.74
1967	.15	.12	.21	.14	.09	.04	.09	.09	.08	.09	.10	.16	1.35
1968	.17	.11	.12	.15	.10	.00	.07	.03	.07	.10	.12	.15	1.19
1969	.03	.15	.07	.20	.00	.12	.11	.09	.06	.10	.02	.05	1.01
1970	.11	.10	.20	.04	.11	.10	.08	.04	.08	.06	.10	.16	1.16
1971	.10	.07	.07	.13	.08	.00	.10	.05	.07	.10	.11	.17	1.05
1972	.11	.01	.19	.18	.03	.10	.00	.10	.08	.09	.01	.08	.99
1973	.17	.03	.11	.08	.00	.00	.03	.10	.05	.09	.11	.17	.94
1974	.15	.06	.00	.05	.00	.06	.06	.09	.08	.10	.12	.00	.78
1975	.17	.00	.05	.06	.00	.00	.08	.04	.08	.10	.13	.10	.81
1976	.08	.08	.14	.04	.12	.05	.09	.10	.07	.10	.12	.08	1.06
1977	.01	.08	.09	.00	.08	.02	.05	.10	.08	.10	.09	.07	.77
1978	.05	.11	.00	.17	.00	.07	.08	.07	.08	.07	.03	.14	.87
1979	.11	.10	.11	.14	.05	.11	.07	.09	.08	.10	.12	.04	1.10
1980	.15	.01	.00	.03	.00	.13	.09	.09	.05	.10	.06	.12	.84
1981	.17	.09	.15	.10	.15	.09	.11	.10	.06	.09	.13	.12	1.34
1982	.03	.14	.10	.11	.15	.08	.10	.05	.07	.07	.11	.16	1.17
1983	.08	.06	.00	.16	.14	.00	.02	.10	.07	.09	.07	.15	.95
1984	.06	.16	.19	.00	.02	.12	.13	.09	.06	.10	.13	.15	1.21
1985	.01	.10	.06	.10	.08	.08	.10	.10	.03	.10	.09	.16	1.01
1986	.00	.11	.03	.09	.00	.00	.12	.10	.05	.10	.00	.00	.59
1987	.11	.10	.06	.06	.00	.03	.07	.09	.03	.05	.12	.13	.85
1988	.05	.13	.03	.18	.00	.10	.12	.07	.06	.10	.12	.16	1.12
1989	.12	.00	.04	.20	.08	.07	.05	.09	.08	.10	.06	.17	1.05
1990	.13	.17	.01	.02	.00	.11	.13	.09	.05	.10	.13	.13	1.07
1991	.00	.09	.06	.16	.02	.10	.11	.10	.08	.10	.10	.16	1.07
1992	.16	.07	.10	.19	.01	.03	.08	.10	.08	.10	.13	.12	1.16
1993	.00	.06	.02	.06	.07	.00	.08	.08	.08	.08	.10	.17	.79
1994	.13	.16	.17	.01	.11	.00	.11	.09	.08	.10	.13	.11	1.19

Third phase irrigation water use for 1995 – TM14PDB.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.55	.42	1.20	.00	.63	.26	.81	.52	.31	.83	1.41	.23	
1926	.71	.36	.70	.55	.00	.00	.85	.77	.64	.55	.92	1.76	
1927	.49	.88	.13	.26	.52	.02	.71	.55	.64	.83	1.29	1.25	
1928	1.00	.97	.56	.26	.55	.00	.57	.70	.05	.42	1.31	.33	
1929	1.31	.00	.44	.00	.10	.40	.60	.75	.57	.71	1.11	1.35	
1930	1.27	1.05	.20	.00	.22	.34	.72	.76	.64	.59	1.41	1.83	
1931	1.16	.56	.61	.21	.00	.22	.88	.04	.49	.81	1.41	1.42	
1932	1.54	.61	.55	1.00	.31	.01	.61	.76	.63	.45	1.40	1.77	
1933	1.68	.00	.19	.00	.43	.21	.66	.31	.44	.37	.68	1.80	
1934	.81	.50	.00	.61	.37	.03	.31	.68	.53	.82	1.40	1.57	
1935	1.52	1.20	.92	.06	.00	.00	.86	.00	.64	.82	1.41	1.66	
1936	.96	.00	.96	.14	.00	.31	.81	.77	.61	.82	1.40	1.48	
1937	1.53	1.00	.10	.30	.14	.60	.44	.77	.00	.39	1.17	1.33	
1938	.00	.76	.00	.38	.00	.59	.79	.08	.63	.36	1.22	1.00	
1939	1.19	.00	.28	.34	.45	.36	.67	.00	.34	.82	1.39	1.14	
1940	1.18	.07	.14	.49	.06	.48	.00	.77	.64	.71	1.39	1.59	
1941	1.10	1.00	.14	.06	.00	.00	.39	.55	.54	.83	.99	1.29	
1942	.99	.00	.49	.00	.37	.23	.00	.00	.64	.00	.00	1.75	
1943	.00	.00	.27	.57	.00	.81	.93	.75	.00	.83	1.41	.17	
1944	1.18	.86	.76	.75	.40	.00	.72	.67	.63	.82	1.39	1.77	
1945	1.68	1.22	1.21	.31	.64	.02	.82	.66	.64	.83	1.41	1.66	
1946	.39	.00	.84	.92	.00	.27	.64	.77	.00	.79	1.38	1.39	
1947	1.08	.00	.49	.19	.77	.21	.57	.64	.64	.81	1.41	1.44	
1948	.66	.60	.75	.00	.13	.46	.13	.70	.59	.82	1.41	1.40	
1949	.74	.67	.13	.68	.29	.39	.39	.34	.61	.81	1.06	1.75	
1950	1.01	.58	.34	.82	.66	.32	.50	.66	.59	.68	.21	1.54	
1951	1.11	1.30	.10	.00	.71	.26	.35	.44	.63	.13	1.37	1.74	
1952	1.15	.14	1.04	.15	.00	.45	.19	.75	.60	.83	.51	1.68	
1953	1.43	.00	.82	.79	.00	.21	.73	.21	.57	.83	1.41	.97	
1954	.11	.00	.82	.00	.00	.57	.61	.76	.61	.83	1.40	1.75	
1955	.70	.48	.66	1.00	.20	.02	.95	.32	.64	.83	1.36	1.28	
1956	1.00	.00	.00	.00	.40	.20	.48	.75	.37	.00	.85	.00	
1957	.01	.95	.89	.34	.03	.05	.00	.77	.64	.83	1.41	1.24	
1958	.96	.08	.30	.72	.00	.74	.48	.06	.64	.70	1.35	1.62	
1959	.45	.21	.92	.23	.34	.29	.04	.72	.64	.82	.94	1.50	
1960	.89	.05	.14	1.03	.36	.00	.15	.38	.57	.83	1.41	1.25	
1961	1.39	.25	.78	.00	.02	.79	.35	.76	.64	.83	1.01	1.47	
1962	1.53	.30	.28	.21	.85	.00	.59	.69	.20	.00	1.41	1.83	
1963	1.06	.55	.98	.00	.60	.32	.49	.77	.17	.79	1.29	1.03	
1964	.15	.45	.57	.00	.29	.96	.57	.72	.00	.61	1.14	1.40	
1965	1.13	.69	.89	.00	.59	1.11	.20	.55	.59	.83	1.01	1.55	
1966	1.23	.46	.39	.00	.29	.00	.08	.70	.64	.81	1.40	1.68	
1967	1.45	.30	.71	1.08	.70	.28	.83	.70	.64	.82	.81	1.78	
1968	1.49	.60	.62	.39	.00	.00	.20	.53	.60	.65	1.41	1.73	
1969	.21	1.01	.59	.38	.00	.95	.55	.53	.52	.70	.54	1.33	
1970	.84	.60	1.13	.00	.64	.12	.35	.10	.61	.48	.93	1.68	
1971	1.08	.88	.24	.00	.00	.00	.84	.61	.56	.82	1.13	1.70	
1972	1.24	.50	1.13	.54	.00	.70	.01	.75	.64	.83	.35	.86	
1973	1.37	.00	.70	.00	.01	.41	.02	.74	.35	.77	1.28	1.82	
1974	1.47	.05	.35	.17	.00	.51	.26	.64	.64	.83	1.32	.00	
1975	1.33	.05	.26	.00	.00	.00	.25	.38	.64	.81	1.21	1.54	
1976	.34	.63	.54	.00	.69	.00	.27	.64	.64	.82	1.36	.98	
1977	.20	.72	.53	.00	.25	.00	.36	.77	.62	.83	.96	.84	
1978	.00	.55	.68	.42	.00	.79	.74	.57	.63	.11	.66	.81	
1979	1.35	.60	.72	.20	.03	.16	.75	.69	.64	.83	1.39	.75	
1980	.93	.08	.06	.00	.00	.79	.53	.70	.13	.83	.86	.90	
1981	1.26	.48	.96	.40	.91	.02	.83	.72	.60	.77	1.41	1.17	
1982	.00	.89	.99	.16	.82	.39	.68	.43	.54	.67	1.10	1.73	
1983	.62	.00	.30	.00	.65	.00	.26	.76	.39	.69	.50	1.52	
1984	.53	.90	.53	.00	.00	.93	.95	.73	.64	.83	1.40	1.51	
1985	.00	.05	.16	.00	.00	.27	.53	.77	.23	.83	1.28	1.72	
1986	1.07	.85	.23	.48	.00	.00	.71	.75	.58	.83	.46	.00	
1987	.86	.24	.57	.30	.00	.31	.41	.74	.20	.10	1.40	1.26	
1988	.46	.65	.04	.20	.00	.37	.66	.70	.46	.83	1.38	1.81	
1989	.99	.00	.48	.75	.50	.51	.23	.72	.64	.83	.86	1.83	
1990	1.13	.97	.00	.05	.00	.52	.94	.71	.30	.79	1.39	1.55	
1991	.00	.54	.00	.85	.00	.61	.10	.77	.64	.83	1.13	1.80	
1992	1.50	.51	.97	.57	.01	.30	.67	.77	.64	.83	1.22	1.59	
1993	.00	.19	.16	.10	.03	.00	.61	.77	.64	.68	.84	1.79	
1994	1.25	1.08	.57	.32	.85	.23	.65	.37	.64	.83	1.36	1.67	

Third phase irrigation water use for 1995 – TM14_MPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.45	.38	1.01	.01	.54	.25	.68	.43	.25	.66	1.10	.17	
1926	.58	.33	.60	.49	.01	.03	.72	.62	.51	.44	.71	1.38	
1927	.41	.74	.14	.25	.46	.05	.61	.45	.51	.66	1.00	.97	
1928	.81	.83	.51	.26	.47	.02	.49	.57	.05	.34	1.02	.25	
1929	1.05	.03	.40	.02	.12	.36	.52	.62	.47	.56	.86	1.05	
1930	1.02	.88	.20	.01	.21	.31	.61	.62	.51	.46	1.10	1.43	
1931	.93	.51	.54	.22	.00	.21	.74	.05	.40	.64	1.10	1.11	
1932	1.23	.54	.47	.85	.29	.06	.53	.62	.51	.36	1.09	1.39	
1933	1.33	.00	.18	.00	.38	.20	.56	.26	.36	.29	.52	1.41	
1934	.66	.44	.02	.54	.33	.07	.27	.56	.43	.65	1.09	1.23	
1935	1.22	1.00	.78	.08	.00	.03	.72	.00	.51	.65	1.10	1.30	
1936	.77	.01	.82	.15	.01	.28	.68	.62	.49	.65	1.09	1.16	
1937	1.22	.84	.11	.28	.14	.52	.38	.62	.00	.31	.91	1.05	
1938	.02	.65	.02	.35	.00	.51	.67	.08	.51	.28	.95	.79	
1939	.96	.00	.27	.32	.40	.33	.56	.00	.27	.65	1.08	.89	
1940	.95	.11	.15	.43	.09	.41	.02	.62	.51	.56	1.08	1.25	
1941	.90	.85	.16	.08	.02	.03	.36	.46	.44	.66	.77	1.00	
1942	.80	.00	.42	.00	.33	.23	.00	.01	.51	.00	.00	1.37	
1943	.00	.02	.26	.51	.00	.68	.78	.62	.01	.66	1.10	.13	
1944	.95	.73	.65	.65	.36	.00	.61	.55	.51	.65	1.08	1.38	
1945	1.34	1.02	1.02	.29	.56	.06	.69	.54	.51	.66	1.10	1.30	
1946	.32	.02	.72	.79	.00	.25	.55	.62	.01	.62	1.07	1.08	
1947	.87	.03	.43	.19	.65	.21	.49	.53	.51	.64	1.10	1.13	
1948	.54	.53	.64	.02	.13	.40	.14	.57	.47	.65	1.10	1.10	
1949	.60	.58	.13	.60	.27	.35	.34	.29	.49	.64	.82	1.37	
1950	.82	.51	.31	.70	.57	.30	.43	.54	.47	.54	.16	1.20	
1951	.90	1.09	.11	.01	.62	.24	.32	.37	.51	.11	1.07	1.36	
1952	.93	.16	.87	.16	.00	.40	.19	.61	.48	.66	.39	1.32	
1953	1.15	.02	.71	.68	.00	.20	.61	.17	.46	.66	1.10	.76	
1954	.10	.00	.71	.00	.02	.50	.53	.62	.50	.66	1.09	1.37	
1955	.57	.43	.57	.86	.19	.06	.80	.27	.51	.66	1.06	1.00	
1956	.81	.03	.00	.03	.36	.20	.42	.62	.30	.00	.66	.00	
1957	.02	.81	.76	.31	.07	.09	.00	.62	.51	.66	1.10	.97	
1958	.78	.11	.29	.63	.02	.63	.42	.07	.51	.55	1.05	1.27	
1959	.38	.22	.78	.23	.31	.27	.07	.59	.51	.65	.73	1.17	
1960	.72	.09	.14	.88	.33	.02	.15	.32	.46	.66	1.10	.98	
1961	1.11	.25	.67	.01	.05	.66	.31	.62	.51	.66	.79	1.15	
1962	1.22	.28	.26	.22	.72	.01	.50	.56	.16	.00	1.10	1.43	
1963	.84	.47	.84	.03	.53	.30	.42	.62	.14	.62	1.00	.80	
1964	.14	.40	.50	.03	.27	.81	.49	.59	.00	.49	.88	1.09	
1965	.90	.59	.76	.00	.51	.92	.20	.45	.47	.66	.79	1.21	
1966	.99	.42	.36	.00	.26	.00	.10	.57	.51	.64	1.09	1.31	
1967	1.15	.28	.62	.91	.60	.26	.70	.57	.51	.65	.63	1.39	
1968	1.20	.52	.54	.36	.04	.00	.20	.44	.49	.51	1.10	1.35	
1969	.19	.86	.51	.34	.02	.79	.48	.44	.42	.56	.41	1.03	
1970	.68	.52	.96	.02	.56	.14	.32	.09	.50	.38	.72	1.31	
1971	.84	.74	.22	.01	.03	.01	.71	.49	.45	.64	.88	1.33	
1972	.98	.43	.95	.47	.00	.60	.04	.62	.51	.66	.27	.68	
1973	1.11	.02	.62	.00	.05	.36	.06	.60	.28	.60	1.00	1.42	
1974	1.18	.09	.31	.17	.01	.45	.24	.52	.51	.66	1.03	.00	
1975	1.08	.09	.25	.01	.01	.00	.24	.31	.51	.64	.94	1.20	
1976	.28	.55	.47	.03	.59	.01	.26	.52	.51	.64	1.06	.76	
1977	.18	.62	.48	.00	.23	.04	.32	.62	.50	.66	.74	.66	
1978	.01	.49	.60	.38	.00	.67	.62	.47	.51	.09	.51	.63	
1979	1.08	.52	.61	.19	.06	.18	.63	.57	.51	.66	1.08	.58	
1980	.76	.12	.09	.02	.02	.68	.46	.57	.11	.65	.67	.71	
1981	1.02	.43	.82	.36	.77	.05	.70	.59	.49	.60	1.10	.91	
1982	.01	.75	.83	.18	.70	.35	.58	.36	.44	.53	.85	1.35	
1983	.52	.02	.26	.00	.56	.03	.24	.62	.32	.54	.39	1.19	
1984	.43	.77	.48	.00	.00	.78	.80	.60	.51	.65	1.09	1.18	
1985	.01	.09	.18	.01	.03	.25	.46	.62	.19	.66	.99	1.35	
1986	.86	.73	.21	.42	.02	.00	.60	.61	.47	.66	.35	.00	
1987	.69	.24	.50	.26	.01	.27	.37	.61	.17	.09	1.09	.98	
1988	.38	.56	.07	.21	.00	.34	.57	.57	.38	.66	1.07	1.42	
1989	.80	.00	.41	.64	.44	.44	.21	.59	.51	.66	.67	1.43	
1990	.90	.83	.04	.07	.01	.45	.78	.58	.25	.62	1.08	1.21	
1991	.02	.49	.03	.71	.03	.52	.14	.62	.51	.66	.88	1.41	
1992	1.20	.45	.81	.51	.04	.26	.57	.62	.51	.66	.95	1.24	
1993	.00	.20	.16	.13	.07	.03	.52	.62	.51	.54	.65	1.40	
1994	1.01	.91	.50	.30	.72	.22	.56	.31	.51	.66	1.06	1.31	

Third phase irrigation water use for 1995 – TM24PD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.66	.30	.58	.85	.99	.76	.53	.33	.00	.41	.67	.04	6.13
1926	.86	.37	.21	.68	.17	.24	.60	.39	.31	.16	.55	1.20	5.75
1927	.42	.82	.00	.69	.90	.52	.42	.36	.31	.41	.50	.63	5.99
1928	.86	.82	.17	.70	1.30	.00	.61	.36	.00	.08	.63	.00	5.53
1929	.75	.00	.04	.00	1.13	1.16	.10	.38	.30	.25	.53	.84	5.49
1930	1.02	.94	.00	.00	.66	1.00	.41	.40	.31	.31	.67	1.22	6.93
1931	.99	.59	.56	.67	.22	.39	.51	.03	.28	.40	.67	.98	6.27
1932	1.05	.50	.00	1.41	1.20	.51	.20	.39	.31	.21	.66	1.20	7.63
1933	1.14	.00	.00	.00	1.14	.52	.28	.19	.31	.11	.30	1.19	5.19
1934	.77	.06	.00	.74	.27	.36	.21	.33	.26	.41	.61	.93	4.95
1935	1.02	.92	.49	.00	.43	.00	.53	.00	.31	.41	.67	1.07	5.85
1936	.72	.00	.83	.00	.27	1.06	.22	.40	.31	.41	.66	.89	5.76
1937	1.14	.86	.00	.75	.90	1.13	.04	.35	.00	.21	.48	1.04	6.90
1938	.00	.75	.00	.58	.00	.59	.65	.11	.31	.13	.55	.91	4.58
1939	.90	.00	.00	.65	.52	1.37	.29	.00	.00	.40	.66	.54	5.33
1940	1.04	.14	.00	.69	.39	.44	.00	.40	.31	.39	.66	.98	5.46
1941	.92	.70	.12	.00	.09	.71	.22	.23	.14	.41	.47	.45	4.46
1942	.61	.00	.00	.00	1.16	.23	.00	.23	.29	.00	.00	1.12	3.64
1943	.00	.08	.00	.57	.00	1.04	.67	.39	.00	.41	.67	.00	3.82
1944	.26	.82	.73	1.16	.97	.00	.19	.37	.30	.41	.66	1.17	7.02
1945	1.34	1.04	1.02	.15	.77	.03	.59	.37	.31	.41	.67	1.16	7.87
1946	.44	.16	.43	1.14	.00	.68	.23	.40	.01	.37	.65	1.01	5.53
1947	.92	.00	.00	.04	.85	.58	.48	.31	.31	.41	.67	.73	5.30
1948	.38	.55	.49	.00	.24	.59	.00	.39	.30	.41	.67	.86	4.88
1949	.40	.29	.00	.76	.85	.92	.00	.20	.29	.39	.45	1.10	5.66
1950	.69	.63	.00	1.00	.58	.85	.11	.32	.28	.20	.12	1.10	5.88
1951	.54	.98	.00	.19	1.47	1.00	.23	.33	.31	.00	.65	1.16	6.88
1952	1.02	.00	.31	.00	.00	.90	.07	.40	.25	.41	.03	1.05	4.44
1953	.97	.20	.46	1.02	.00	.37	.51	.10	.22	.41	.67	.61	5.53
1954	.30	.00	.66	.02	.07	.74	.31	.38	.29	.41	.64	1.14	4.98
1955	.44	.59	.29	1.01	.30	.19	.62	.09	.29	.41	.66	.78	5.68
1956	.64	.00	.00	.58	.53	.14	.00	.37	.13	.00	.37	.08	2.84
1957	.02	.87	.53	.09	.40	.25	.00	.38	.31	.41	.67	.65	4.58
1958	.53	.35	.00	.95	.21	.94	.25	.13	.31	.30	.66	.94	5.58
1959	.37	.00	.17	1.03	.49	1.00	.00	.34	.31	.40	.45	.93	5.49
1960	.58	.32	.00	1.45	1.16	.18	.00	.26	.28	.41	.67	.73	6.04
1961	.96	.24	.35	.26	.34	1.02	.35	.39	.31	.41	.43	.91	5.97
1962	1.14	.44	.38	.04	1.67	.63	.43	.32	.00	.00	.67	1.23	6.95
1963	.55	.15	.65	.27	1.07	.92	.02	.39	.00	.40	.51	.74	5.68
1964	.00	.31	.00	.29	.54	1.48	.26	.38	.00	.30	.47	.91	4.92
1965	.49	.48	.52	.00	1.00	1.52	.14	.28	.30	.41	.43	.79	6.36
1966	.78	.31	.00	.00	.60	.82	.01	.37	.31	.40	.66	1.10	5.38
1967	.93	.20	.05	1.14	1.60	.62	.37	.33	.31	.40	.28	1.15	7.38
1968	1.27	.34	.03	.42	.83	.00	.00	.28	.27	.30	.67	.98	5.39
1969	.02	.78	.11	.75	.41	1.31	.24	.27	.27	.31	.20	.81	5.46
1970	.26	.59	.65	.00	1.03	.87	.00	.01	.30	.26	.42	.93	5.31
1971	.64	.63	.00	.69	.23	.00	.46	.27	.28	.40	.63	1.23	5.46
1972	.65	.33	.66	.89	.53	1.02	.00	.39	.31	.40	.00	.56	5.76
1973	1.06	.00	.33	.25	.12	.88	.00	.36	.13	.29	.57	1.12	5.10
1974	1.07	.00	.00	.31	.00	1.14	.01	.36	.31	.41	.65	.00	4.27
1975	1.08	.16	.00	.00	.44	.00	.03	.06	.31	.41	.65	1.00	4.13
1976	.10	.68	.00	.05	1.32	.49	.44	.37	.31	.41	.66	.81	5.62
1977	.63	.89	.00	.00	.54	.54	.08	.39	.31	.41	.32	.61	4.73
1978	.41	.54	.00	.77	.54	1.33	.40	.34	.28	.13	.15	.56	5.45
1979	1.12	.57	.05	.00	.15	1.08	.47	.39	.31	.41	.64	.42	5.61
1980	.91	.53	.01	.62	.45	1.39	.41	.38	.15	.41	.37	.54	6.18
1981	.87	.72	.67	.42	1.46	.72	.58	.35	.31	.35	.67	.98	8.09
1982	.01	.98	.52	.81	1.42	.84	.37	.20	.26	.34	.47	1.16	7.38
1983	.31	.00	.00	.00	1.08	.03	.30	.39	.19	.28	.15	1.03	3.76
1984	.00	.66	.39	.00	.00	1.35	.69	.39	.28	.39	.66	.95	5.76
1985	.02	.15	.00	.00	.21	.73	.13	.40	.19	.41	.63	1.08	3.95
1986	.61	.49	.00	.41	.21	.98	.26	.38	.25	.41	.20	.00	4.21
1987	.15	.06	.00	.63	.63	.34	.48	.35	.15	.36	.66	1.01	4.81
1988	.25	.70	.00	.57	.00	.99	.63	.37	.19	.41	.66	1.21	5.98
1989	.63	.00	.00	1.15	.80	.16	.20	.37	.31	.39	.54	1.23	5.78
1990	1.10	1.09	.00	.18	.00	.80	.68	.35	.00	.41	.66	.86	6.12
1991	.00	.50	.00	1.03	.00	1.11	.42	.40	.31	.41	.29	1.19	5.65
1992	.96	.53	.39	1.31	.00	1.08	.44	.40	.31	.41	.53	1.01	7.37
1993	.00	.52	.00	.00	.49	.64	.32	.36	.31	.31	.48	1.08	4.52
1994	.60	.85	.00	.19	1.07	.30	.26	.33	.31	.41	.67	1.23	6.24

Third phase irrigation water use for 1995 – TM26PD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.00	.00	.00	.24	.04	.23	.18	.00	.00	.25	.71	.32	1.96
1926	.17	.00	.00	.17	.00	.30	.00	.00	.11	.01	.71	.84	2.32
1927	.00	.00	.00	.28	.00	.08	.00	.00	.11	.25	.65	.50	1.86
1928	.00	.00	.00	.08	.32	.00	.05	.00	.00	.19	.62	.28	1.54
1929	.00	.00	.00	.00	.40	.41	.00	.00	.07	.16	.59	.88	2.51
1930	.36	.00	.00	.00	.00	.34	.00	.00	.11	.03	.71	.88	2.43
1931	.19	.00	.00	.27	.00	.00	.07	.00	.00	.24	.71	.81	2.27
1932	.03	.00	.00	.55	.00	.38	.00	.00	.08	.17	.71	.80	2.71
1933	.04	.00	.00	.00	.43	.13	.00	.00	.08	.02	.41	.88	1.99
1934	.03	.00	.00	.01	.03	.00	.05	.00	.03	.26	.70	.76	1.87
1935	.02	.00	.00	.00	.36	.00	.09	.00	.08	.25	.71	.72	2.24
1936	.00	.00	.00	.00	.00	.57	.15	.00	.11	.25	.71	.59	2.37
1937	.00	.00	.00	.22	.65	.33	.00	.00	.00	.15	.57	.78	2.70
1938	.00	.00	.00	.00	.00	.08	.20	.00	.11	.00	.47	.74	1.60
1939	.07	.00	.00	.08	.30	.25	.03	.00	.00	.26	.71	.68	2.38
1940	.04	.00	.00	.00	.00	.33	.00	.00	.11	.25	.68	.77	2.19
1941	.12	.00	.00	.00	.32	.04	.00	.00	.00	.26	.56	.37	1.66
1942	.00	.00	.00	.00	.00	.04	.00	.00	.11	.00	.40	.66	1.21
1943	.00	.00	.00	.24	.00	.33	.16	.00	.00	.26	.71	.25	1.94
1944	.00	.00	.00	.35	.10	.00	.13	.00	.11	.26	.67	.87	2.49
1945	.32	.00	.12	.00	.13	.00	.17	.00	.11	.25	.68	.86	2.65
1946	.00	.00	.00	.15	.00	.16	.00	.00	.00	.17	.71	.68	1.87
1947	.18	.00	.00	.00	.56	.00	.04	.00	.11	.26	.71	.55	2.40
1948	.00	.00	.00	.00	.32	.07	.00	.00	.11	.26	.71	.55	2.00
1949	.00	.00	.00	.05	.30	.43	.00	.00	.04	.26	.38	.69	2.15
1950	.00	.00	.00	.07	.55	.55	.05	.00	.11	.26	.22	.81	2.62
1951	.00	.00	.00	.00	.46	.31	.00	.00	.11	.00	.71	.87	2.46
1952	.10	.00	.00	.26	.00	.27	.00	.00	.09	.26	.63	.77	2.37
1953	.13	.00	.00	.20	.09	.07	.00	.00	.03	.22	.71	.36	1.81
1954	.00	.00	.00	.00	.00	.05	.04	.00	.10	.23	.67	.82	1.91
1955	.00	.00	.00	.28	.00	.00	.07	.00	.11	.20	.70	.43	1.78
1956	.00	.00	.00	.18	.08	.12	.00	.00	.00	.00	.43	.00	.81
1957	.00	.00	.00	.00	.48	.52	.00	.00	.11	.26	.71	.44	2.52
1958	.00	.00	.00	.29	.29	.40	.00	.00	.11	.23	.62	.59	2.52
1959	.00	.00	.00	.15	.15	.30	.00	.00	.11	.24	.56	.61	2.12
1960	.00	.00	.00	.30	.38	.04	.00	.00	.00	.26	.71	.34	2.01
1961	.01	.00	.00	.22	.40	.46	.01	.00	.11	.26	.60	.66	2.72
1962	.10	.00	.00	.00	.57	.22	.00	.00	.00	.00	.70	.89	2.49
1963	.00	.00	.07	.00	.57	.42	.00	.00	.06	.26	.61	.73	2.72
1964	.00	.00	.00	.05	.35	.52	.00	.00	.00	.21	.59	.68	2.41
1965	.00	.00	.00	.08	.13	.70	.11	.00	.08	.26	.58	.48	2.42
1966	.00	.00	.00	.00	.00	.44	.00	.00	.11	.06	.62	.80	2.03
1967	.00	.00	.00	.27	.62	.00	.13	.00	.11	.25	.34	.85	2.57
1968	.16	.00	.00	.00	.43	.00	.00	.00	.09	.21	.70	.61	2.21
1969	.00	.00	.00	.20	.24	.54	.05	.00	.02	.18	.46	.70	2.39
1970	.00	.00	.00	.00	.37	.36	.00	.00	.10	.23	.67	.62	2.35
1971	.00	.00	.00	.00	.08	.04	.03	.00	.09	.26	.69	.88	2.07
1972	.10	.00	.00	.00	.00	.14	.00	.00	.11	.25	.10	.41	1.12
1973	.00	.00	.00	.00	.11	.23	.00	.00	.00	.10	.66	.83	1.93
1974	.11	.00	.00	.00	.00	.39	.00	.00	.11	.25	.70	.41	1.98
1975	.00	.00	.00	.07	.14	.01	.00	.00	.11	.26	.69	.78	2.05
1976	.00	.00	.00	.00	.15	.23	.05	.00	.11	.26	.63	.56	1.99
1977	.00	.00	.00	.00	.00	.45	.00	.00	.11	.26	.44	.48	1.74
1978	.00	.00	.00	.41	.52	.53	.00	.00	.08	.05	.29	.47	2.35
1979	.06	.00	.00	.00	.00	.59	.10	.00	.11	.26	.68	.54	2.33
1980	.13	.00	.00	.00	.00	.10	.01	.00	.02	.22	.49	.47	1.45
1981	.00	.00	.00	.00	.71	.46	.11	.00	.10	.21	.71	.81	3.10
1982	.00	.00	.00	.23	.68	.29	.00	.00	.05	.19	.48	.87	2.79
1983	.00	.00	.00	.00	.35	.04	.01	.00	.00	.00	.30	.76	1.46
1984	.00	.00	.00	.00	.00	.65	.19	.00	.07	.25	.71	.81	2.67
1985	.00	.00	.00	.00	.07	.20	.00	.00	.00	.26	.68	.77	1.97
1986	.01	.00	.00	.18	.21	.41	.08	.00	.01	.20	.32	.00	1.43
1987	.00	.00	.00	.00	.46	.30	.07	.00	.02	.12	.59	.73	2.29
1988	.00	.00	.00	.00	.00	.47	.00	.00	.00	.24	.67	.89	2.28
1989	.00	.00	.00	.06	.26	.00	.00	.00	.11	.26	.58	.89	2.16
1990	.00	.00	.00	.00	.00	.00	.21	.00	.00	.26	.68	.78	1.92
1991	.00	.00	.00	.42	.00	.60	.13	.00	.11	.26	.63	.87	3.01
1992	.04	.00	.00	.30	.00	.14	.00	.00	.11	.26	.68	.73	2.27
1993	.00	.00	.00	.00	.16	.00	.02	.00	.11	.26	.65	.80	2.00
1994	.00	.00	.00	.01	.42	.19	.00	.00	.10	.26	.68	.88	2.53

Third phase irrigation water use for 1995 – V3PDB.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	1.38	.82	.65	1.15	1.87	.41	.90	.36	.00	.62	.97	.00	
1926	1.64	.84	.53	2.14	.82	.57	1.02	.59	.49	.00	.95	1.51	
1927	.77	1.54	.13	1.64	1.65	1.46	.69	.58	.49	.62	.64	1.09	
1928	1.23	1.35	.00	2.05	2.15	.00	.79	.60	.00	.35	.95	.24	
1929	.26	.53	.55	.26	1.77	1.79	.85	.60	.49	.25	.66	1.29	
1930	1.71	1.35	.00	.16	1.84	2.32	.14	.61	.49	.43	.97	1.80	
1931	1.71	1.07	1.20	2.11	.08	.52	.74	.00	.19	.61	.97	1.64	
1932	1.92	1.64	.00	1.84	2.10	1.94	.65	.61	.49	.25	.97	1.64	
1933	1.51	.00	.00	.10	1.94	1.13	.64	.42	.49	.17	.44	1.64	
1934	1.09	.43	.00	1.64	1.48	1.59	.21	.53	.48	.62	.89	1.62	
1935	1.49	1.61	.06	.00	1.34	.33	.79	.00	.49	.61	.96	.95	
1936	1.09	.00	1.38	.34	.53	1.83	.97	.61	.49	.62	.97	1.23	
1937	1.69	1.24	.22	1.42	1.59	1.23	.00	.61	.06	.34	.87	1.43	
1938	.59	1.10	.00	.76	.00	.66	.94	.31	.49	.01	.79	1.50	
1939	1.15	.08	1.00	2.14	1.30	2.13	.61	.00	.00	.62	.95	1.20	
1940	1.44	.61	.30	1.82	1.01	1.87	.00	.61	.49	.59	.97	1.30	
1941	1.62	1.22	.55	.00	1.07	.04	1.04	.37	.04	.62	.78	.95	
1942	1.17	.00	.16	1.41	1.09	.36	.00	.36	.48	.00	.00	1.51	
1943	.12	.20	.00	.54	.48	1.60	1.11	.60	.00	.62	.97	.50	
1944	.59	1.39	1.54	1.58	.89	.00	.75	.52	.49	.62	.97	1.63	
1945	2.00	1.30	1.62	1.14	1.54	1.01	.84	.59	.49	.61	.95	1.33	
1946	.76	.71	1.08	1.93	.82	1.39	.67	.61	.03	.43	.94	1.69	
1947	1.37	.00	.00	1.91	.26	1.08	.96	.51	.49	.62	.97	1.01	
1948	.80	.98	1.12	.27	.82	1.61	.00	.61	.49	.62	.97	1.25	
1949	.50	1.00	.00	1.80	1.87	1.47	.33	.38	.41	.60	.69	1.80	
1950	1.24	.80	.52	2.09	2.20	1.30	.19	.49	.47	.62	.00	1.43	
1951	.86	1.69	.00	.38	2.19	1.39	.24	.55	.48	.00	.97	1.80	
1952	1.91	.19	.65	2.19	.00	1.85	.20	.61	.41	.62	.62	1.56	
1953	1.62	.23	1.15	2.03	.05	1.86	.73	.37	.37	.62	.97	.94	
1954	.52	.01	1.06	.00	.01	1.57	.75	.60	.45	.61	.95	1.69	
1955	.43	.85	.64	2.42	.07	.75	.95	.12	.49	.62	.97	1.13	
1956	.53	.38	.00	1.36	1.69	.88	.00	.51	.21	.00	.75	.00	
1957	.00	1.54	1.22	1.35	1.71	1.71	.00	.60	.49	.58	.97	1.25	
1958	.85	.49	.05	1.44	1.36	1.94	.67	.21	.49	.59	.89	1.27	
1959	.52	.46	.49	2.40	1.19	1.56	.04	.39	.49	.62	.68	.99	
1960	.78	.08	.00	2.29	.73	1.46	.00	.39	.25	.62	.96	.78	
1961	1.33	.53	.88	.46	1.21	1.88	.78	.57	.49	.62	.59	1.23	
1962	1.14	.01	.00	.85	2.65	1.20	.57	.57	.00	.00	.97	1.79	
1963	.55	.37	1.40	.53	1.81	1.83	.76	.61	.23	.62	.78	1.57	
1964	.00	.94	.26	.35	1.67	2.20	.75	.59	.08	.47	.62	1.30	
1965	.83	.61	1.19	.61	1.30	2.34	.56	.49	.38	.62	.58	.87	
1966	1.26	1.20	.31	.00	.98	1.17	.80	.57	.49	.52	.94	1.69	
1967	1.05	.09	.36	1.54	2.53	1.17	.99	.60	.49	.60	.46	1.74	
1968	1.79	.57	.11	1.19	1.91	.50	.24	.50	.48	.47	.97	1.30	
1969	.07	1.14	.32	1.46	1.38	1.92	.66	.49	.37	.49	.51	1.10	
1970	.59	.92	.86	.75	2.25	1.92	.00	.23	.49	.50	.76	1.42	
1971	.74	1.06	.01	1.00	.73	1.14	.86	.33	.37	.60	.95	1.75	
1972	1.42	.74	1.01	1.63	.39	1.59	.00	.59	.49	.61	.01	.95	
1973	1.58	.70	.66	.91	1.47	1.21	.12	.48	.25	.31	.91	1.72	
1974	1.46	.05	.00	.49	.48	1.58	.00	.54	.49	.58	.96	.20	
1975	1.70	.33	.00	.79	1.25	.57	.13	.22	.49	.62	.94	1.46	
1976	.20	.89	.00	.34	1.86	1.02	.87	.61	.49	.62	.93	.94	
1977	.91	.62	.24	.00	.95	2.00	.09	.56	.49	.60	.48	.89	
1978	.25	.44	.82	1.25	1.47	2.04	.53	.51	.38	.33	.11	.65	
1979	1.49	.84	.71	.14	1.15	2.06	.95	.58	.49	.62	.94	.94	
1980	1.65	.28	.00	.00	1.12	1.17	.59	.48	.28	.57	.55	.63	
1981	1.55	1.25	.96	.74	2.11	1.22	.92	.59	.46	.56	.97	1.42	
1982	.56	1.51	.82	1.41	2.50	1.33	.50	.19	.44	.52	.57	1.76	
1983	.88	.00	.00	.00	1.69	.93	.47	.59	.23	.21	.30	1.26	
1984	1.00	1.20	1.09	1.23	.00	2.10	1.09	.57	.49	.59	.96	1.49	
1985	.00	.65	.18	.25	.85	1.01	.50	.61	.23	.62	.91	1.53	
1986	1.37	.84	.00	.63	1.75	1.09	.56	.61	.36	.62	.22	.00	
1987	.49	.25	.29	.57	2.17	1.67	.64	.57	.08	.28	.82	1.48	
1988	.55	.77	.00	1.39	.38	1.65	.74	.52	.17	.62	.91	1.76	
1989	.79	.00	.29	1.80	1.51	1.09	.00	.59	.49	.59	.75	1.80	
1990	1.47	1.53	.37	.26	.16	1.33	1.10	.43	.25	.60	.94	1.48	
1991	.19	1.29	.00	1.54	1.23	2.11	.79	.61	.49	.61	.79	1.69	
1992	1.60	.92	.21	1.85	.77	1.61	.80	.61	.49	.62	.79	1.51	
1993	.00	.92	.64	.91	.95	1.11	.64	.61	.49	.55	.76	1.72	
1994	.88	1.43	.25	1.09	2.32	1.21	.58	.50	.49	.62	.97	1.80	

Third phase irrigation water use for 1995 – V3_RORPD.IRD Units – 10^6m^3

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.34	.23	.19	.49	.54	.34	.27	.18	.00	.18	.30	.10	
1926	.31	.17	.14	.40	.03	.13	.28	.23	.14	.04	.26	.52	
1927	.21	.43	.00	.38	.56	.35	.25	.23	.14	.18	.23	.29	
1928	.34	.38	.11	.29	.57	.00	.21	.23	.00	.09	.29	.03	
1929	.32	.01	.14	.21	.50	.47	.06	.23	.14	.12	.23	.36	
1930	.40	.43	.00	.00	.37	.52	.19	.24	.14	.13	.30	.55	
1931	.43	.34	.43	.42	.00	.09	.25	.03	.12	.18	.30	.47	
1932	.50	.29	.00	.64	.49	.33	.15	.24	.13	.04	.29	.53	
1933	.43	.00	.00	.01	.44	.25	.18	.12	.14	.03	.11	.52	
1934	.40	.04	.00	.44	.37	.35	.03	.20	.12	.18	.28	.44	
1935	.49	.39	.02	.00	.09	.02	.27	.00	.14	.18	.30	.47	
1936	.31	.00	.37	.01	.15	.37	.18	.24	.14	.18	.30	.41	
1937	.51	.38	.00	.23	.26	.39	.05	.24	.00	.05	.26	.47	
1938	.02	.37	.00	.24	.13	.29	.27	.08	.14	.06	.26	.37	
1939	.38	.00	.03	.43	.39	.50	.03	.00	.00	.18	.29	.29	
1940	.27	.11	.01	.30	.25	.31	.00	.24	.14	.17	.30	.42	
1941	.42	.29	.06	.00	.18	.27	.28	.18	.07	.18	.22	.22	
1942	.27	.00	.00	.05	.53	.46	.00	.06	.12	.00	.00	.49	
1943	.00	.03	.00	.29	.02	.46	.28	.23	.00	.18	.30	.02	
1944	.27	.43	.21	.51	.43	.00	.11	.22	.14	.18	.30	.52	
1945	.58	.45	.44	.24	.57	.19	.24	.23	.14	.18	.30	.51	
1946	.12	.06	.20	.56	.03	.36	.17	.24	.01	.17	.28	.43	
1947	.35	.00	.00	.19	.22	.26	.16	.20	.14	.17	.30	.37	
1948	.15	.25	.18	.01	.27	.25	.02	.23	.13	.18	.30	.38	
1949	.17	.27	.00	.46	.48	.38	.01	.10	.13	.18	.21	.52	
1950	.33	.21	.01	.50	.51	.28	.15	.18	.14	.16	.05	.42	
1951	.31	.48	.00	.25	.68	.41	.07	.20	.14	.05	.29	.52	
1952	.54	.07	.13	.20	.00	.42	.02	.23	.12	.18	.12	.50	
1953	.53	.08	.27	.51	.00	.32	.18	.04	.12	.18	.30	.23	
1954	.12	.00	.34	.00	.04	.40	.18	.22	.14	.18	.29	.52	
1955	.26	.15	.17	.58	.00	.32	.30	.04	.14	.18	.30	.35	
1956	.24	.01	.00	.19	.39	.18	.00	.22	.08	.00	.15	.00	
1957	.00	.40	.26	.17	.45	.30	.00	.23	.14	.18	.30	.41	
1958	.28	.15	.03	.48	.29	.56	.14	.09	.14	.11	.28	.44	
1959	.24	.09	.09	.47	.29	.41	.00	.22	.14	.18	.24	.34	
1960	.28	.04	.00	.65	.41	.25	.00	.11	.11	.18	.30	.33	
1961	.40	.11	.27	.15	.33	.46	.11	.21	.14	.18	.23	.43	
1962	.47	.09	.00	.21	.77	.19	.14	.20	.00	.00	.30	.55	
1963	.17	.01	.36	.02	.51	.46	.10	.23	.01	.18	.24	.27	
1964	.00	.15	.03	.04	.40	.66	.17	.23	.00	.13	.21	.40	
1965	.28	.22	.28	.02	.40	.68	.10	.15	.13	.18	.20	.42	
1966	.42	.23	.01	.03	.20	.34	.04	.22	.14	.18	.30	.50	
1967	.35	.10	.01	.50	.67	.33	.23	.20	.14	.18	.13	.52	
1968	.57	.17	.00	.35	.35	.02	.01	.17	.12	.15	.30	.45	
1969	.06	.36	.01	.10	.21	.54	.13	.18	.12	.14	.02	.30	
1970	.09	.21	.29	.13	.63	.49	.00	.06	.14	.09	.21	.48	
1971	.13	.28	.00	.30	.20	.05	.25	.12	.10	.18	.28	.53	
1972	.28	.11	.24	.31	.13	.46	.00	.23	.14	.18	.01	.32	
1973	.54	.02	.32	.02	.30	.47	.00	.21	.05	.13	.25	.54	
1974	.52	.00	.00	.16	.03	.44	.00	.20	.14	.18	.28	.01	
1975	.50	.09	.00	.12	.24	.20	.03	.05	.14	.18	.29	.44	
1976	.01	.31	.00	.12	.61	.17	.22	.23	.14	.18	.29	.19	
1977	.18	.22	.15	.00	.19	.43	.09	.22	.13	.18	.17	.29	
1978	.03	.16	.19	.26	.26	.58	.16	.20	.13	.06	.04	.20	
1979	.52	.30	.07	.02	.40	.52	.21	.23	.14	.18	.29	.19	
1980	.44	.18	.00	.04	.31	.54	.14	.21	.03	.18	.16	.23	
1981	.46	.26	.32	.31	.57	.21	.27	.23	.14	.16	.30	.35	
1982	.02	.40	.11	.38	.64	.35	.21	.14	.12	.14	.19	.53	
1983	.27	.00	.00	.00	.44	.03	.16	.23	.09	.12	.09	.41	
1984	.13	.31	.32	.18	.00	.59	.30	.23	.14	.15	.30	.40	
1985	.02	.09	.07	.08	.26	.30	.12	.24	.06	.18	.28	.45	
1986	.37	.31	.00	.29	.35	.20	.15	.22	.10	.18	.09	.00	
1987	.22	.17	.14	.07	.39	.29	.19	.22	.06	.11	.28	.39	
1988	.15	.24	.00	.39	.01	.45	.26	.22	.08	.18	.29	.54	
1989	.33	.00	.13	.55	.41	.33	.00	.22	.14	.18	.20	.55	
1990	.38	.41	.01	.18	.00	.39	.26	.15	.03	.17	.29	.42	
1991	.04	.28	.00	.41	.34	.48	.17	.24	.14	.18	.24	.53	
1992	.48	.20	.02	.54	.13	.25	.21	.24	.14	.18	.22	.47	
1993	.00	.17	.01	.25	.38	.26	.13	.23	.14	.14	.24	.47	
1994	.36	.40	.02	.32	.63	.23	.20	.18	.14	.18	.29	.55	

Third phase irrigation water use for 1995 – WAGPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.07	.12	.17	.07	.06	.11	.09	.08	.02	.07	.10	.00	.96
1926	.04	.09	.00	.05	.07	.05	.09	.10	.07	.07	.05	.12	.80
1927	.03	.18	.02	.00	.13	.03	.11	.07	.07	.07	.08	.08	.88
1928	.05	.16	.05	.03	.05	.00	.08	.09	.00	.00	.09	.02	.61
1929	.08	.03	.12	.00	.06	.00	.09	.10	.05	.07	.09	.11	.79
1930	.09	.15	.13	.05	.12	.09	.04	.10	.07	.01	.10	.13	1.08
1931	.10	.16	.11	.02	.00	.06	.11	.04	.07	.07	.10	.07	.91
1932	.13	.03	.05	.15	.01	.06	.09	.10	.07	.02	.10	.13	.93
1933	.12	.00	.05	.00	.10	.05	.04	.03	.07	.02	.02	.11	.62
1934	.08	.00	.00	.17	.00	.05	.09	.07	.05	.07	.09	.12	.78
1935	.15	.15	.11	.00	.00	.06	.11	.00	.07	.07	.10	.10	.93
1936	.09	.02	.12	.10	.04	.11	.11	.10	.05	.07	.10	.12	1.03
1937	.14	.12	.03	.05	.08	.10	.00	.09	.04	.01	.07	.11	.85
1938	.02	.13	.05	.11	.00	.06	.10	.05	.07	.05	.08	.06	.78
1939	.07	.05	.04	.08	.07	.05	.09	.00	.01	.07	.10	.06	.69
1940	.14	.09	.00	.07	.00	.00	.05	.10	.07	.06	.10	.12	.80
1941	.08	.16	.10	.00	.00	.00	.05	.06	.06	.06	.06	.10	.73
1942	.09	.01	.03	.00	.09	.06	.00	.01	.06	.00	.00	.11	.46
1943	.00	.02	.10	.09	.00	.11	.12	.08	.03	.07	.10	.00	.73
1944	.12	.10	.17	.12	.07	.00	.08	.07	.07	.07	.10	.13	1.10
1945	.15	.17	.14	.04	.04	.05	.09	.09	.07	.07	.10	.13	1.13
1946	.07	.06	.11	.13	.00	.02	.08	.10	.00	.07	.10	.08	.83
1947	.06	.04	.03	.01	.05	.02	.05	.08	.07	.07	.10	.11	.69
1948	.11	.13	.07	.03	.04	.01	.07	.08	.07	.07	.10	.07	.84
1949	.13	.05	.05	.11	.09	.00	.07	.05	.07	.05	.03	.10	.81
1950	.13	.14	.01	.05	.08	.02	.08	.09	.07	.07	.01	.07	.82
1951	.10	.19	.06	.00	.06	.01	.11	.08	.07	.03	.08	.10	.88
1952	.08	.09	.00	.11	.00	.10	.07	.09	.07	.07	.04	.12	.83
1953	.08	.07	.06	.13	.00	.07	.07	.04	.07	.07	.10	.05	.79
1954	.06	.03	.05	.00	.00	.02	.05	.06	.06	.07	.10	.11	.62
1955	.13	.16	.02	.16	.00	.00	.10	.09	.07	.07	.09	.09	.98
1956	.13	.06	.00	.00	.06	.01	.04	.08	.07	.03	.03	.00	.50
1957	.00	.14	.09	.01	.03	.09	.03	.09	.07	.07	.10	.10	.83
1958	.11	.08	.10	.07	.00	.10	.05	.00	.07	.05	.08	.12	.83
1959	.06	.07	.06	.10	.01	.01	.03	.09	.07	.07	.08	.09	.72
1960	.09	.07	.00	.16	.04	.01	.04	.09	.07	.07	.08	.07	.79
1961	.15	.10	.08	.00	.00	.01	.02	.08	.07	.07	.07	.12	.77
1962	.12	.03	.06	.05	.12	.00	.08	.09	.05	.04	.10	.13	.86
1963	.08	.04	.12	.03	.12	.04	.08	.09	.03	.07	.10	.01	.81
1964	.00	.08	.09	.10	.11	.14	.07	.07	.00	.05	.02	.08	.80
1965	.13	.13	.10	.00	.09	.14	.08	.06	.06	.07	.06	.11	1.04
1966	.11	.02	.07	.00	.00	.00	.00	.08	.07	.06	.10	.12	.63
1967	.10	.06	.09	.10	.10	.07	.09	.09	.07	.07	.07	.11	1.03
1968	.14	.11	.08	.09	.06	.00	.06	.03	.07	.07	.10	.07	.86
1969	.05	.16	.05	.08	.01	.12	.12	.09	.06	.07	.00	.03	.83
1970	.08	.14	.12	.03	.10	.11	.08	.03	.07	.03	.05	.12	.97
1971	.07	.10	.10	.05	.05	.00	.08	.05	.07	.06	.09	.12	.86
1972	.08	.03	.16	.05	.03	.05	.03	.09	.07	.06	.01	.03	.70
1973	.15	.06	.06	.00	.02	.00	.03	.09	.04	.05	.09	.13	.73
1974	.13	.07	.04	.00	.00	.09	.07	.09	.07	.07	.09	.00	.73
1975	.13	.04	.00	.00	.00	.00	.08	.04	.07	.07	.10	.09	.62
1976	.05	.13	.10	.02	.14	.04	.03	.10	.07	.07	.09	.06	.87
1977	.03	.11	.07	.00	.09	.04	.02	.10	.07	.07	.07	.05	.73
1978	.05	.10	.00	.06	.06	.06	.09	.01	.07	.04	.01	.10	.66
1979	.12	.14	.09	.05	.09	.09	.10	.09	.07	.07	.09	.03	1.04
1980	.14	.07	.00	.00	.00	.11	.09	.09	.04	.07	.02	.10	.73
1981	.15	.07	.12	.05	.13	.01	.08	.10	.06	.07	.09	.03	.97
1982	.04	.17	.12	.07	.14	.05	.06	.07	.07	.03	.07	.12	1.01
1983	.07	.03	.06	.07	.12	.02	.05	.09	.05	.06	.04	.12	.79
1984	.07	.13	.11	.00	.00	.10	.13	.09	.06	.07	.10	.11	.97
1985	.01	.03	.09	.05	.07	.09	.08	.10	.04	.07	.04	.12	.80
1986	.05	.11	.09	.07	.02	.02	.11	.10	.06	.07	.00	.00	.68
1987	.11	.14	.13	.03	.00	.00	.08	.06	.00	.05	.09	.10	.79
1988	.12	.11	.02	.07	.01	.09	.10	.08	.06	.07	.10	.13	.98
1989	.10	.04	.10	.10	.10	.06	.07	.10	.06	.07	.03	.12	.95
1990	.11	.15	.00	.00	.05	.12	.12	.09	.05	.07	.10	.10	.97
1991	.00	.12	.00	.13	.02	.09	.08	.10	.07	.07	.09	.13	.89
1992	.12	.11	.00	.06	.00	.05	.09	.08	.07	.07	.10	.08	.85
1993	.00	.11	.05	.06	.03	.02	.07	.08	.07	.06	.07	.13	.75
1994	.11	.19	.04	.06	.13	.03	.10	.09	.07	.07	.10	.12	1.11

Third phase irrigation water use for 1995 – ZAAIDPD.IRD Units – $10^6 m^3$

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1925	.06	.00	.06	.22	.75	.44	.40	.00	.00	.57	1.58	.98	5.06
1926	.33	.00	.00	.37	.00	.57	.14	.00	.25	.06	1.57	1.94	5.23
1927	.00	.00	.00	.80	.78	.22	.00	.00	.25	.57	1.40	1.27	5.29
1928	.12	.00	.00	.28	1.08	.00	.12	.00	.00	.36	1.43	.47	3.86
1929	.00	.00	.00	.00	1.24	1.11	.02	.00	.21	.37	1.40	1.82	6.17
1930	.57	.00	.00	.00	.38	.88	.00	.00	.25	.28	1.58	1.97	5.91
1931	.40	.00	.00	.66	.00	.16	.17	.00	.10	.56	1.58	1.77	5.39
1932	.21	.00	.00	1.23	.03	.77	.00	.00	.16	.32	1.58	1.84	6.14
1933	.32	.00	.00	.00	.96	.62	.08	.00	.21	.10	1.05	1.93	5.26
1934	.05	.00	.00	.41	.42	.25	.16	.00	.15	.58	1.56	1.73	5.30
1935	.26	.00	.00	.00	.94	.18	.25	.00	.23	.57	1.58	1.70	5.71
1936	.02	.00	.00	.00	.00	1.39	.35	.00	.25	.58	1.58	1.55	5.72
1937	.23	.00	.00	.69	1.32	1.00	.00	.00	.00	.42	1.32	1.78	6.75
1938	.00	.00	.00	.02	.00	.60	.41	.00	.24	.00	1.17	1.70	4.14
1939	.29	.00	.00	.16	.81	.99	.04	.00	.00	.57	1.57	1.59	6.02
1940	.33	.00	.00	.23	.44	.51	.00	.00	.25	.54	1.56	1.78	5.65
1941	.33	.00	.00	.00	.71	.38	.00	.00	.04	.58	1.28	1.20	4.52
1942	.00	.00	.00	.02	.50	.09	.00	.00	.25	.00	.53	1.71	3.10
1943	.00	.00	.00	.77	.00	.79	.43	.00	.00	.58	1.58	.70	4.85
1944	.00	.00	.00	.93	.50	.00	.24	.00	.25	.58	1.55	1.95	5.99
1945	.76	.00	.14	.00	.46	.00	.36	.00	.25	.57	1.56	1.96	6.05
1946	.00	.00	.00	.64	.02	.54	.00	.00	.00	.24	1.57	1.76	4.77
1947	.45	.00	.00	.00	1.02	.49	.11	.00	.25	.58	1.58	1.24	5.71
1948	.10	.00	.07	.00	.64	.58	.00	.00	.24	.58	1.58	1.49	5.28
1949	.00	.00	.00	.50	.82	.43	.00	.00	.16	.57	1.14	1.82	5.42
1950	.02	.00	.00	.66	.49	1.33	.06	.00	.20	.48	.82	1.81	5.88
1951	.00	.00	.00	.00	1.37	1.13	.00	.00	.25	.00	1.57	1.95	6.28
1952	.42	.00	.00	.34	.00	.67	.00	.00	.21	.58	1.38	1.77	5.37
1953	.51	.00	.00	.66	.13	.22	.09	.00	.13	.55	1.58	1.09	4.95
1954	.00	.00	.00	.00	.00	.60	.17	.00	.22	.55	1.54	1.88	4.97
1955	.00	.00	.00	.95	.15	.00	.23	.00	.23	.52	1.58	1.39	5.06
1956	.00	.00	.00	.47	.53	.18	.00	.00	.04	.00	1.03	.35	2.60
1957	.00	.00	.00	.00	1.04	.83	.00	.00	.24	.58	1.58	1.31	5.57
1958	.07	.00	.00	.94	.92	1.00	.00	.00	.25	.51	1.52	1.56	6.77
1959	.00	.00	.00	.76	.53	.75	.00	.00	.25	.55	1.29	1.53	5.66
1960	.00	.00	.00	1.01	.93	.31	.00	.00	.00	.58	1.58	1.00	5.40
1961	.20	.00	.00	.32	.74	1.14	.14	.00	.25	.58	1.32	1.51	6.19
1962	.37	.00	.00	.00	1.44	.78	.06	.00	.00	.00	1.58	2.00	6.23
1963	.00	.00	.09	.00	.97	.94	.00	.00	.08	.58	1.36	1.56	5.57
1964	.00	.00	.00	.10	.89	1.40	.00	.00	.00	.47	1.29	1.74	5.89
1965	.03	.00	.01	.38	.83	1.64	.24	.00	.19	.58	1.27	1.17	6.35
1966	.02	.00	.00	.00	.30	1.24	.00	.00	.25	.35	1.46	1.82	5.44
1967	.00	.00	.00	.62	1.58	.04	.23	.00	.24	.57	1.00	1.93	6.21
1968	.49	.00	.00	.00	1.09	.00	.00	.00	.17	.44	1.58	1.54	5.31
1969	.00	.00	.00	.39	.83	1.38	.15	.00	.11	.39	1.04	1.59	5.88
1970	.00	.00	.00	.19	1.11	.82	.00	.00	.24	.50	1.40	1.51	5.78
1971	.00	.00	.00	.00	.37	.09	.15	.00	.22	.58	1.52	1.97	4.89
1972	.23	.00	.00	.24	.00	.56	.00	.00	.25	.56	.41	1.16	3.40
1973	.00	.00	.00	.17	.37	.71	.00	.00	.07	.34	1.47	1.67	4.81
1974	.38	.00	.00	.00	.04	1.10	.00	.00	.25	.57	1.56	.88	4.79
1975	.19	.00	.00	.40	.40	.21	.00	.00	.25	.57	1.56	1.78	5.36
1976	.00	.00	.00	.00	.66	.59	.17	.00	.25	.58	1.46	.44	4.15
1977	.00	.00	.00	.00	.53	1.10	.00	.00	.25	.57	1.00	1.27	4.71
1978	.00	.00	.00	1.13	1.25	1.18	.07	.00	.22	.18	.71	1.18	5.93
1979	.31	.00	.00	.00	.26	1.52	.30	.00	.24	.58	1.53	1.30	6.04
1980	.26	.00	.00	.00	.00	1.03	.02	.00	.06	.53	1.13	1.14	4.17
1981	.21	.00	.00	.00	1.69	1.20	.33	.00	.23	.47	1.58	1.76	7.48
1982	.00	.00	.00	.86	1.50	1.05	.09	.00	.18	.45	1.16	1.97	7.25
1983	.00	.00	.00	.00	.82	.17	.08	.00	.00	.00	.76	1.83	3.66
1984	.00	.00	.00	.16	.00	1.39	.44	.00	.16	.57	1.58	1.83	6.13
1985	.00	.00	.00	.02	.22	.49	.02	.00	.01	.58	1.50	1.77	4.62
1986	.08	.00	.00	.52	.76	1.17	.20	.00	.07	.47	.85	.03	4.14
1987	.00	.00	.00	.00	1.09	.40	.25	.00	.02	.23	1.49	1.61	5.10
1988	.00	.00	.00	.00	.00	1.13	.02	.00	.00	.57	1.51	1.99	5.22
1989	.00	.00	.00	.33	.74	.30	.00	.00	.25	.58	1.32	1.96	5.47
1990	.13	.00	.00	.00	.11	.11	.46	.00	.00	.57	1.53	1.70	4.63
1991	.00	.00	.00	1.07	.16	1.46	.34	.00	.25	.58	1.38	1.94	7.17
1992	.27	.00	.00	.75	.08	.56	.00	.00	.25	.58	1.55	1.65	5.69
1993	.00	.00	.00	.00	.67	.00	.04	.00	.25	.58	1.41	1.80	4.75
1994	.00	.00	.00	.24	.98	.51	.00	.00	.22	.55	1.54	1.95	5.98

APPENDIX L

IFR AND EFR DATA FROM THE JULY 1998 MEETING

Data for IFR A FROM JULY 1998 MEETING

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	0.2	0.0	0.4	0.0	0.4	0.0	0.5	0.0	0.7	0.0	0.6	0.0	0.3	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.2
0.6	0.2	0.8	0.4	0.8	0.4	2.8	0.5	4.1	0.7	4.0	0.6	2.8	0.3	2.2	0.2	1.8	0.1	1.2	0.1	1.1	0.1	0.8	0.2
0.7	0.4	1.0	0.7	1.4	0.8	5.0	1.0	8.0	1.2	6.3	1.0	4.5	0.6	2.9	0.3	2.1	0.2	1.5	0.2	1.2	0.2	0.9	0.3
0.9	0.7	1.8	1.3	3.3	1.6	9.4	1.8	14.9	2.5	11.4	2.0	7.1	1.0	3.9	0.5	2.7	0.3	1.8	0.3	1.4	0.2	1.1	0.3
1.2	1.0	3.7	1.9	6.2	2.2	12.8	2.3	19.1	3.8	15.9	2.7	8.3	1.3	4.4	0.8	3.0	0.4	2.1	0.3	1.6	0.3	1.2	0.4
1.5	1.1	5.2	2.2	10.0	2.5	18.2	2.8	25.8	5.6	21.9	3.2	9.8	1.6	4.8	0.8	3.3	0.5	2.3	0.4	1.8	0.4	1.4	0.6
2.2	1.3	9.5	2.4	12.9	2.8	26.0	3.2	32.5	6.5	26.6	3.5	12.3	1.7	5.4	0.9	3.7	0.5	2.6	0.4	1.9	0.5	1.7	0.7
7.0	1.4	15.8	2.5	20.6	3.0	39.4	3.3	51.0	7.1	38.2	3.7	16.8	1.8	7.0	0.9	4.8	0.6	3.2	0.5	2.5	0.5	2.5	0.8
999.0	1.4	999.0	2.5	999.0	3.1	999.0	3.3	999.0	7.2	999.0	3.8	999.0	1.8	999.0	0.9	999.0	0.6	999.0	0.5	999.0	0.5	999.0	0.9

* Combined flow from inflow files TM01, TM03, TM04 and TM05.

Data for IFR B FROM JULY 1998 MEETING

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	0.2	0.0	0.4	0.0	0.4	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.4	0.0	0.2	0.0	0.2	0.0	0.1	0.0	0.2	0.0	0.3
0.0	0.2	0.0	0.4	0.0	0.4	0.0	0.6	0.9	0.6	0.9	0.6	0.1	0.4	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.2	0.0	0.3
0.0	0.4	0.0	0.7	0.2	0.7	1.8	0.9	1.9	1.2	1.5	0.9	0.4	0.5	0.1	0.3	0.1	0.2	0.1	0.2	0.0	0.2	0.0	0.3
0.1	0.7	0.2	1.2	0.6	1.4	2.2	1.4	4.1	2.2	2.9	1.6	0.9	0.8	0.3	0.4	0.1	0.3	0.1	0.3	0.1	0.3	0.1	0.5
0.2	0.9	1.1	1.6	1.3	1.9	4.0	1.8	7.5	3.6	4.6	2.2	1.5	1.0	0.6	0.5	0.2	0.4	0.1	0.3	0.1	0.3	0.1	0.6
0.8	1.1	2.3	1.9	3.1	2.3	7.7	2.2	13.7	5.1	7.7	2.5	2.9	1.1	1.0	0.6	0.4	0.4	0.2	0.4	0.1	0.4	0.1	0.7
1.7	1.2	3.5	2.1	5.7	2.6	12.6	2.4	20.5	5.9	11.3	2.7	4.3	1.2	1.3	0.6	0.6	0.4	0.3	0.4	0.1	0.4	0.2	0.7
4.1	1.3	11.0	2.2	16.3	2.7	29.0	2.5	40.0	6.5	22.0	2.8	7.5	1.3	2.7	0.7	1.3	0.5	1.1	0.4	0.8	0.5	1.7	0.8
999.0	1.3	999.0	2.2	999.0	2.8	999.0	2.5	999.0	6.6	999.0	2.9	999.0	1.3	999.0	0.7	999.0	0.5	999.0	0.4	999.0	0.5	999.0	0.8

* Combined flow from inflow nodes TM11 and TM07.

Data for IFR 2 FROM JULY 1998 MEETING

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	1.3	0.0	2.0	0.0	3.0	0.0	3.5	0.0	4.0	0.0	3.5	0.0	3.0	0.0	2.0	0.0	1.5	0.0	1.0	0.0	1.0	0.0	1.0
1.2	1.3	1.4	2.0	1.1	3.0	8.0	3.5	11.0	4.0	9.6	3.5	6.6	3.0	4.2	2.0	3.0	1.5	2.3	1.0	2.0	1.0	1.6	1.0
1.6	1.8	3.0	3.8	4.7	3.6	12.0	8.0	17.0	6.4	15.9	6.0	11.0	3.6	5.8	2.7	4.5	1.6	3.0	1.0	2.4	1.0	1.7	1.0
2.5	2.5	9.1	5.0	6.0	9.4	20.0	10.0	28.2	13.0	31.8	10.0	13.2	6.0	6.9	4.8	4.9	3.3	3.2	1.7	2.5	1.5	1.9	1.5
4.4	2.9	16.3	6.1	14.0	10.8	31.5	12.2	38.8	25.0	43.0	13.0	19.4	8.0	8.6	4.8	5.8	3.5	3.7	2.2	2.7	1.8	2.2	1.8
7.2	3.3	20.1	6.4	25.0	12.2	48.6	13.3	62.0	34.0	54.1	13.8	23.1	9.3	10.0	5.2	6.1	3.7	3.9	2.7	2.9	1.9	2.9	2.1
13.0	3.3	42.5	6.4	32.0	13.4	92.5	14.5	72.0	39.0	70.0	13.8	31.0	9.3	11.6	5.2	7.4	3.7	5.0	2.7	3.2	2.2	3.2	2.1
23.0	4.0	68.0	6.4	52.0	13.4	126.0	15.2	143.0	39.0	124.0	13.8	58.0	9.3	15.0	5.2	9.2	3.7	6.5	2.7	5.4	2.2	6.0	2.1
999.0	4.0	999.0	6.4	999.0	13.4	999.0	15.2	999.0	42.0	999.0	15.0	999.0	12.0	999.0	5.2	999.0	3.7	999.0	2.7	999.0	2.2	999.0	2.1

* Combined flow from inflow files TM01, TM03, TM04, TM05, TM07, TM10, TM08 and TM11.

Data for IFR 3 FROM JULY 1998 MEETING

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	0.5	0.0	1.0	0.0	1.2	0.0	2.7	0.0	1.3	0.0	1.2	0.0	0.8	0.0	0.7	0.0	0.5	0.0	0.4	0.0	0.4	0.0	0.4
0.6	0.5	0.6	1.0	1.5	1.2	3.0	2.7	5.7	1.3	3.0	1.2	2.3	0.8	1.5	0.7	1.2	0.5	0.8	0.4	0.6	0.4	0.6	0.4
0.8	0.5	1.0	1.4	3.0	1.6	7.1	2.8	7.7	2.4	4.1	1.3	2.9	0.8	2.1	0.7	1.6	0.5	1.1	0.4	0.9	0.4	0.8	0.4
0.9	0.7	2.0	1.6	4.2	2.3	9.4	3.5	9.7	3.5	5.9	1.7	4.0	1.3	2.5	1.2	1.8	0.7	1.2	0.5	1.2	0.6	1.0	0.5
1.2	0.8	5.0	2.3	6.8	2.3	12.7	4.3	11.0	5.3	6.8	2.6	5.2	1.7	2.7	1.5	1.9	0.8	1.3	0.6	1.3	0.7	1.1	0.6
1.8	0.9	7.5	2.5	9.4	3.1	14.2	4.6	13.6	7.3	9.3	2.8	6.6	2.2	3.0	1.6	2.0	1.0	1.4	0.7	1.4	0.7	1.2	0.7
5.3	1.1	10.0	2.6	10.8	3.6	16.9	5.1	16.3	8.6	9.9	3.7	13.6	2.2	4.1	1.6	2.5	1.0	1.6	0.7	1.8	0.7	1.2	0.7
7.2	1.3	18.0	2.6	16.8	3.8	26.7	5.1	29.0	8.6	12.0	4.2	16.8	2.6	6.0	1.6	3.6	1.0	1.9	0.7	2.5	0.7	1.8	0.7
999.0	1.3	999.0	2.6	999.0	3.8	999.0	5.1	999.0	8.6	999.0	4.2	999.0	2.6	999.0	1.6	999.0	1.0	999.0	0.7	999.0	0.7	999.0	0.7

* Combined flow from inflow files TM19, TM18, TM13, TM17 and TM09.

Data for IFR 5 FROM JULY 1998 MEETING

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	1.8	0.0	3.5	0.0	5.0	0.0	8.5	0.0	10.0	0.0	8.0	0.0	4.8	0.0	2.8	0.0	2.0	0.0	1.4	0.0	1.4	0.0	1.7
0.9	1.8	1.0	3.5	2.0	5.0	6.0	8.5	9.0	10.0	9.0	8.0	5.5	4.8	3.2	2.8	2.2	2.0	1.8	1.4	1.3	1.4	1.1	1.8
1.2	1.8	1.7	3.7	3.8	8.0	9.5	9.5	15.0	17.0	13.0	10.0	6.8	5.0	3.8	3.3	2.6	2.0	2.0	1.4	1.4	1.4	1.2	2.3
1.8	4.3	6.5	3.9	5.1	10.8	14.0	11.0	22.0	25.0	17.0	12.0	8.1	5.2	4.7	3.3	2.9	2.0	2.3	1.4	1.7	1.4	1.4	2.7
2.5	4.6	8.1	7.2	11.5	13.4	23.4	12.5	32.0	33.0	24.0	15.0	11.1	7.7	5.0	5.4	3.5	3.3	2.6	2.1	2.0	1.7	1.5	2.8
3.8	4.8	11.9	8.2	19.8	15.5	29.4	16.8	50.0	44.0	37.7	17.0	16.0	11.2	6.0	6.6	4.3	4.8	2.7	4.3	2.1	2.9	1.8	3.5
7.9	4.8	15.0	9.0	31.0	18.0	41.0	18.5	70.0	55.0	43.5	18.5	26.0	12.4	6.8	7.7	4.6	5.5	3.0	4.3	2.8	3.7	2.4	3.6
9.5	5.7	23.0	9.0	67.0	18.0	66.0	20.0	143.0	55.0	107.0	18.5	60.0	12.4	16.0	7.7	7.8	5.5	5.5	4.3	5.0	3.8	2.9	3.6
999.0	5.7	999.0	9.0	999.0	18.0	999.0	20.0	999.0	55.0	999.0	18.5	999.0	12.4	999.0	7.7	999.0	5.5	999.0	4.3	999.0	3.8	999.0	3.6

* Combined flow from inflow files TM05, TM07, TM10, TM16, TM08, TM11, TM13, TM09, TM14 and TM15.

Data for the EFR FROM JULY 1998 MEETING

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.0	2.0	0.0	5.0	0.0	10.0	0.0	10.0	0.0	10.0	0.0	5.0	0.0	2.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	2.0
1.7	2.0	4.3	5.0	7.5	10.0	20.5	10.0	29.0	10.0	21.5	5.0	9.7	2.0	4.5	1.0	3.0	1.0	2.2	1.0	1.7	1.0	1.4	2.0
3.6	5.0	10.3	10.0	16.8	10.0	37.0	10.0	56.0	10.0	39.5	5.0	16.1	5.0	6.5	2.0	4.1	2.0	2.7	2.0	2.1	2.0	1.9	2.0
999.0	5.0	999.0	10.0	999.0	10.0	999.0	10.0	999.0	10.0	999.0	5.0	999.0	5.0	999.0	2.0	999.0	2.0	999.0	2.0	999.0	2.0	999.0	2.0

* Combined flow from inflow files TM05, TM07, TM10, TM16, TM08, TM11, TM13, TM09, TM14 and TM15.

APPENDIX M

FINAL FEASIBILITY IFR DATA

IFR A LOW SCENARIO

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.24	0.00	2.53	0.00	3.01	0.00	3.73	0.00	6.00	0.00	4.37	0.00	2.67	0.00	1.27	0.00	0.88	0.00	0.73	0.00	0.65	0.00	0.75
1.40	1.24	1.68	2.53	1.73	3.01	7.23	3.73	8.94	6.00	8.16	4.37	7.78	2.67	5.02	1.27	3.74	0.88	2.93	0.73	2.29	0.65	1.74	0.75
1.77	1.32	3.18	3.09	5.85	4.01	15.61	4.34	28.32	8.67	19.31	4.95	13.70	2.81	8.03	1.29	5.47	0.89	3.72	0.74	2.89	0.65	2.16	0.76
2.31	1.49	5.74	3.97	10.98	5.58	25.12	5.27	32.94	12.84	28.76	5.84	16.03	3.13	8.86	1.32	6.17	0.91	4.30	0.75	3.16	0.67	2.33	0.77
2.87	1.68	8.43	4.71	18.60	6.90	31.86	6.05	41.19	16.36	34.50	6.60	17.82	3.48	9.61	1.36	6.80	0.94	4.67	0.77	3.43	0.69	2.92	0.80
3.76	1.85	10.89	5.22	26.04	7.78	37.16	6.56	48.66	18.70	38.59	7.12	20.74	3.78	10.32	1.39	7.11	0.96	4.86	0.78	3.83	0.70	3.14	0.82
4.76	1.95	15.98	5.51	30.57	8.28	44.04	6.84	56.40	20.05	51.35	7.42	22.45	3.97	11.22	1.41	7.73	0.97	5.47	0.79	4.07	0.71	3.25	0.83
7.20	2.01	19.53	5.66	34.27	8.54	58.56	6.99	73.42	20.75	55.76	7.57	26.62	4.08	12.33	1.42	8.46	0.98	5.88	0.80	4.45	0.72	3.71	0.84
10.34	2.04	25.46	5.74	39.40	8.67	68.11	7.05	80.37	21.00	63.14	7.65	29.68	4.14	13.17	1.43	9.01	0.98	6.34	0.80	4.98	0.72	4.23	0.84
16.25	2.06	31.20	5.77	48.70	8.73	78.04	7.08	101.62	21.25	76.56	7.69	33.75	4.16	15.29	1.43	10.69	0.98	7.27	0.80	5.82	0.72	5.37	0.84
26.52	2.06	38.97	5.78	60.58	8.74	98.06	7.08	133.69	21.27	98.34	7.69	46.66	4.17	18.31	1.43	12.57	0.99	8.19	0.80	7.15	0.72	9.78	0.84
999.00	2.06	999.00	5.78	999.00	8.74	999.00	7.08	999.00	21.27	999.00	7.69	999.00	4.17	999.00	1.43	999.00	0.99	999.00	0.80	999.00	0.72	999.00	0.84

* Combined flow from inflow files TM01, TM02, TM03, TM04 and TM05.

Natural MAR at IFR A = 786.05 x$10^6 m^3$/a

IFR requirement = 109.44 x$10^6 m^3$/a

IFR requirement as a percentage of natural MAR = 14%

IFR A HIGH SCENARIO

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.80	0.00	2.80	0.00	2.80	0.00	3.40	0.00	4.90	0.00	4.05	0.00	2.59	0.00	1.81	0.00	1.60	0.00	1.30	0.00	1.23	0.00	1.33
0.60	1.80	0.70	2.80	0.60	2.80	2.50	3.40	3.90	4.90	3.50	4.05	2.60	2.59	1.90	1.81	1.50	1.60	1.10	1.30	0.90	1.23	0.80	1.33
0.80	2.00	1.30	4.80	2.70	3.90	7.30	6.20	10.90	12.30	9.20	7.97	6.50	2.63	3.50	2.03	2.60	1.71	1.70	1.33	1.30	1.49	1.00	1.55
1.00	2.20	2.10	5.50	3.90	7.40	12.10	7.90	16.00	13.40	14.50	9.29	8.10	4.73	4.20	2.49	2.90	2.12	2.00	1.80	1.40	1.82	1.10	1.95
1.30	2.30	3.90	6.20	8.70	8.60	14.90	10.50	19.40	19.50	16.00	10.02	9.10	6.27	4.70	3.69	3.20	2.94	2.20	2.39	1.50	2.03	1.20	2.20
1.60	2.40	4.70	6.60	10.90	9.80	17.20	11.70	26.10	23.10	20.70	12.27	9.80	7.44	4.90	4.06	3.30	3.19	2.30	2.77	1.70	2.28	1.40	2.41
2.00	2.60	6.90	6.80	14.80	10.20	21.10	12.00	29.90	25.00	24.90	14.11	11.30	9.60	5.20	4.83	3.60	3.62	2.50	3.02	1.90	2.52	1.50	2.66
2.70	3.00	9.90	7.30	16.90	10.60	30.10	12.90	34.00	26.70	28.10	14.41	13.20	9.81	5.70	4.87	3.80	3.65	2.60	3.03	2.00	2.55	1.70	2.74
4.20	3.30	11.90	7.30	19.90	10.60	34.10	13.30	41.70	27.6	31.60	15.16	15.20	10.12	6.10	4.87	4.00	3.65	2.80	3.04	2.20	2.60	1.80	2.75
6.70	3.40	15.90	7.30	23.50	10.60	38.90	13.40	51.60	27.6	38.50	15.18	17.40	10.17	7.20	4.87	4.80	3.65	3.30	3.04	2.50	2.61	2.40	2.75
11.80	3.40	21.20	7.30	32.70	10.60	49.90	13.40	62.00	27.6	44.00	15.18	20.40	10.17	8.80	4.87	5.60	3.65	3.80	3.04	3.00	2.61	3.90	2.75
999.00	3.40	999.00	7.30	999.00	10.90	999.00	13.40	999.00	27.6	999.00	18.53	999.00	10.17	999.00	5.39	999.00	3.65	999.00	3.04	999.00	2.61	999.00	2.75

* Combined flow from inflow files TM01, TM02, TM03, TM04 and TM05.

Natural MAR at IFR A = 786.05 $x10^6 m^3/a$

IFR requirement = 229.17 $x10^6 m^3/a$

IFR requirement as a percentage of natural MAR = 29%

IFR C LOW SCENARIO

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.19	0.00	2.39	0.00	2.83	0.00	3.45	0.00	5.51	0.00	4.06	0.00	2.52	0.00	1.22	0.00	0.86	0.00	0.72	0.00	0.63	0.00	0.70
1.35	1.19	1.59	2.39	1.64	2.83	6.82	3.45	8.37	5.51	7.95	4.06	7.36	2.52	4.79	1.22	3.57	0.86	2.79	0.72	2.18	0.63	1.66	0.70
1.70	1.27	3.06	2.92	5.49	3.77	14.81	4.01	26.76	7.95	18.10	4.59	12.60	2.65	7.27	1.24	5.17	0.87	3.55	0.72	2.74	0.64	2.06	0.71
2.16	1.43	5.23	3.77	10.46	5.22	22.65	4.89	29.36	11.78	26.84	5.42	15.20	2.94	8.21	1.27	5.89	0.89	4.09	0.74	3.02	0.65	2.26	0.73
2.78	1.61	7.84	4.44	17.97	6.45	27.83	5.61	36.70	15.00	32.55	6.13	16.78	3.27	9.12	1.31	6.48	0.91	4.46	0.75	3.24	0.67	2.78	0.75
3.51	1.76	10.38	4.92	24.35	7.26	34.84	6.08	44.84	17.14	36.54	6.00	19.34	3.55	9.76	1.34	6.86	0.93	4.67	0.77	3.67	0.69	3.01	0.77
4.49	1.87	14.40	5.19	29.07	7.23	41.15	6.34	51.02	18.38	45.06	6.88	20.70	3.73	10.66	1.36	7.34	0.95	5.20	0.78	3.90	0.70	3.12	0.78
6.80	1.92	18.68	5.34	31.90	7.98	50.84	6.47	64.33	19.02	48.38	7.03	24.56	3.83	11.32	1.37	7.94	0.95	5.62	0.78	4.20	0.70	3.51	0.79
9.99	1.95	23.48	5.41	35.66	8.09	58.55	6.54	69.08	19.33	53.19	7.10	27.70	3.89	12.54	1.38	8.57	0.96	6.06	0.78	4.75	0.70	4.08	0.79
15.43	1.96	27.69	5.44	41.36	8.15	63.46	6.56	88.10	19.48	64.51	7.13	30.19	3.91	14.37	1.38	10.15	0.96	6.91	0.79	5.55	0.71	5.14	0.79
20.06	1.97	35.20	5.45	54.54	8.15	80.47	6.56	117.00	19.49	84.27	7.14	40.85	3.91	17.01	1.38	11.83	0.96	7.83	0.79	6.69	0.71	9.35	0.79
999.00	1.97	999.00	5.45	999.00	8.15	999.00	6.56	999.00	19.49	999.00	7.14	999.00	3.91	999.00	1.38	999.00	0.96	999.00	0.79	999.00	0.71	999.00	0.79

* Combined flow from inflow nodes TM01, TM02, TM03, TM04 and TM06.

Natural MAR at IFR A = 698.65 $x10^6 m^3/a$

IFR requirement = 126.64 $x10^6 m^3/a$

IFR requirement as a percentage of natural MAR = 18%

IFR C HIGH SCENARIO

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.38	0.00	2.76	0.00	3.31	0.00	4.05	0.00	6.53	0.00	4.80	0.00	3.00	0.00	1.49	0.00	1.08	0.00	0.89	0.00	0.77	0.00	0.83
1.35	1.38	1.59	2.76	1.64	3.31	6.82	4.05	8.37	6.53	7.95	4.80	7.36	3.00	4.79	1.49	3.57	1.08	2.79	0.89	2.18	0.77	1.66	0.83
1.70	1.65	3.06	3.99	5.49	5.24	14.81	6.01	26.76	11.17	18.10	7.09	12.60	3.73	7.27	1.77	5.17	1.25	3.55	1.01	2.74	0.88	2.06	0.95
2.16	2.25	5.23	5.93	10.46	8.25	22.65	9.07	29.36	18.42	26.84	10.66	15.20	5.29	8.21	2.35	5.89	1.62	4.09	1.28	3.02	1.12	2.26	1.23
2.78	2.92	7.84	7.58	17.97	10.79	27.83	11.60	36.17	24.52	32.55	13.70	16.78	7.07	9.12	3.03	6.48	2.05	4.46	1.58	3.24	1.39	2.78	1.55
3.51	3.48	10.38	8.69	24.35	12.49	34.84	13.24	44.84	28.59	36.64	15.74	19.34	8.53	9.76	3.60	6.86	2.42	4.67	1.85	3.67	1.63	3.01	1.82
4.49	3.86	14.40	9.34	29.07	13.46	41.15	14.17	51.02	30.93	45.06	16.93	20.70	9.51	10.66	3.99	7.34	2.67	5.20	2.04	3.90	1.79	3.12	2.01
6.80	4.07	18.68	9.68	31.90	13.97	50.84	14.64	64.33	32.15	48.38	17.56	24.56	10.07	11.3	4.22	7.94	2.82	5.62	2.15	4.20	1.89	3.51	2.12
9.99	4.17	23.48	9.85	35.66	14.21	58.55	14.86	69.08	32.74	53.19	17.87	27.70	10.34	12.54	4.33	8.57	2.90	6.06	2.22	4.75	1.94	4.08	2.17
15.43	4.22	27.69	9.93	41.36	14.32	63.46	14.95	88.10	33.01	64.51	18.01	30.19	10.47	14.37	4.39	10.15	2.93	6.91	2.25	5.55	1.96	5.14	2.20
20.06	4.23	35.20	9.94	54.54	14.34	80.47	14.95	117.00	33.04	84.27	18.03	40.85	10.50	17.01	4.40	11.83	2.95	7.83	2.26	3.69	1.97	9.35	2.21
999.00	4.23	999.00	9.94	999.00	14.34	999.00	14.95	999.00	33.04	999.00	18.03	999.00	10.50	999.00	4.40	999.00	2.95	999.00	2.26	999.00	1.97	999.00	2.21

* Combined flow from inflow nodes TM01, TM02, TM03, TM04 and TM06.

Natural MAR at IFR A = 698.65 $x10^6 m^3/a$

IFR requirement = 253.69 $x10^6 m^3/a$

IFR requirement as a percentage of natural MAR = 36%

IFR 2

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.30	0.00	3.20	0.00	3.40	0.00	3.60	0.00	4.40	0.00	3.50	0.00	3.00	0.00	2.00	0.00	1.50	0.00	1.00	0.00	1.00	0.00	1.00
1.20	1.30	1.10	3.20	1.10	3.40	8.20	3.60	9.30	4.40	8.20	3.50	6.30	3.00	4.10	2.00	2.90	1.50	2.10	1.00	2.10	1.00	1.70	1.00
1.90	1.60	3.10	3.80	6.10	5.20	15.10	8.70	22.80	10.20	18.80	6.90	11.20	3.60	6.20	3.60	4.40	2.60	3.10	1.60	2.40	1.10	1.90	1.50
2.40	2.30	4.80	4.10	8.80	9.50	24.70	10.80	33.20	19.60	28.90	8.90	15.90	7.30	7.50	5.10	5.00	3.40	3.50	2.10	2.60	1.70	2.30	1.60
3.20	2.80	9.10	5.30	17.30	11.60	31.80	12.60	50.30	31.30	37.20	13.10	17.80	8.40	8.50	5.20	5.70	3.60	3.80	2.70	2.90	2.00	2.50	1.80
4.60	3.00	11.30	5.80	23.10	12.40	42.50	13.20	62.60	37.20	44.90	13.50	20.90	9.20	9.60	5.20	5.90	3.70	4.10	2.70	3.30	2.20	2.70	1.90
5.60	3.20	15.50	6.10	29.40	13.30	48.40	14.30	69.00	39.30	53.50	13.70	21.90	9.30	10.30	5.30	6.50	3.70	4.50	2.70	3.50	2.20	2.90	2.10
8.00	3.30	20.80	6.30	39.20	13.40	61.10	14.70	79.30	39.30	63.40	13.70	29.20	9.30	11.10	5.30	7.20	3.70	4.90	2.70	3.80	2.20	3.70	2.10
11.10	3.30	26.10	6.40	47.70	13.40	88.00	14.90	98.30	39.30	71.70	13.70	33.10	9.30	12.40	5.30	7.60	3.70	5.50	2.70	4.70	2.20	4.60	2.10
17.10	3.90	34.00	6.40	59.60	13.40	99.60	15.10	133.00	39.40	89.70	13.70	39.80	9.30	14.10	5.30	8.70	3.70	6.40	2.70	5.10	2.20	5.90	2.10
26.40	4.00	57.10	6.40	69.70	13.40	126.90	15.10	163.80	40.10	113.30	13.70	46.80	9.30	19.20	5.30	10.60	3.70	7.40	2.70	7.60	2.20	12.00	2.10
999.00	4.00	999.00	6.50	999.00	13.40	999.00	15.10	999.00	43.00	999.00	25.10	999.00	15.10	999.00	5.30	999.00	3.70	999.00	2.70	999.00	2.20	999.00	2.10

* Combined flow from inflow files TM01, TM03, TM04, TM05, TM07, TM10,TM08 and TM11.

Natural MAR at IFR A = 1416.53 x$10^6 m^3$/a

IFR requirement = 258.17 x$10^6 m^3$/a

IFR requirement as a percentage of natural MAR = 18%

IFR 3

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	0.50	0.00	1.10	0.00	1.10	0.00	2.60	0.00	1.30	0.00	1.20	0.00	0.90	0.00	0.70	0.00	0.50	0.00	0.40	0.00	0.40	0.00	0.40
0.50	0.50	0.50	1.10	0.80	1.10	2.20	2.60	5.00	1.30	2.50	1.20	2.10	0.90	1.50	0.70	1.10	0.50	0.80	0.40	0.60	0.40	0.50	0.40
1.00	0.50	1.50	1.50	3.40	1.50	6.90	2.80	7.50	1.90	4.60	1.50	2.80	1.00	1.90	0.70	1.40	0.50	1.10	0.40	0.90	0.40	0.80	0.40
1.20	0.80	2.50	1.70	5.10	2.30	8.60	3.00	9.30	3.00	6.60	2.50	4.40	1.20	2.40	0.90	1.70	0.60	1.30	0.60	1.10	0.50	1.00	0.50
1.50	0.90	4.70	2.20	7.00	2.30	10.30	3.70	11.10	5.30	9.00	2.70	5.50	1.70	2.70	1.10	2.00	0.80	1.50	0.70	1.20	0.60	1.20	0.70
2.10	1.00	6.00	2.40	9.10	3.10	11.20	4.10	13.20	6.80	10.90	3.80	6.60	2.10	3.10	1.50	2.10	1.00	1.60	0.70	1.30	0.70	1.30	0.70
2.70	1.00	6.90	2.50	11.10	3.50	13.80	4.50	15.60	7.90	14.00	4.10	7.80	2.10	3.60	1.60	2.40	1.00	1.70	0.70	1.60	0.70	1.50	0.70
3.40	1.00	8.00	2.50	13.20	3.60	15.70	4.80	16.70	8.60	16.40	4.10	9.70	2.10	4.00	1.60	2.60	1.00	1.80	0.70	1.70	0.70	1.70	0.70
5.30	1.00	10.00	2.60	16.00	3.70	20.20	5.00	21.50	8.60	18.00	4.10	12.30	2.10	5.30	1.60	3.20	1.00	2.20	0.70	1.90	0.70	2.20	0.70
7.60	1.20	12.40	2.60	18.40	3.80	27.30	5.00	31.20	8.60	20.40	4.10	15.20	2.10	5.90	1.60	3.50	1.00	2.30	0.70	2.30	0.70	3.10	0.70
9.40	1.30	18.10	2.60	26.90	3.80	35.30	5.00	39.00	8.60	26.50	4.10	19.80	2.60	7.20	1.60	4.70	1.00	3.10	0.70	3.70	0.70	7.00	0.70
999.00	1.30	999.00	2.70	999.00	3.80	999.00	5.00	999.00	8.70	999.00	4.20	999.00	2.60	999.00	1.60	999.00	1.00	999.00	0.70	999.00	0.70	999.00	0.70

Note : * Combined flow from inflow files TM19, TM18, TM13, TM17 and TM09.

Natural MAR at IFR A = 288.21 $x10^6 m^3/a$

IFR requirement = 68.26 $x10^6 m^3/a$

IFR requirement as a percentage of natural MAR = 24%

IFR 5

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.90	0.00	3.70	0.00	9.20	0.00	8.40	0.00	17.40	0.00	7.90	0.00	4.90	0.00	3.10	0.00	2.00	0.00	1.40	0.00	1.40	0.00	2.40
1.10	1.90	0.90	3.70	0.90	9.20	6.20	8.40	7.50	17.40	7.00	7.90	5.70	4.90	3.10	3.10	2.10	2.00	1.60	1.40	1.60	1.40	1.30	2.40
1.80	3.90	2.90	5.40	5.90	12.40	12.00	14.40	15.90	35.30	14.70	13.40	9.30	7.60	4.50	5.30	3.00	3.10	2.30	1.40	1.90	1.40	1.70	2.80
2.40	4.50	6.10	6.60	9.30	13.40	25.00	17.20	26.40	36.20	20.20	15.70	11.30	8.50	5.60	5.90	3.60	3.50	2.60	1.50	2.10	1.60	2.00	3.10
3.50	4.90	8.80	7.80	13.00	15.10	30.70	17.80	45.60	44.90	32.20	17.00	14.00	11.40	6.30	7.20	3.90	4.70	2.90	3.50	2.40	3.30	2.20	3.50
4.50	4.90	11.30	8.80	17.80	16.80	36.50	18.90	58.00	53.30	36.30	18.30	15.80	11.80	7.20	7.70	4.70	5.50	3.00	4.30	2.70	3.70	2.50	3.60
6.50	4.90	12.70	8.90	23.80	17.70	41.50	19.60	66.80	55.60	41.30	18.40	21.30	12.10	7.80	7.70	5.00	5.50	3.40	4.30	3.00	3.70	2.70	3.60
7.90	5.70	17.00	9.00	34.30	18.00	57.80	20.00	76.00	55.60	55.00	18.40	23.90	12.30	9.60	7.70	5.20	5.50	3.60	4.30	3.20	3.70	3.30	3.60
10.40	5.70	24.00	9.00	48.80	18.00	88.50	20.10	96.10	55.60	59.80	18.40	27.00	12.30	10.20	7.70	5.90	5.50	4.60	4.30	3.70	3.70	4.60	3.60
18.50	5.70	35.30	9.00	58.00	18.00	113.40	20.10	129.50	55.60	85.20	18.40	32.80	12.30	12.60	7.70	7.10	5.50	5.40	4.30	5.50	3.70	6.20	3.60
24.40	5.70	57.10	9.10	80.70	18.10	149.50	20.10	160.90	56.20	99.00	26.80	41.00	12.30	14.50	8.10	8.50	5.50	6.90	4.30	7.40	3.70	12.60	3.60
999.00	5.70	999.00	9.50	999.00	18.20	999.00	20.10	999.00	56.30	999.00	33.60	999.00	13.50	999.00	9.50	999.00	5.50	999.00	4.30	999.00	3.70	999.00	3.60

* Combined flow from inflow files TM05, TM07, TM10, TM16, TM08, TM11, TM13, TM09, TM14 and TM15.

Natural MAR at IFR A = 2013.20 x$10^6 m^3$/a

IFR requirement = 348.96 x$10^6 m^3$/a

IFR requirement as a percentage of natural MAR = 17%

IFR SUN

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	0.29	0.00	0.58	0.00	0.49	0.00	0.73	0.00	0.68	0.00	0.67	0.00	0.40	0.00	0.25	0.00	0.21	0.00	0.19	0.00	0.29	0.00	0.27
0.20	0.29	0.20	0.58	0.10	0.49	1.00	0.73	0.80	0.68	1.00	0.67	0.90	0.40	0.50	0.25	0.40	0.21	0.30	0.19	0.30	0.29	0.30	0.27
0.40	0.33	0.70	0.68	1.20	0.60	1.60	1.07	1.70	0.82	1.90	0.78	1.40	0.44	0.90	0.27	0.60	0.22	0.50	0.20	0.40	0.31	0.40	0.29
0.60	0.46	0.90	0.93	1.70	0.88	2.40	1.79	3.20	1.18	2.50	1.06	1.80	0.54	1.00	0.33	0.80	0.27	0.60	0.24	0.50	0.37	0.50	0.35
0.80	0.62	1.60	1.23	1.90	1.22	3.30	2.63	5.20	1.61	3.80	1.39	2.10	0.67	1.10	0.40	0.90	0.33	0.60	0.29	0.60	0.45	0.60	0.42
1.00	0.76	2.10	1.50	2.50	1.52	5.90	3.35	7.70	1.99	4.00	1.69	2.30	0.78	1.30	0.47	1.00	0.38	0.70	0.34	0.60	0.52	0.60	0.48
1.30	0.86	2.40	1.69	3.80	1.74	7.50	3.87	10.50	2.27	5.20	1.90	2.50	0.86	1.60	0.52	1.10	0.42	0.70	0.38	0.70	0.56	0.70	0.52
1.50	0.92	3.20	1.80	6.30	1.87	9.60	4.18	13.90	2.43	7.30	2.03	3.30	0.91	1.60	0.55	1.10	0.44	0.90	0.40	0.70	0.59	0.80	0.55
2.50	0.95	4.70	1.87	8.70	1.93	14.60	4.35	20.50	2.52	8.90	2.10	3.60	0.94	1.90	0.56	1.20	0.45	1.10	0.41	0.90	0.61	1.10	0.56
3.50	0.97	9.50	1.90	11.30	1.97	22.50	4.43	22.40	2.56	11.30	2.13	4.40	0.95	2.20	0.57	1.40	0.46	1.20	0.41	1.20	0.62	1.40	0.57
7.70	0.98	16.40	1.91	16.90	1.98	35.40	4.47	31.30	2.58	15.50	2.15	7.40	0.96	3.30	0.57	1.70	0.46	1.50	0.42	1.60	0.62	2.50	0.57
999.00	0.98	999.00	1.91	999.00	1.98	999.00	4.47	999.00	2.58	999.00	2.15	999.00	0.96	999.00	0.57	999.00	0.46	999.00	0.42	999.00	0.62	999.00	0.57

* Combined flow from inflow files TM14 and TM15.

Natural MAR at IFR A = 193.31 x$10^6$$m^3$/a

IFR requirement = 35.79 x$10^6$$m^3$/a

IFR requirement as a percentage of natural MAR = 19%

IFR BUF

October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	1.34	0.00	2.96	0.00	2.21	0.00	3.04	0.00	2.73	0.00	2.65	0.00	1.60	0.00	1.00	0.00	0.78	0.00	0.89	0.00	0.93	0.00	0.90
0.50	1.34	0.60	2.96	0.50	2.21	3.30	3.04	4.00	2.73	3.20	2.65	2.80	1.60	1.30	1.00	0.70	0.78	0.70	0.89	0.60	0.93	0.70	0.90
1.50	1.61	2.60	3.66	5.10	2.89	6.90	4.85	11.70	3.57	7.80	3.30	4.50	1.82	1.90	1.13	1.30	0.87	0.90	0.98	0.90	1.04	0.90	0.99
2.10	2.40	6.00	5.39	7.40	4.56	13.00	8.74	18.40	5.63	10.40	4.92	5.40	2.47	2.80	1.52	1.60	1.15	1.10	1.27	1.10	1.33	1.20	1.27
3.40	3.40	9.70	7.49	10.00	6.57	26.10	13.30	28.20	8.13	14.20	6.88	8.20	3.28	3.30	2.00	1.80	1.50	1.40	1.64	1.30	1.71	1.50	1.61
4.60	4.29	12.60	9.33	16.30	8.34	32.20	17.20	38.20	10.30	19.00	8.61	8.80	4.00	3.60	2.43	2.30	1.81	1.50	1.99	1.60	2.04	1.80	1.92
5.20	4.93	13.80	10.70	18.40	9.61	43.30	20.00	48.60	11.90	25.10	9.84	10.40	4.52	4.40	2.74	2.60	2.03	1.70	2.24	1.80	2.29	2.20	2.14
7.10	5.32	17.80	11.50	34.20	10.40	52.80	21.70	59.00	12.90	32.70	10.60	13.40	4.84	5.00	2.93	3.20	2.17	2.40	2.39	2.10	2.43	2.60	2.28
10.30	5.53	27.40	11.90	51.70	10.80	75.10	22.60	77.40	13.40	45.10	11.00	16.00	5.01	6.60	3.03	3.80	2.24	3.00	2.47	2.70	2.51	3.10	2.35
14.90	5.63	62.50	12.10	62.20	11.00	99.60	23.10	112.10	13.60	66.50	11.20	24.70	5.09	7.80	3.08	4.60	2.27	3.70	2.51	3.60	2.55	5.50	2.39
28.90	5.67	78.60	12.20	107.40	11.10	129.20	23.30	176.50	13.70	81.10	11.30	33.10	5.13	13.70	3.10	5.60	2.29	4.70	2.52	5.60	2.56	10.60	2.40
999.00	5.67	999.00	12.20	999.00	11.10	999.00	23.30	999.00	13.70	999.00	11.30	999.00	5.13	999.00	3.10	999.00	2.29	999.00	2.52	999.00	2.56	999.00	2.40

* Combined flow from inflow files TM24, TM25, TM26, TM31, TM27 and TM28.

Natural MAR at IFR A = 844.05 $x10^6 m^3/a$

IFR requirement = 187.8 $x10^6 m^3/a$

IFR requirement as a percentage of natural MAR = 22%

EFR

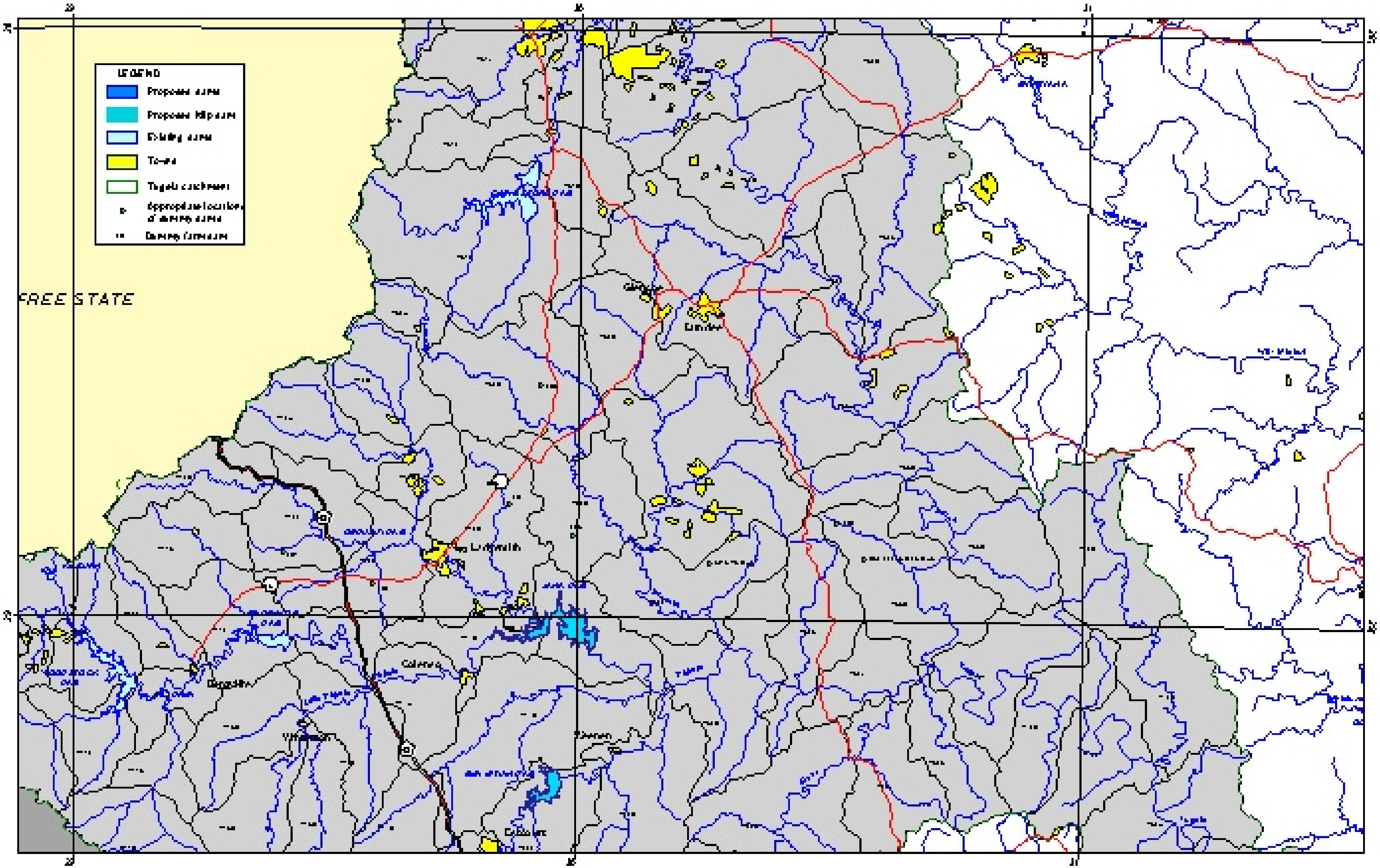
October		November		December		January		February		March		April		May		June		July		August		September	
Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow	Nodal flow *	IFR flow
0.00	4.00	0.00	5.00	0.00	10.00	0.00	10.00	0.00	10.00	0.00	5.00	0.00	5.00	0.00	2.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	4.00
1.10	4.00	0.90	5.00	0.90	10.00	6.20	10.00	7.50	10.00	7.00	5.00	5.70	5.00	3.10	2.00	2.10	1.00	1.60	1.00	1.60	1.00	1.30	4.00
1.80	4.00	2.90	5.00	5.90	10.00	12.00	10.00	15.90	10.00	14.70	5.00	9.30	5.00	4.50	2.00	3.00	1.00	2.30	1.00	1.90	1.00	1.70	4.00
2.40	4.00	6.10	5.00	9.30	10.00	25.00	10.00	26.40	10.00	20.20	5.00	11.30	5.00	5.60	2.00	3.60	1.00	2.60	1.00	2.10	1.00	2.00	4.00
3.50	7.00	8.80	10.00	13.00	10.00	30.70	10.00	45.60	10.00	32.20	5.00	14.00	5.00	6.30	5.00	3.90	2.00	2.90	2.00	2.40	2.00	2.20	7.00
4.50	7.00	11.30	10.00	17.80	10.00	36.50	10.00	58.00	10.00	36.30	5.00	15.80	5.00	7.20	5.00	4.70	2.00	3.00	2.00	2.70	2.00	2.50	7.00
6.50	7.00	12.70	10.00	23.80	10.00	41.50	10.00	66.80	10.00	41.30	5.00	21.30	5.00	7.80	5.00	5.00	2.00	3.40	2.00	3.00	2.00	2.70	7.00
7.90	7.00	17.00	10.00	34.30	10.00	57.80	10.00	76.00	10.00	55.00	5.00	23.90	5.00	9.60	5.00	5.20	2.00	3.60	2.00	3.20	2.00	3.30	7.00
10.40	7.00	24.00	10.00	48.80	10.00	88.50	10.00	96.10	10.00	59.80	5.00	27.00	5.00	10.20	5.00	5.90	2.00	4.60	2.00	3.70	2.00	4.60	7.00
18.50	7.00	35.30	10.00	58.00	10.00	113.40	10.00	129.50	10.00	85.20	5.00	32.80	5.00	12.60	5.00	7.10	2.00	5.40	2.00	5.50	2.00	6.20	7.00
24.40	7.00	57.10	10.00	80.70	10.00	149.50	10.00	160.90	10.00	99.00	5.00	41.00	5.00	14.50	5.00	8.50	2.00	6.90	2.00	7.40	2.00	12.60	7.00
999.00	7.00	999.00	10.00	999.00	10.00	999.00	10.00	999.00	10.00	999.00	5.00	999.00	5.00	999.00	5.00	999.00	2.00	999.00	2.00	999.00	2.00	999.00	7.00

- Combined flow from inflow files TM05, TM07, TM10, TM16, TM08, TM11, TM13, TM09, TM14 and TM15.

Natural MAR at IFR A = 3402.2 $x10^6m^3/a$

IFR requirement = 191.41 $x10^6m^3/a$

IFR requirement as a percentage of natural MAR = 6%



Thukela Water Project
Feasibility Study
Water Resource Evaluation
and System Analysis Task

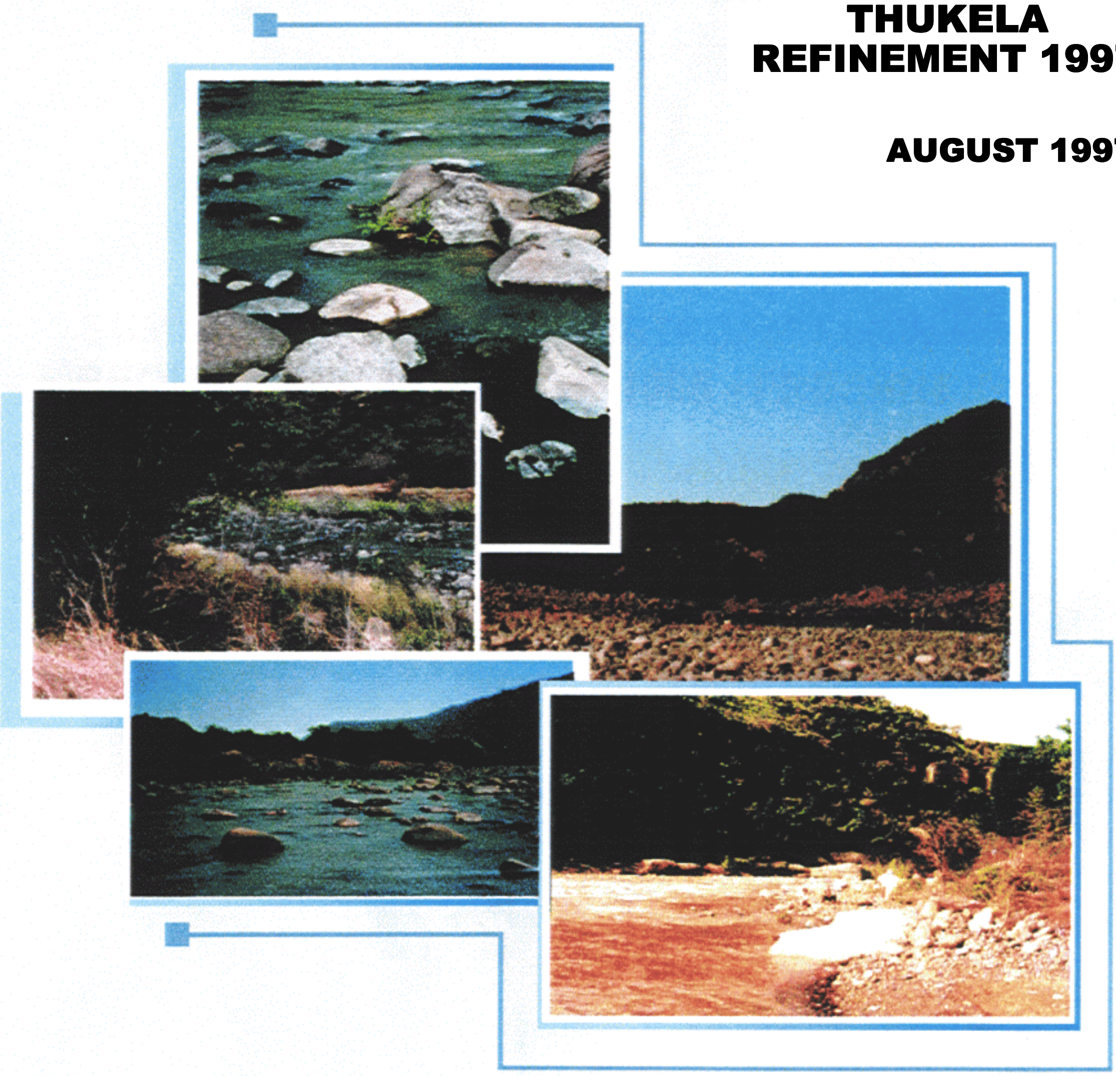
Department of Water Affairs and Forestry

Proposed Location of Dams

Republic of South Africa
Department of Water Affairs and Forestry

Thukela Water Project
Feasibility Study

INSTREAM FLOW REQUIREMENTS:



THUKELA
REFINEMENT 1997

AUGUST 1997

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APPENDIX 1:

CONTENTS

1. Introduction and Background

INTRODUCTION & BACKGROUND

MD Louw

Integrated Environmental Management (IEM)

Integrated Environmental Management (IEM) is a process that ensures *"that environmental considerations are efficiently and adequately taken into account at all stages of the development process"* [Council for the Environment, 1989]. The aims of this process are to collect and synthesise relevant data; to identify potential environmental impacts; to minimise potential negative impacts; to maximise potential positive impacts; to liaise with all public groups, to resolve conflict; and to document all these IEM actions. [Department of Environment Affairs, 1992]

Prior to 1989, the Department of Water Affairs and Forestry (DWAF) was applying some of the elements of the Council's IEM process during project development. With time, further elements were added to this process so that by 1987 the Department had formulated its own procedure for the practical application of IEM. As experience was gained, the process was revised and is still being revised. It is believed that the process applied presently complies with the requirements of the IEM procedure as determined by the Council of the Environment and for the adjusted IEM guidelines, produced by the Department of Environment Affairs in 1992.

As part of the IEM procedure, Environmental Impact Assessments are undertaken to evaluate and document the impacts of all proposed developments and to identify further necessary studies. The determination of the Instream Flow Requirement (IFR) of the river which will be affected by the proposed development is almost always identified as a necessary study. The change in flow regime of the river is one of the most important direct impacts of most water development projects. As no source of information regarding the IFRs for South African rivers exist (except for the rivers where DWAF has commissioned the work to be undertaken), this study usually needs to be undertaken during this stage.

Building Block Methodology (BBM) & starter document

The DWAF has in conjunction with consultants in the aquatic sciences field developed an IFR methodology which is being applied for most major and/or important rivers where development is taking place. This method is called the Building Block Methodology (BBM) and consists of various actions and studies. Most of these are undertaken in preparation for an IFR workshop where the IFR is determined, and the results of this preparatory work are documented in a starter document.

The purpose of the starter document is to familiarise and prepare all workshop participants with the collected baseline information for the IFR study before the workshop. Limited time will therefore have to be spent during the workshop in presenting and discussing this information and most time can be devoted to the determination of the actual IFR.

Background to the Tugela IFR Refinement study

As part of the Pre-feasibility study during 1995, an IFR study for the Tugela River and the Northern and Southern Tributaries based on 8 IFR sites was undertaken. The results of the workshop were analysed at the end of the workshop and the following actions were specified for the Feasibility phase of the study:

- Cross-sectional surveys for all the sites need to re-surveyed.
- Hydraulic calculations for the all the sites need to be repeated and calibrated with observed data.
- Additional IFR sites in the tributaries need to be investigated if any of the proposed options in the tributaries are investigated during the feasibility phase.
- All normal IFR investigations for any new IFR sites need to be undertaken.
- IFR site 2 need to be shifted to a more representative site in the gorge.
- The results of the IFR need to be modelled to determine how they can be supplied by the proposed developments.
- A monitoring protocol need to be determined for the Design, Construction and Operation phases.

Although the formal Feasibility Study will be initiated only in 1997, the IFR co-ordinator was requested to initiate the IFR refinement study during June 1996 so as to ensure that work that needs to be undertaken during the low flow season will be done. This IFR refinement study was focused on the main Thukela River downstream of Upper Jana Dam and the Bushmens River downstream of Mielietuin Dam (i.e. the Southern Tributaries). The Northern Tributaries will be investigated as a next phase in the IFR process.

The IFR actions that are being undertaken during the Refinement study for the Southern Tributaries are the following:

- Reselection of sites on the Thukela and Bushmens River.
- Selection of new sites on the Bushmens River.
- Cross-sectional surveys of the above sites at the required standard.
- Hydraulic calculations with at least 4 calibration points.
- Riparian vegetation and fluvial geomorphological investigations for the new sites.
- Photo-point monitoring of all the sites at known flows.
- Hydrological analysis of the previous data for the new sites as well as a check on the

adequacy of the data.

- Modelling of the IFR results with the IFR release model (Hughes) to determine the transition between maintenance and drought flows.
- Yield analysis modelling of the above results to determine different scenarios of possible supply of the IFR.
- Determination of an acceptable scenario from the environmental viewpoint and the implications of any other scenarios.
- The determination of a monitoring protocol

The above actions include all the actions as set out in the attached flow diagram which depicts the IFR actions that should take place during the feasibility phase.

REFERENCES

- Council for the Environment, 1989. IEM in South Africa. Joan Lotter Publications.
- Department of Environment Affairs, 1992. Integrated Environmental Management Guideline Series, Vol 1 - 6. Pretoria, South Africa.

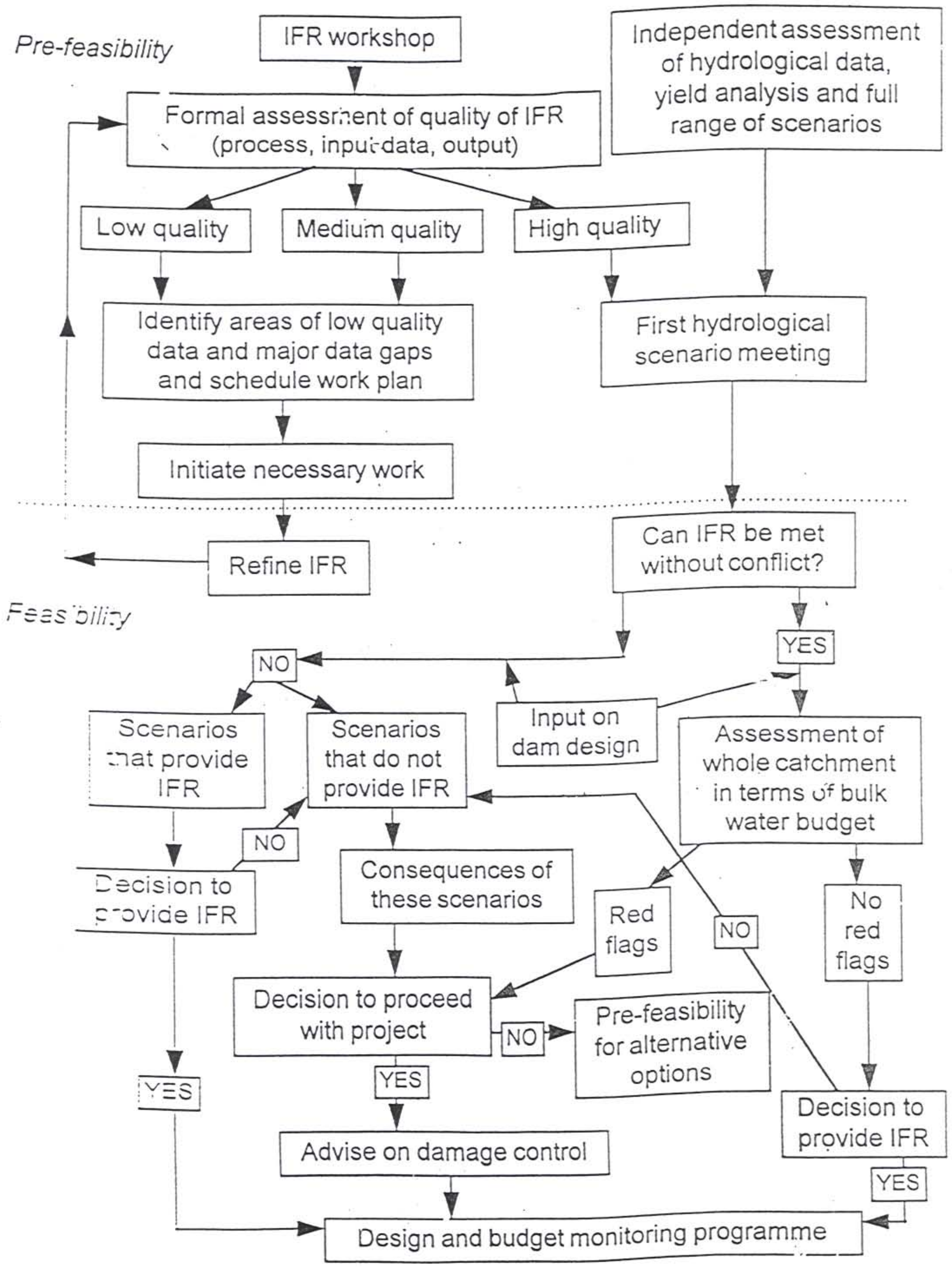

Figure 6.1 Suggested flow path for BBM-related activities during DWAF's Feasibility Phase

2. IFR 1995 Results

IFR 1995 RESULTS

MD Louw
December 1996

The draft document for the IFR 1995 workshop was utilised to present the results in the same tables that will be used for the refinement workshop. This will simplify the process of comparing the 1995 results with the refinement results.

Problems were encountered with the following:

- IFR 2 : No detail motivations were given as, due to the inadequacy of the site and the poor hydraulic information, a scaling of the IFR 1 results were used to calculate the flows for IFR 2.
- Motivations for the recommended flows were not documented by each specialist as is now the norm. Some of the motivations are therefore hidden within a report and had to extracted and at places assumptions made regarding the motivations.
- Depths or inundation levels for each flow were not recorded.

IFR 2 1995 RESULTS

Objective for this part of the river which is represented by this site:

- Recommend flows that will maintain the high (Class 2) riparian and instream habitat integrity. The main modifiers at present are vegetation removal, exotic vegetation encroachment, limited bank erosion, water abstraction and flow modification.
- Recommend flows that will maintain the wild and scenic character of this section of the Tugela River
- Recommend flow that could address possible poor water quality situation

December to March :	Wet months
April to May:	Transitional months
June to September:	Dry months
October to November:	Transitional months

August and February were selected to determine low flows tested by scaling IFR 1 hydrology to IFR 2.

August : A flow of 2,5 m^3/s was acceptable for fish and invertebrates with a reasonable diversity in hydraulic biotopes. This flow gave a maximum depth of 30 cm and an average depth of 16 cm. These depths were also sufficient for *Amphilius* sp which is a riffle dwelling species. Water also reached the marginal vegetation (reeds) at this flow. Due to all the uncertainties regarding the hydraulics, this flow was increased and finalised at $3m^3/s$.

The complete results are presented in table 1 on the next page. Note that the depths given was calculated from the flows by means of the 95 hydraulic discharge tables. No specific depths were specified as the flows were extrapolated from IFR 1.

Table 1 : COMPARISONS OF 95 IFR AND REFINED IFR : IFR 2 (Tugela Estates) vs IFR 2 (Tugela Gorge)
VIRGIN MAR 372 X $10^6 m^3$ at Tugela Estates

(Discharges in m^3s^{-1}, volumes in million m^3, depth in brackets in (m), flood duration expression in days after the depths

IFR BUILDING BLOCKS		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	%
IFR for MAINTEN.	LOW FLOWS 95 IFR	3,7 (,33)	4,2 (,34)	6 (,42)	6 (,42)	6 (,42)	6 (,42)	5,4 (,37)	4,9 (,36)	4,4 (,36)	3,8 (,34)	3,3 (,32)	3,3 (,32)	245	16
	REF IFR														
	FLOODS 95 IFR	10 (,5) 1	10 (,5) 1	80 (2) 11	80 (2) 11	170 (3) 15	10 (,5) 1							291	19
	REF IFR														
IFR FOR DROUGHT SITUATION [b]	LOW FLOWS WS IFR	2 (,25)	3,3 (,33)	3,3 (,33)	3,3 (,33)	3,3 (,33)	3,3 (,33)	3,3 (,33)	2 (,25)	2 (,25)	2 (,25)	2 (,25)	2 (,25)		
	REF IFR														
	FLOODS WS IFR	10 (,5)	10 (,5)		60 (1,7)		10 (,5)								
	REF IFR														

2

IFR 3 1995 RESULTS

Objective for this part of the river which is represented by this site:

- Recommend flows that will maintain the scenic character of parts of this river.
- Recommend flows that will address the possibility of poor water quality
- Recommend flows that will maintain the possible high habitat integrity in parts of the river and maintain or improve the possible lower habitat integrity in the other parts of the river.

December to March :	Wet months
April to May:	Transitional months
June to August:	Dry months
September to November:	Transitional months

LOW FLOWS

August flows: 0,5m^3/s

- The channel will be in a good state at these flows and the water will reach the marginal vegetation. Some inundation of lateral areas such as patches of grasses and sedges are provided which are habitat for fish fry and juveniles if any early spawning has occurred. It will also act as a refuge.
- Maintenance of instream habitat is achieved.
- Some inundation of large bedrock platforms, boulders, and interspersed gravel and sand producing adequate coverage of cobble beds for early, pre-fresh flows and spawning of *Labeo* sp.
- This flow will also provide refuge and habitat for larger fish in pools, as well as moderately high velocity flows down chutes and focal points for fish feeding at the head of pools.

October - November flows: Gradually increasing water depths open up lateral habitat, contribute to increased food supplies and frog spawning habitat etc. Fish will have more opportunities for migration past or through barriers.

December - March flows : 2m^3/s

- Fish require 75cm flow depth which requires flow rates of 1m^3/s to 2m^3/s. This flow will cover some of the rocks and inundate marginal vegetation where cat fish breed.
- Lower flows could cause algal blooms associated with high nutrients and high water temperature. This will cater for water quality problems caused by irrigation return flows, but not for industrial pollution.
- Flow will cater for tadpoles that need good quality water of not too high temperature and habitat in pools between the sedges.
- Flow should enhance invertebrate productivity, but not promote blackfly breeding.

- Provide fish habitat in the main channel and in lateral sedge areas and maintain sedges which seem to be an important feature of the vegetation at this site.

FLOODS

October : $3m^3/s$

- Initial cue for fish spawning and migrations.

February : $30m^3/s$

- A flow that reach the macro channel will require a depth of 1,5m.
- The flow velocity will be low and only recharge the substrate but not scour.
- Channel forming, channel scouring, renewal of accumulated sediments and periphyton must take place.
- Major spawning stimulus for all species as it inundates the full channel width and provide maximum instream habitat as well as wetting the riparian zone.

December/January : 2 x $8m^3/s$

- Keep floodplain wet for amphibians and other organisms.
- Flow should recede gradually so that fish do not get stranded on the floodplain.

November : $8m^3/s$

- Early spawning

March : $8m^3/s$

- Late spawning

Attached find the complete IFR table. Note that no depths could be given for the flows due to the inaccurate hydraulics and the inadequate scale of the stage discharge curves.

Table 2 : COMPARISONS OF 95 IFR AND REFINED IFR : IFR 3 (Darkest Africa) vs IFR 3 (Darkest Africa upstream of previous cross-section) VIRGIN MAR 312 X $10^6 m^3$

(Discharges in m^3s^{-1}, volumes in million m^3, depth in brackets in (m), flood duration expression in days after the depths

IFR BUILDING BLOCKS		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	%
IFR for MAINTEN.	LOW FLOWS 95 IFR	,8 0	1,5 0	1,5 0	1,5 0	1,5 0	1,5 0	1,5 0	1 0	,8 0	,7 0	0,5 0	0,5 0	35	11
	REF IFR														
	FLOODS 95 IFR	3 0 1	8 0 4	8 0 5	8 0 5	30 0 7	8 0 5							16	5
	REF IFR														
IFR FOR DROUGHT SITUATION	LOW FLOWS WS IFR	0,4 0	0,7 0	0,7 0	0,7 0	0,7 0	0,7 0	0,7 0	0,4 0	0,4 0	0,4 0	0,4 0	0,4 0		
	REF IFR														
	FLOODS WS IFR		5 0	5 0	5 0	8 0	5 0								
	REF IFR														

5

IFR 5 1995 RESULTS

Objective for this part of the river which is represented by this site:

- Recommend flows that will:
  - maintain the potential for the medium to low (Class 3 & 4) riparian habitat integrity (main modifiers are vegetation removal and bank erosion);
  - improve the medium (Class 3) instream habitat integrity (main modifier is the impact of bed modification)
- Recommend flows that will ensure the sustainability of a healthy riverine ecosystem to produce resources for local users.
- Recommend flows that will improve water quality.

December to March :	Wet months
April to May:	Transitional months
June to September:	Dry months
October to November:	Transitional months

General comments :

- Flows are relatively fast in a narrow watercourse, pools are not deep enough for fish.
- Even though spawning does take place, it is recommended that habitat be improved. A low survival rate is expected.
- Pools are a bigger concern than the riffles.
- Fish habitat can be improved either through scouring or through increasing flow.
- The rural community irrigates small lands
- Vegetation does not exist because of grazing by goats.

LOW FLOWS

July flows:

- Pools should be kept deep.
- Invertebrates - keep roots and pebbles as wet as possible.
- Enough flow to maintain water quality should be available.
- Riparian vegetation is insignificant in this reach
- Low flow is necessary for brick and block making, an important social activity.

July flows : $6m^3/s$

- A width of 15m and a depth of 0,6m is required.

February flows : $20m^3/s$

- Maintain a range of habitat variability.

Transitional months:

- Fish require more water in September than in July, and flows should be scaled up to October for breeding and migration.

FLOODS

- It was accepted that larger floods, above the 1:20 year events, will happen anyway and not be attenuated by upstream storage.
- Floods between mean annual (900m^3/s) and 1:20 year, will be significantly attenuated; this will be favourable for the system.

October : 30m^3/s
- Clean cobbles and channel
- Scour for fish breeding
- Maintain water quality

February : 300m^3/s
- Depth of 2,4m and a width of 105m.
- Channel scouring
- Removal of silt
- Pool maintenance.

November : 50m^3/s
- Depth of 1,3m and a width of 90m
- Clean channel
- Fish breeding

December/January/March/April :
- Required for geomorphological considerations, some bank encroachment, but the middle section must not silt up.
- Biological reasons with at least one flood during the wet months.
- Variability in the system above the minimum flows is recommended.
- More that one flood is required to maintain variability.

Table 2 : COMPARISONS OF 95 IFR AND REFINED IFR : IFR 5 (Tugela Ferry)
VIRGIN MAR 2107 X $10^6 m^3$

(Discharges in m^3s^{-1}, volumes in million m^3, depth in brackets in (m), flood duration expression in days after the depths

IFR BUILDING BLOCKS		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	%
IFR for MAINTEN.	LOW FLOWS 95 IFR	12 (,7)	15 (,75)	18 (,8)	20 (,83)	20 (,83)	18 (,8)	15 (,75)	10 (,68)	8 (,64)	6 (,6)	8 (,64)	10 (,68)	420	20
	REF IFR														
	FLOODS 95 IFR	30 (,9) 3	50 (1,3) 3	100 (1.8) 7	100 (1,8) 7	300 (2,4) 7	100 (1,8) 7	50 (1,3) 5						214	10
	REF IFR														
IFR FOR DROUGHT SITUATION b	LOW FLOWS WS IFR	6 (,6)	10 (,68)	10 (,68)	13 (,71)	13 (,71)	10 (,68)	6 (,6)	4 (,5)	3 (,4)	2 (,3)	3 (,4)	4 (,5)		
	REF IFR														
	FLOODS WS IFR	20 (,8)	20 (,8)	20 (,8)	20 (,8)	50 (1,3)	20 (,8)								
	REF IFR														

8

3. Future Desired State:
Thukela and Bushmens Rivers

FUTURE DESIRED STATE : THUKELA AND BUSHMENS RIVERS

MD Louw

December 1996

A fixed procedure for determining the Future Desired State of a river has during previous IFR studies not been established. The process consisted previously of dividing the river in logical regions, based on tributaries and the results of the habitat integrity, and coupling a future desired state to each of the regions. This process followed more or less the following steps:

1. Determine during the planning meeting whether specialists are aware of any vital information on specific communities or problems related to the river which warrants mention in a future desired state. This included social aspects.

2. Based on the above information, an overall or 'motherhood' statement was formulated during the planning meeting.

3. After the habitat integrity report became available, the river was divided into zones of the same habitat integrity status.

4. These regions/zones were then given to the biophysical and social specialists who then coupled a future desired state from their specialist viewpoint for each of these zones.

5. During a short discussion period at the beginning of the workshop, this information was presented to the participants to confirm the overall future desired state and agree on the specific future desired states for each zones.

Problems were experienced with this process as it was not consistent and differed from river to river. The description of the future desired state also tended to sound similar for most rivers and the process was not quantifiable.

A new process was devised and is based on a river classification system as described in the attached document. The process is as follows:

- The biophysical and social specialists must devise the PRESENT class (according to the classes described in the attached document) of
  - the Bushmens River reach downstream of the Mielietuin Dam;

- the Thukela River downstream of the Upper Jana Dam to a point below the Buffalo River. Possibly, the Thukela River could be split into 2 zones, one reflected by the gorge and IFR 2 and one for the area outside of the gorge reflected by IFR 5;

from their SPECIALIST viewpoint. I.e. the fish specialist will for example present this information based on the status of fish presence and fish habitat.

- A half page motivation should accompany the decision on the present class as decided by the specialist.

- The specialist must then give the **REALISTIC** FUTURE DESIRED STATE (FDS) class using the same classification system as used above but based on the desired state classes (A - D) for the same river zones. To determine the realistic FDS, the river importance has to be considered as motivation for the FDS.

- A half page motivation should again accompany the decision on the FDS.

- This information is then sent to the IFR co-ordinator who will try and compile an overall present category for the river and an overall FDS for the river.

- During the workshop, the results are discussed and agreement on the FDS from the participants are obtained.

This information is usually presented in the attached tables.

This process is in its infancy and will develop as future IFR studies are undertaken. As the principles of this process as described in the attached draft document will be taken up in the new water act, it is expected that this will be the most logical way forward.

A FDS was determined for the Thukela River during the previous IFR study. The purpose of revisiting the FDS during the refinement study is to formalise the FDS, couple motivations to the FDS and to fit in with the Water Law Review principles which are presently utilising and refining these categories.

The 1995 IFR FDS was:

- To determine a flow regime which will promote/facilitate
    - the natural ecological state (at least maintain as is - no further degradation)
    - aesthetic quality (wild & scenic character)

- conservation of the natural heritage including species biodiversity and landscapes.

- To maintain a perennial flows
- To determine a flow regime that will promote the sustainability of the riverine resources for those depending on the presence of a healthy riverine ecosystem.

Previously concerns regarding the legitimacy of river ecologists setting the FDS were expressed at various workshops. With experience and new insight, the following conclusions have been reached:

- A FDS based on the classification of the desired ecological integrity status of the river will be determined. This relates to the 'ecological reserve' or 'resource base' (terms used in the Water Law Review Documentation). Although the term ECOLOGICAL integrity is used, the needs and utilisation of communities based on the natural functioning of the river on a sustainable basis are included.

- The reasoning behind the above argument is that other 'users' of the river (irrigation, potable water, industry etc) have had the opportunity to quantify their requirements and their future desired state (e.g. a volume of X to increase irrigation, a volume of Y to stabilise drinking water supply). The riverine ecology by means of the IFR studies is given the opportunity of stating its requirements and its future desired state.
- Once all the water needs are defined (everybody on the equal footing), the facilitating to determine the water environment objective / overall desired state is initiated.

4. Abstract from Water Environment Objectives: A first contribution by Kleynhans for the Water Law Review

ABSTRACT FROM WATER ENVIRONMENT OBJECTIVES :
A FIRST CONTRIBUTION BY KLEYNHANS FOR THE WATER LAW REVIEW

1. The role of classification systems in setting of receiving water environment objectives.

The successful application of a classification system will depend on our ability to measure and quantify ecological integrity, and to quantify the water quality, flow and habitat characteristics required in order to maintain a desired level of ecological integrity. The Resource Base and the Resource Base Reserve are concepts which allows us to define and protect a template for ecological functioning and integrity: monitoring of biotic response enables us to assess whether the template is correct.

For the purpose of setting receiving water environment objectives, the resource can be classified based on the following:

- Ecological integrity status
- Importance of the resource
- Sustainability of the resource for different uses
- Desired state of the resource

1.1 Ecological integrity status

This refers to the current ecological integrity status of the resource, compared to what it is known or derived to have been under natural conditions, e.g. when only natural disturbance regimes regulated and determined the ecological functioning of the resource. Two components of ecological integrity can be distinguished and compared to the natural conditions:

- Habitat integrity status; assessment of the physical or structural aspects as well as water quality and quantity characteristics which provide the abiotic template for biota to inhabit and utilise the resource. Habitat integrity status is usually regarded as a precursor to the assessment of biotic integrity status.

- Biotic integrity status; assessment of the biotic components of the resource as a measure of the degree to which the potential of the habitat (template) is realised.

Both habitat integrity and biotic integrity status provide a perspective on ecological integrity.

However, the relationship between the two assessments also provides an integration which defines ecological integrity status. Ecological integrity status may be appraised according to the following classification:

A **UNMODIFIED, NATURAL;** the resource base reserve has not been decreased - the supply capacity of the resource has not been exploited.

B **LARGELY NATURAL WITH FEW MODIFICATIONS;** the resource base reserve has been decreased to a small extent. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.

C **MODERATELY MODIFIED;** the resource base reserve has been decreased to a moderate extent. A change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.

D **LARGELY MODIFIED;** the resource base reserve has been decreased to a large extent. A large change of natural habitat, biota and basic ecosystem functions have occurred.

E **SERIOUSLY MODIFIED;** the resource base reserve has been seriously decreased and regularly exceeds the resource base. The loss of natural habitat, biota and basic ecosystem functions are extensive.

F **CRITICALLY MODIFIED;** the resource base reserve has been critically decreased and permanently exceeds the resource base. Modifications have reached a critical level and the resource has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

1.3 Importance of the resource

Each resource has an intrinsic value which can be equated to its ecological importance, whereas the supply capacity of the resource is regarded as the importance of the resource in terms of human related uses.

The importance of the resource then relates to:

- Ecological importance; this refers to various ecological aspects such as biodiversity, rarity, uniqueness and fragility from a habitat, species, community and ecosystem perspective. The intrinsic conservation value of the resource, as well as its importance to the functioning of neighbouring ecosystems is the main concern. Implicit in ecological importance assessment is also a classification or grouping of aquatic resources according to ecologically similar types.

- Importance in terms of human related uses; this refers to the various components of economic importance (agriculture, industries, mining, etc.), basic human needs and social importance (recreation, tourism, religion, etc.).

The importance attached to these two categories will determine the desired ecological state and the user desired state for sustainable supply capacity. It follows that a resource with a particular ecological importance will be associated with a certain desired ecological integrity status which may be compatible or incompatible with a particular user desired state.

Ecological importance may conceivably be classified according to the following:

A **EXTRAORDINARY ECOLOGICAL IMPORTANCE;** extremely rare or unique and highly sensitive (low resilience) ecological features not duplicated nationally or internationally.

B **HIGH IMPORTANCE;** unique, highly sensitive (low resilience) ecological features with rare occurrence nationally.

C **MODERATE IMPORTANCE;** regularly occurring ecological features with a moderate sensitivity (moderate resilience).

D **LOW IMPORTANCE;** commonly occurring ecological features with low sensitivity (high resilience).

Importance in terms of human related uses may be assessed based on the current uses of the resource:

A **EXTRAORDINARY HUMAN USE IMPORTANCE;** critical importance with relation to economic (agricultural, industrial and mining) activities and/or for direct human use and social purposes.

B **HIGH HUMAN USE IMPORTANCE;** high importance with relation to economic (agricultural, industrial and mining) activities and/or for direct human use and social purposes.

C **MODERATE HUMAN USE IMPORTANCE;** moderate importance with relation to economic (agricultural, industrial and mining) activities and/or for direct human use and social purposes.

D **LOW HUMAN USE IMPORTANCE;** low importance with relation to economic (agricultural, industrial and mining) activities as well as for direct human use and social purposes.

3.3 Sustainability of the resource for different uses

The capability of the resource to supply products or services for human related uses on a sustainable basis (without exceeding the resource base level) is the crux of this classification:

A Resources which are extremely limited in their supply capacity due their limited proportions, high fragility, low resilience, rarity of type or uniqueness.

B Resources which have a supply capacity compatible only with basic human needs.

C Resources which have a supply capacity compatible with basic human needs as well as for the provision of limited industrial, agricultural or mining needs.

D Resources which have a supply capacity compatible with basic human needs as well as for the extensive provision of industrial, agricultural and mining needs.

3.4 Desired state of the resource

Inherent in the classification and determination of the desired state of the resource, is the philosophy that the resource base may not be exceeded by user demands. The resource base is therefore considered to be a fundamental capability of the resource to meet the supply capacity on a sustainable basis in the long term. This in turn refers to products and services provided by a self-sustainable resource to the human community. It is also evident, however, that the resource may be modified to a certain degree without impairing its self-sustainability and thereby decreasing its supply capacity, as long as the resource base is not exceeded or damaged. The implication of such modification of the resource will be that the resource base reserve will be decreased with a consequent increase in the risk of approaching or exceeding the resource base. The desired state then refers to the degree of intactness of the resource base reserve as it approaches the resource base.

Based on the assessment of the resource importance and sustainability of the resource for different uses, the desired state of the resource can be specified in terms of sustainable management as:

A **UNMODIFIED, NATURAL;** the natural abiotic template should not be modified. The characteristics of the resource should be completely determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic maintenance of the resource. The supply capacity of the resource will not be used.

B **LARGELY NATURAL WITH FEW MODIFICATIONS;** only a small risk of modifying the natural abiotic template and exceeding the resource base should be allowed. Although the risk to the well-being and survival of especially intolerant biota (depending on the nature of the disturbance) at a very limited number of localities may be slightly higher than expected under natural conditions, the resilience and adaptability of biota must not be compromised. The impact of acute disturbances must be totally mitigated by the presence of sufficient refuge areas.

C **MODERATELY MODIFIED;** a moderate risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the well-being and survival of intolerant biota (depending on the nature of the disturbance) may generally be increased with some reduction of resilience and adaptability at a small number of localities. However, the impact of local and acute disturbances must at least partly be mitigated by the presence of sufficient refuge areas.

D **LARGELY MODIFIED;** large risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the well-being and survival of intolerant biota (depending on the nature of the disturbance) may be allowed to generally increase substantially with resulting low abundances and frequency of occurrence, and a reduction of resilience and adaptability at a large number of localities. However, the associated increase in the abundance of tolerant species must not be allowed to assume pest proportions. The impact of local and acute disturbances must at least to some extent be mitigated by refuge areas.

CLASSIFICATION OF PRESENT STATE FOR THE RIVER OR RIVER REACHES			
CLASSIFICATION	DESCRIPTION	THUKELA ZONE	BUSHMENS ZONE
A UNMODIFIED, NATURAL	The resource base reserve has not been decreased - the supply capacity of the resource has not been exploited.		
B LARGELY NATURAL WITH FEW MODIFICATIONS	The resource base reserve has been decreased to a small extent. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.		
C MODERATELY MODIFIED	The resource base reserve has been decreased to a moderate extent. A change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.		
D LARGELY MODIFIED	The resource base reserve has been decreased to a large extent. A large change of natural habitat, biota and basic ecosystem functions have occurred.		
E SERIOUSLY MODIFIED	The resource base reserve has been seriously decreased and regularly exceeds the resource base. The loss of natural habitat, biota and basic ecosystem functions are extensive.		
F CRITICALLY MODIFIED	The resource base reserve has been critically decreased and permanently exceeds the resource base. Modifications have reached a critical level and the resource has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible		

CLASSIFICATION OF FUTURE DESIRED STATE FOR THE RIVER OR RIVER REACHES			
CLASSIFICATION	**DESCRIPTION**	THUKELA ZONE	BUSHMENS ZONE
A UNMODIFIED, NATURAL	The natural abiotic template should not be modified. The characteristics of the resource should be completely determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic maintenance of the resource.		
B LARGELY NATURAL WITH FEW MODIFICATIONS	Only a small risk of modifying the natural abiotic template and exceeding the resource base should be allowed. Although the risk to the well-being and survival of especially intolerant biota (depending on the nature of the disturbance) at a very limited number of localities may be slightly higher than expected under natural conditions, the resilience and adaptability of biota must not be compromised. The impact of acute disturbances must be totally mitigated by the presence of sufficient refuge areas.		
C MODERATELY MODIFIED	A moderate risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the well-being and survival of intolerant biota (depending on the nature of the disturbance) may generally be increased with some reduction of resilience and adaptability at a small number of localities. However, the impact of local and acute disturbances must at least partly be mitigated by the presence of sufficient refuge areas.		
D LARGELY MODIFIED	Large risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the well-being and survival of intolerant biota (depending on the nature of the disturbance) may be allowed to generally increase substantially with resulting low abundances and frequency of occurrence, and a reduction of resilience and adaptability at a large number of localities. However, the associated increase in the abundance of tolerant species must not be allowed to assume pest proportions.		

5. Thukela Refinement Study: A summary of the process followed for IFR site selection

THUKELA IFR REFINEMENT STUDY:
A SUMMARY OF THE PROCESS FOLLOWED FOR IFR SITE SELECTION

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NP Kemper (Ninham Shand Incorporated)

December 1996

(Refer to maps in the locality section)

1. PURPOSE OF IFR SITES

In order to determine the Instream Flow Requirements (IFRs) of a river system, it is necessary to determine the flow requirements at a number of points within the system.

More that one IFR site is usually chosen within the system for a number of reasons :

- Tributaries entering the system may introduce different channel, bank and or habitat conditions which may need to be considered separately.
- The desired future conditions of particular reaches of the river may differ from the rest and may therefore require specific IFRs.
- A river system displays biological diversity along its length, and consequently, a single IFR point is unlikely to adequately reflect this range of diversity.
- Various hydrological stage points are required within the system to cater for the sequential inflows of tributaries and losses down the length of the system.

A range of hydrological, hydraulic, geomorphological and ecological data is collected at each IFR site. This information is then utilised during the IFR workshop to determine the IFRs for the system.

2. SELECTION OF IFR SITES

The selection of IFR sites is guided by a number of considerations such as:

- The locality of gauging weirs with good quality hydrological data.
- The locality of the proposed developments.
- The locality and characteristics of tributaries.
- The habitat integrity/conservation status of the different river reaches.

- The reaches where social communities depend on a healthy river ecosystem.
- The suitability of the sites for follow-up monitoring.
- The habitat diversity for aquatic organisms, marginal and riparian vegetation.
- The suitability of the sites for accurate hydraulic modelling throughout the range of flows, especially low flows.
- Accessibility of the sites.
- An area or site that could be critical for ecosystem functioning. This is often a riffle which will stop flowing during periods of low or no flow. Cessation of flow constitutes a break in the functioning of the river. Those biota dependant on this habitat and/or on continuity of flow will be adversely affected. Pools are not considered as critical since they are still able to function as an ecosystem or at least maintain life during periods of no flow.
- The locality of geomorphological reaches and representative reaches within these.

When selecting IFR sites, a decision making process is followed which consists of the following steps:

2.1 IFR STUDY AREA

As the IFR sites need to be located within the IFR study area, the first step in selecting the IFR sites is defining the IFR study area. This is also necessary due to the inherent complexity of river systems, and the need to confine the IFR assessment to specific stretches of the river.

Factors which were considered for this study were the location of features such as the proposed development (which will define its upstream extent), perennial tributaries and points of access.

The study area was identified as the Thukela and Bushmens Rivers downstream from the proposed development.

2.2 SELECTING RIVER STRETCHES IN WHICH IFR SITES SHOULD BE SITUATED

Prior to selecting the exact IFR sites, river stretches in which the IFR sites must be situated are identified on a map with input from hydrologists, river ecologists and planners. The same considerations as described under 2 are applicable when selecting the river stretches.

The relevant river stretches identified during the 1995 study were:

- The Thukela River downstream from Upper Jana Dam site and upstream of the Bushmens River confluence. (IFR 2)
- The Thukela River downstream from the Sundays River and upstream from Mooi River. (IFR 5)
- The Thukela River downstream from the Mooi River and upstream from the Buffalo River. (IFR 6)
- The Thukela River downstream from the Buffalo River for about 30 km. (IFR 8)
- The Bushmens River downstream of the Mielietuin Dam site (IFR 3).

It was planned that the same river stretches would be applicable for the refinement study, except that two IFR sites would be necessary in the Bushmens River.

2.3 HELICOPTER FLIGHT TO SELECT IFR SITES

This process of selecting IFR sites can be aided by means of a helicopter flight which is usually undertaken for the sake of the habitat integrity determination and capturing the river on video. During this flight, the location of potential IFR sites are recorded using a GPS (Global Positioning System).

2.4 USE OF THE RIVER VIDEO FOR THE IDENTIFICATION OF POSSIBLE IFR SITES

A multidisciplinary team (consisting of the IFR co-ordinator, a riparian vegetation specialist, a fluvial geomorphologist, the relevant fish and aquatic invertebrate specialist and an hydraulic engineer) is identified to select the IFR sites. The first step in this process requires viewing of the stretches identified in 2.2 and the sites identified during 2.3. The objective of this was to eliminate possible IFR sites and to streamline the next step in the process, the identification of the sites on the ground.

The following persons formed part of the IFR site selection team for the refinement study:

MD Louw	IFR co-ordinator, IFR site identification
NP Kemper	IFR site identification, Riparian vegetation
A Birkhead	Hydraulic engineer
M Coke	Fish
K Rowntree	Fluvial geomorphology

During the IFR 1995 study, possible sites were identified during the helicopter flight. No watching of video was however undertaken by the site selection team.

The video did not include the Bushmens River and could therefore not be used for site selection of that river during the 1996 refinement study. Except for site 2, the sites in the Thukela River were not to be changed. As a probable area for the new site 2 was already identified, further video analysis was not necessary during the refinement study.

2.5 GROUND TRUTHING - FINAL SELECTION OF SITES

A site visit was undertaken by Louw, Kemper and Birkhead during August 1996. Due to prior commitments, Coke and Rowntree could not participate but furnished the team with information regarding their specialist requirements at the IFR sites and possible areas where the sites could be selected as well as giving input in the decisions below.

Thukela River :

IFR 2 S 28° 44,585 E 30° 08,369

During the IFR workshop, it was determined that the locality of IFR 2 did not lend itself to the determination of IFRs and that it should be shifted slightly upstream in the gorge section of the river channel. This would ensure that the site was geomorphologically representative and that the gorge section of the river would be catered for.

This area was investigated and a site just upstream of the old IFR 2 site and upstream of the Bloukrans Tributary was selected. The site included requirements specified by the fish specialist and the geomorphologist and consisted of a pool/rapid-riffle/pool section with some slack water areas and marginal vegetation. Riparian vegetation was disturbed due to floods and grazing.

IFR 5 S 28° 45,350 E 30° 32,867

All the other Thukela sites were investigated before a final decision was taken. Geomorphologically and biologically IFR 5, 6 and 8 were very similar. IFR 8 was found to be significantly changed by the 1996 floods. The size of the river, difficulty associated with surveying, the secondary channel caused by Buffalo River flooding (IFR 8), and the high flows that prevented flow measurements caused the IFR site selection team to reconsider the appropriateness of these sites. The obtaining of accurate stage discharge relationships at all these sites could cause major problems. Site 6 and 8 are out of the way and would imply extensive travel to include with the other sites. The increased size of the river at these sites did not lend itself to hand flow measurements which implirf that the calibration of the hydraulics except at very low flows cannot be undertaken. No biological indicators that is not duplicated at IFR 5 existed at IFR 6 and 8. The only difference between the two sites is in the hydrology, i.e. the increase of flows caused by the Mooi and Buffaloes Rivers. It was therefore decided to include IFR 5 in the refinement study and not IFR 6 and 8. These sites could be considered as future monitoring sites. Extrapolation of the IFR 5 site, which will still form part of the study, will be used to determine the refined results at IFR sites 6 and 8 and lower down the river.

Bushmens River :

It was stated at the 1995 workshop that one IFR site in a major tributary is insufficient and that during the refinement stage, an additional site must be added. The existing site will be known as IFR 3 B and the new site which will be selected upstream of the existing site will be known as IFR 3 A.

IFR 3A S 28° 53,395 E 30° 1,031

The geomorphologist was requested to identify areas in which a second site should be selected in the Bushmens River. The area of highest priority from a geomorphological viewpoint lay in the extensive irrigation areas and it was decided to move slightly upstream to the Weenen Nature Reserve which is less disturbed. The fish specialist was asked to select possible sites. A riffle area near the border of the reserve was selected. It had diverse habitat with a secondary channel, good marginal vegetation cover and some clear terraces.

IFR 3 B S 28° 48,01 E 30° 10,681

The old site was visited and it was noted that the floods caused extensive changes in the site. The clearing of riparian vegetation by the land owner has also removed some of the most important indicators at this site. The criteria that therefore made this site suitable for IFRs and made the determination of IFRs possible were not present. No island, flooded areas or marginal vegetation were present. The rocks had moved and the cross-section was unrecognisable. Extensive scouring has taken place and the channel is now deeper than before. It was decided to look for a more suitable site in the immediate area. A site slightly upstream in the gorge consisting of a bedrock rapid with upstream and downstream pools was selected. Some marginal vegetation was present but limited riparian vegetation due to the floods and steep sloping rocky banks existed.

6. Tugela River IFR Revision - Hydrology

TUGELA RIVER IFR REVISION - HYDROLOGY

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Introduction

It was the initial intention of the authors to make use of the same daily time series data that was used for the 1995 Tugela IFR study. However, there seemed to be a number of difficulties with this approach, partly related to the availability of those data, partly related to the difference in locations of the new IFR sites and partly related to the approaches that were used to generate the earlier time series. These difficulties and the approaches used to generate the revised time series are summarised in the following sections (one for each IFR site). The details of available streamflow gauges have not been repeated in this document and reference can be made to the 1995 starter document and appendices.

IFR2

Site IFR2 is located on the Tugela River just above the confluence with the Bloukrans River and has a catchment area of 6818 km^2, which is just upstream of the original IFR2 site used in the 1995 workshop. The WR90 report on the Surface Water Resources of South Africa indicates that the catchment area above the new IFR2 site consists of tertiary catchments V11, V12, V13 and V14, except quaternary areas V14C and V14D (Bloukrans River). Summing the MAR values for these areas gives an MAR of 1558 * 10^6 m^3, compared with 1512 * 10^6 m^3 quoted for the old IFR2 site in the 1995 workshop starter document. A large part of this discrepancy is caused by the difference between the 1995 workshop value for the MAR at IFR1 (1140 * 10^6 m^3, equivalent to gauge V1H001) and the WR90 value based on tertiary areas V11 and V13 plus quaternary area V14A (1256 * 10^6 m^3). This discrepancy could be related to the different lengths and periods of data used in the two analyses, however, an explanation of how the MAR at the old IFR2 site was calculated is not provided in the 1995 starter document.

The method used for generating a daily flow sequence at the new IFR2 site in the new study is similar to that used for the previous workshop, in that the daily flows at gauge V1H001 have been scaled. However, the scaling factors have been based on a comparison between the monthly flow distributions at V1H001 and the sum of the monthly flow distributions for the relevant tertiary and quaternary catchments, provided in WR90 (table 1). The contributions of V11 and V13 have been reduced by 0.91 (1140/1256) in an attempt to generate a time series with a similar MAR to that used in the original workshop. These factors have been used to adjust the calender month duration curves for V1H001 and the adjusted curves used to generate daily flows at IFR2 using the 'Patching' model (Hughes and Smakhtin, 1996) based on source sites V1H001 (weight 0.999) and V6H002 (weight 0.001 - mainly to fill small amounts of missing data in V1H001) and using data for the period 1951 to 1971 (i.e. before the construction of Spionkop Dam). The resulting MAR is 1519 * 10^6 m^3.

IFR3

IFR3B is located on the Bushman's River (catchment area of approximately 1920 km^2) close to the confluence with the Tugela and the original IFR3 site and is the only site 3 dealt with in this starter document. The pattern of flows at IFR site 3A (approximately 1410 $km^{2)}$ are expected to be similar and can be simply scaled by the ratio of MAR's at the two sites (283/313 = 90%). IFR 3B is roughly equivalent to WR90 tertiary area V70 which has a quoted MAR of 313 * 10^6 m^3, which is the same as the value given in the original workshop starter document. The nearest gauge with reasonably long and unaffected records is at V7H017, located upstream of Wagendrift Dam. The calender month duration curves at V7H017 have therefore been weighted by the ratio of the mean monthly flows for V70 and V7H017 and the 'Patching' model applied in a similar way as for IFR2, mainly using V7H017 (1972 to present day) as the source gauge (patching weight 0.7), but also using V7H012 (Little Bushman's at Estcourt, 1963 to present day, patching weight 0.25) and V7H018 (Little Bushman's at Loch Sloy Craig, 1972 to present day, patching weight 0.05) to help generate a complete time series for 1963 to 1994. The monthly duration curve weights are given in table 1 and the MAR for the whole time series is 288 * 10^6 m^3, while the MAR for the period 1972 to 1994 is 311 * 10^6 m^3 and therefore closer to the figure given in the original starter document. The implication is that the 1963 to 1972 period was relatively dry, a conclusion supported by the plot of annual flows given in figure 6.

Table 1 Monthly duration curve scaling factors used to generate daily flows at IFR2 (from V1H001) and IFR3 (from V7H017)

Month	Scaling Factors for IFR2	Scaling Factors for IFR3
October	1.57	3.27
November	1.53	3.52
December	1.37	2.43
January	1.47	2.19
February	1.37	1.97
March	1.50	2.11
April	1.32	2.51
May	1.20	2.06
June	1.22	1.63
July	1.09	1.55
August	1.57	2.20
September	1.40	1.84

IFR5

The original starter document refers to the problems with the gauged records at V6H002 and how the flows recorded at this site are often far greater than those at V6H007, just upstream. However, V6H002 has data for 1927 to the present day, while V6H007 was only opened in 1982 and has records for approximately 5 years. The original starter document suggests that the flows at IFR5 were estimated by dividing the flows at V6H002 by 3.7 and then reduced by 0.7 $m^3 s^{-1}$, which was expected to under-estimate flows above 2 $m^3 s^1$. However, the duration curve provided in the hydrology appendix appears to be based on un-modified data from V6H002 and it was not clear to the current authors what data were actually used for IFR5.

An alternative approach was used in this study and was based on a comparison of low to moderate flows at V6H002 (up to 50 $m^3 s^{-1}$ recorded at this site) and V6H007 for the period 1982 to 1987, but because there are relatively few high flows for this period a different comparison was used for flows over 50 $m^3 s^{-1}$. The resulting correction equation for flows up to 50 $m^3 s^1$ was derived to be $0.06 * Q^{1.5}$, while for flows greater than this the equation used was $0.315 * Q^{.08}$ (where Q is the DWAF recorded flow at station V6H002). The correction equations were applied to the flow values of the calender month duration curves, taken from the observed flows at V6H002 for the period 1951 to 1971 (considered to be largely unmodified), and the resulting curves assumed to be applicable for site IFR5. The 'Patching' model was then applied to generate a 20 year time series at IFR5 using flows at V6H002 (patching weight 0.95) and at IFR site 2 (patching weight 0.05 for filling in missing data at V6H002). The resulting MAR is $2160 * 10^6$ m^3, which is slightly higher than the figure ($2107 * 10^6$ m^3) given in the original starter document, but is probably based on a different length record.

General comments

The diagrams given below include plots of the annual time series for each site (figures 1, 6 and 11) and for sites 2 and 5 the period beyond 1971 has been included to illustrate the effects of development. The second set of diagrams are monthly distributions for three wet, intermediate and dry years (figures 2, 7 and 12). The third set of diagrams are 1-day duration curves for the natural parts of the time series used (figures 3, 8 and 13), while the final set (figures 4, 5, 9, 10, 14 and 15) represent 300 day daily time series for two wet and two dry years for each site (the last 65 days of the year has been ommited for the purposes of presentation at the scale used). Samples of three month daily time series (October to January, February to May and June to September) for wet, intermediate and dry years will be made available for display at the workshop.

It is unfortunate that the natural time series used in the analyses are not all able to include the dry period that seems to have prevailed during the 1980s. The annual flow plot for IFR5 (figure 11) shows this quite clearly, but these flows are based on patching from V6H002, data that are affected by upstream developments. A similar situation exists with IFR2 (figure 1), where the period after 1971 is affected by the construction of Spionkop Dam. The annual flow plot for IFR3 (figure 6) does not show the drought as clearly and this is based on patching from V7H017 which is not affected by upstream abstractions. One explanation could be that the Bushman's River was less affected by the 1980s drought, while another is that the drought was exacerbated by the water resource developments in the catchment and therefore shows up more clearly when the source gauges used for patching include the influences of these developments.

It is unfortunate that the natural time series used in the analyses are not all able to include the dry period that seems to have prevailed during the 1980s. The annual flow plot for IFR5 (figure 11) shows this quite clearly, but these flows are based on patching from V6H002, data that are affected by upstream developments. A similar situation exists with IFR2 (figure 1), where the period after 1971 is affected by the construction of Spionkop Dam. The annual flow plot for IFR3 (figure 6) does not show the drought as clearly and this is based on patching from V7H017 which is not affected by upstream abstractions. One explanation could be that the Bushman's River was less affected by the 1980s drought, while another is that the drought was exacerbated by the water resource developments in the catchment and therefore shows up more clearly when the source gauges used for patching include the influences of these developments.

Figures 9 and 10 illustrate an interesting feature, which is a stepped drop in the baseflows at the end of April and May (approximately days 212 and 243 from October). The April step is also noticeable at IFR site 2 (figures 4 and 5). It is difficult to ascribe such a regularly occuring feature to any natural phenomena and it must therefore be related to the monthly duration curve correction factors. The implication is that the mean monthly values given in the WR90 reports do not change gradually enough through March to June, relative to those at the gauging stations used for the patching model. Without further detailed study it is difficult to know the best way to correct this and some allowance will have to be made for this characteristic of the estimated flow regimes at these sites during the workshop.

IFR Site 2 - Tugela

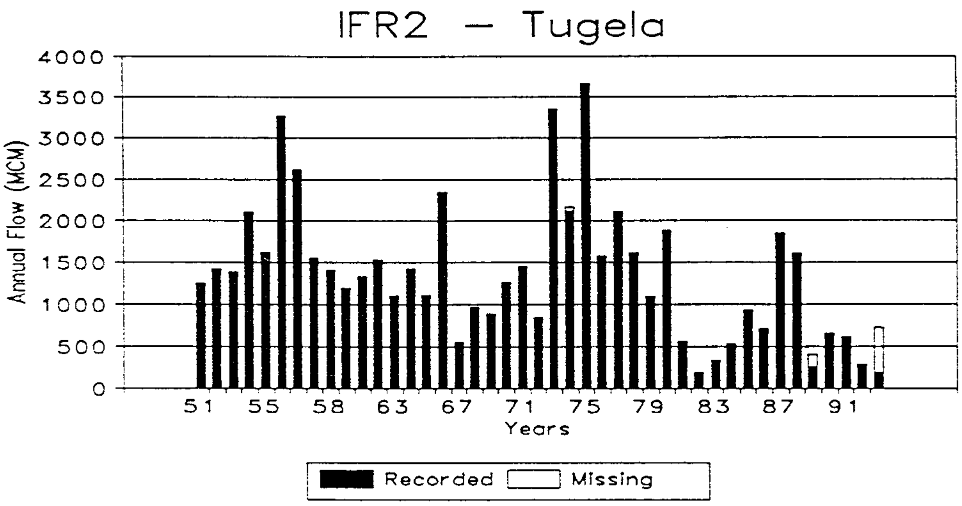

Figure 1 Annual flow volumes (MCM = $m^3 * 10^6$) for IFR site 2.

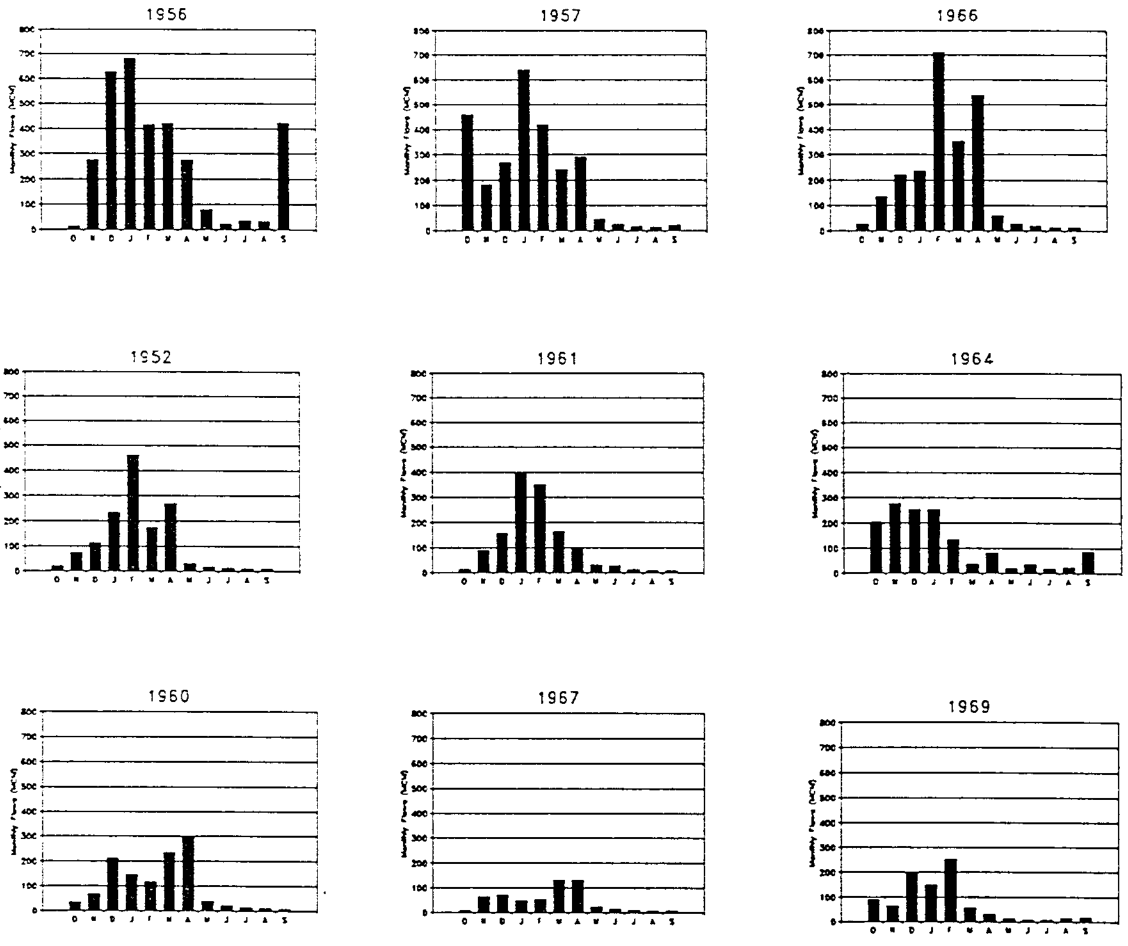

Figure 2 IFR2, Monthly flow volumes for present day and virgin conditions for three wet, three intermediate and three dry years

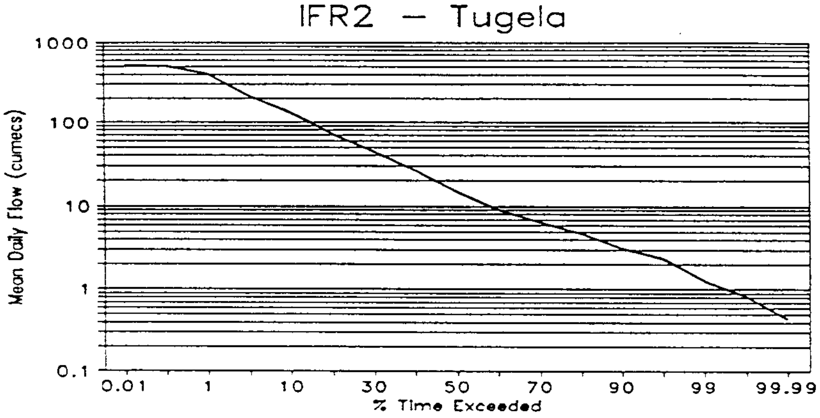

Figure 3 Annual 1-day duration curve for virgin conditions, IFR site 2

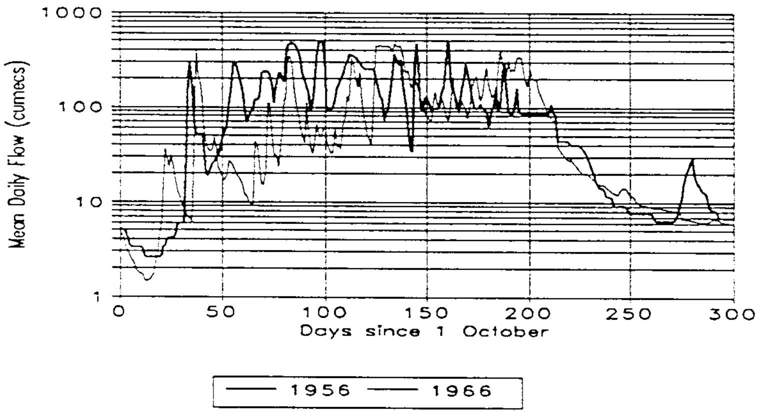

Figure 4 Daily time series for two wet years (1956 and 1966)

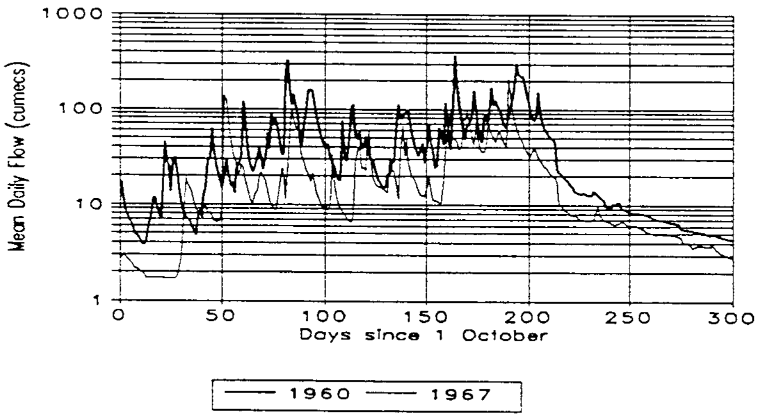

Figure 5 Daily time series for two dry years (1960 and 1967)

IFR Site 3B - Bushman's

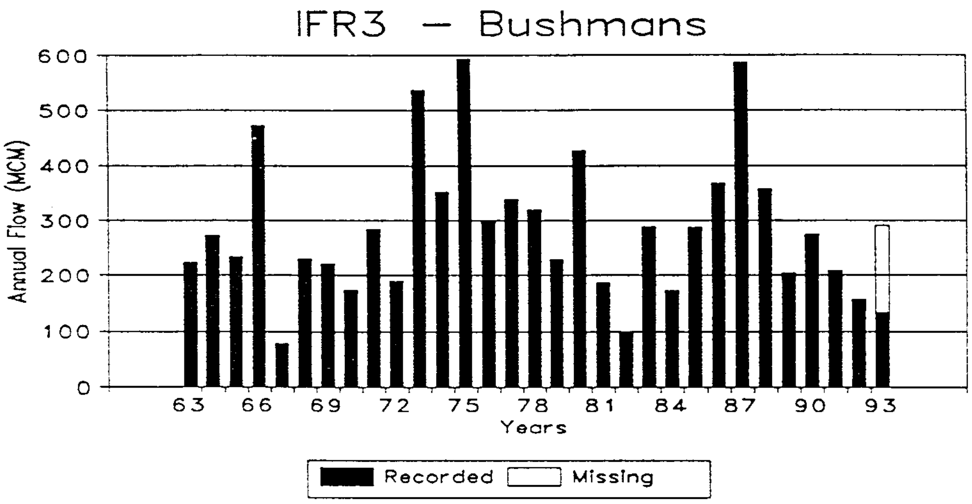

Figure 6 Annual flow volumes (MCM = $m^3 * 10^6$) for IFR site 3B.

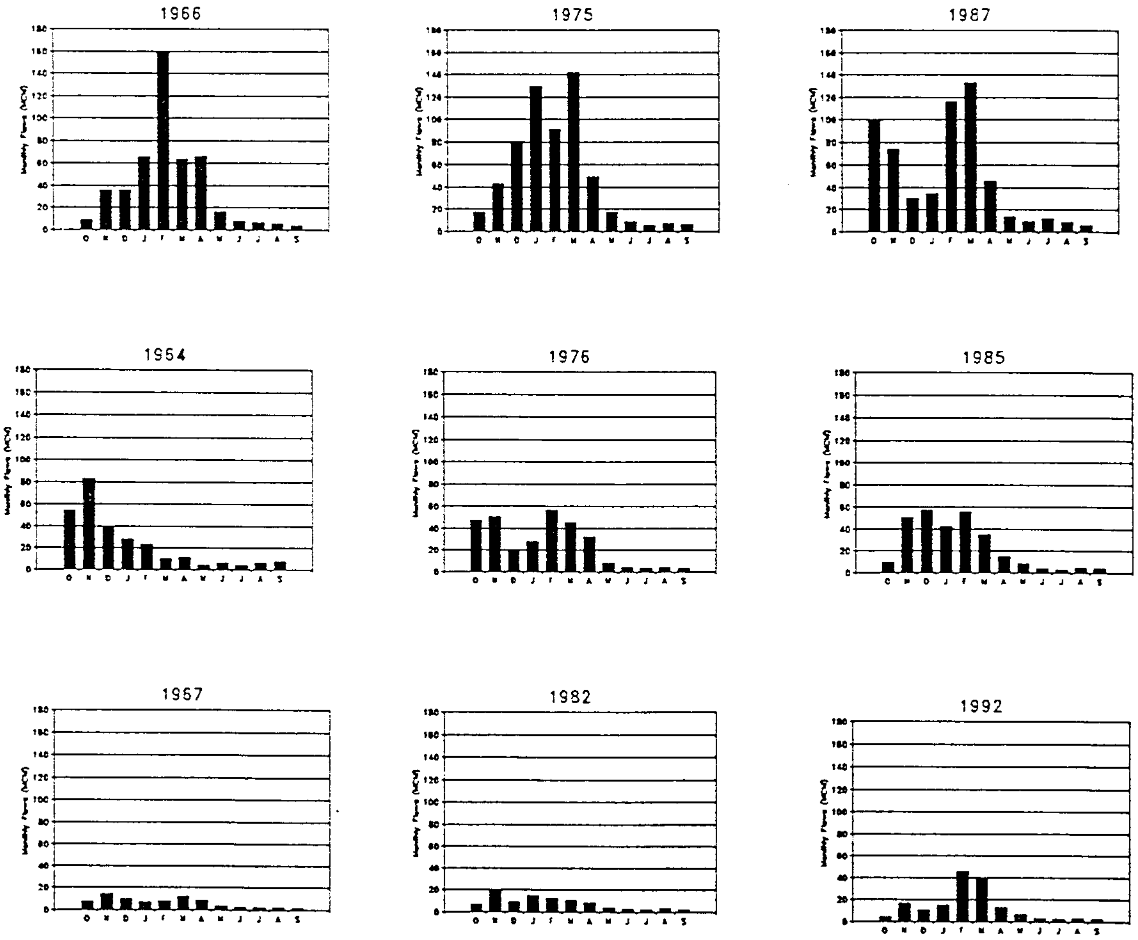

Figure 7 IFR3B, Monthly flow volumes for present day and virgin conditions for three wet, three intermediate and three dry years

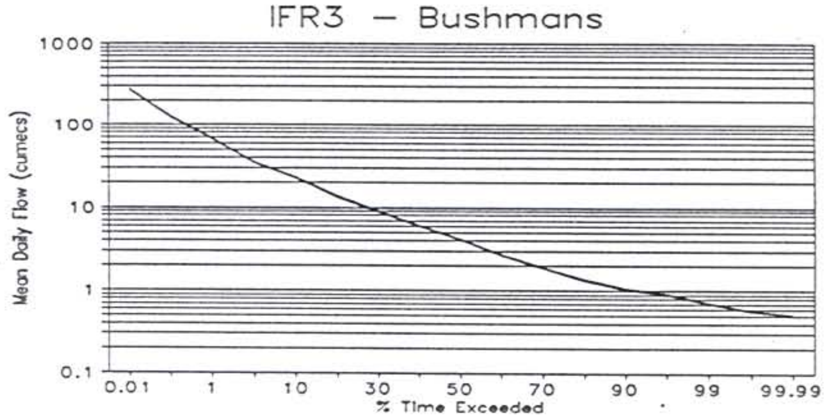

Figure 8 Annual 1-day duration curve for virgin conditions, IFR site 3B

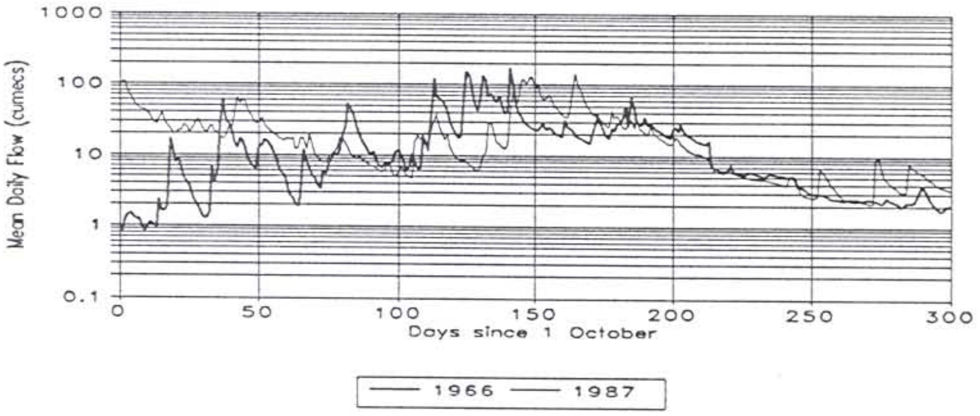

Figure 9 Daily time series for two wet years (1966 and 1967)

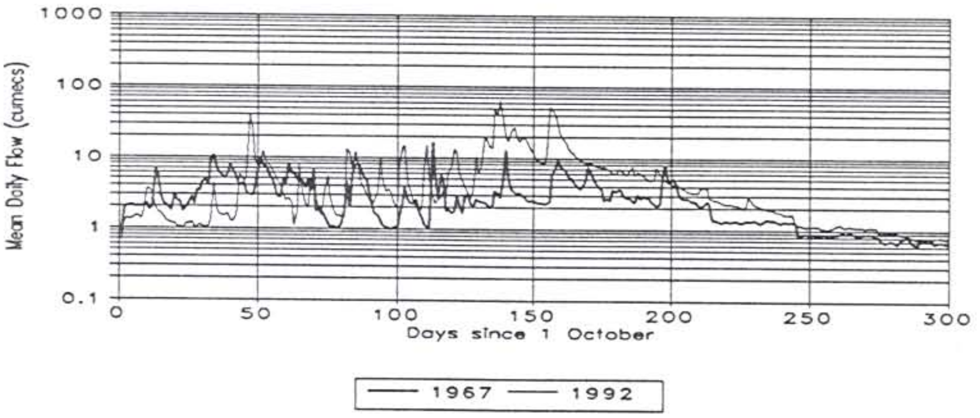

Figure 10 Daily time series for two dry years (1967 and 1992)

IFR Site 5 - Tugela

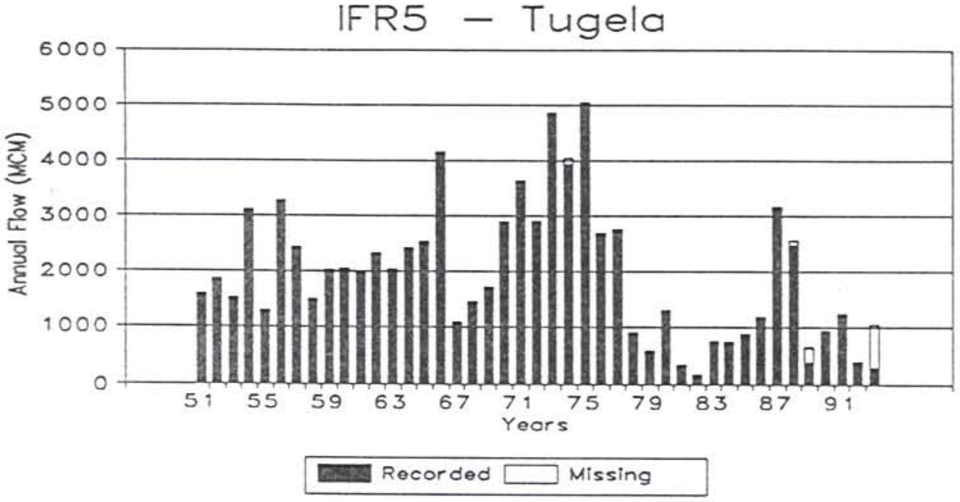

Figure 11 Annual flow volumes (MCM = $m^3 * 10^6$) for IFR site 5

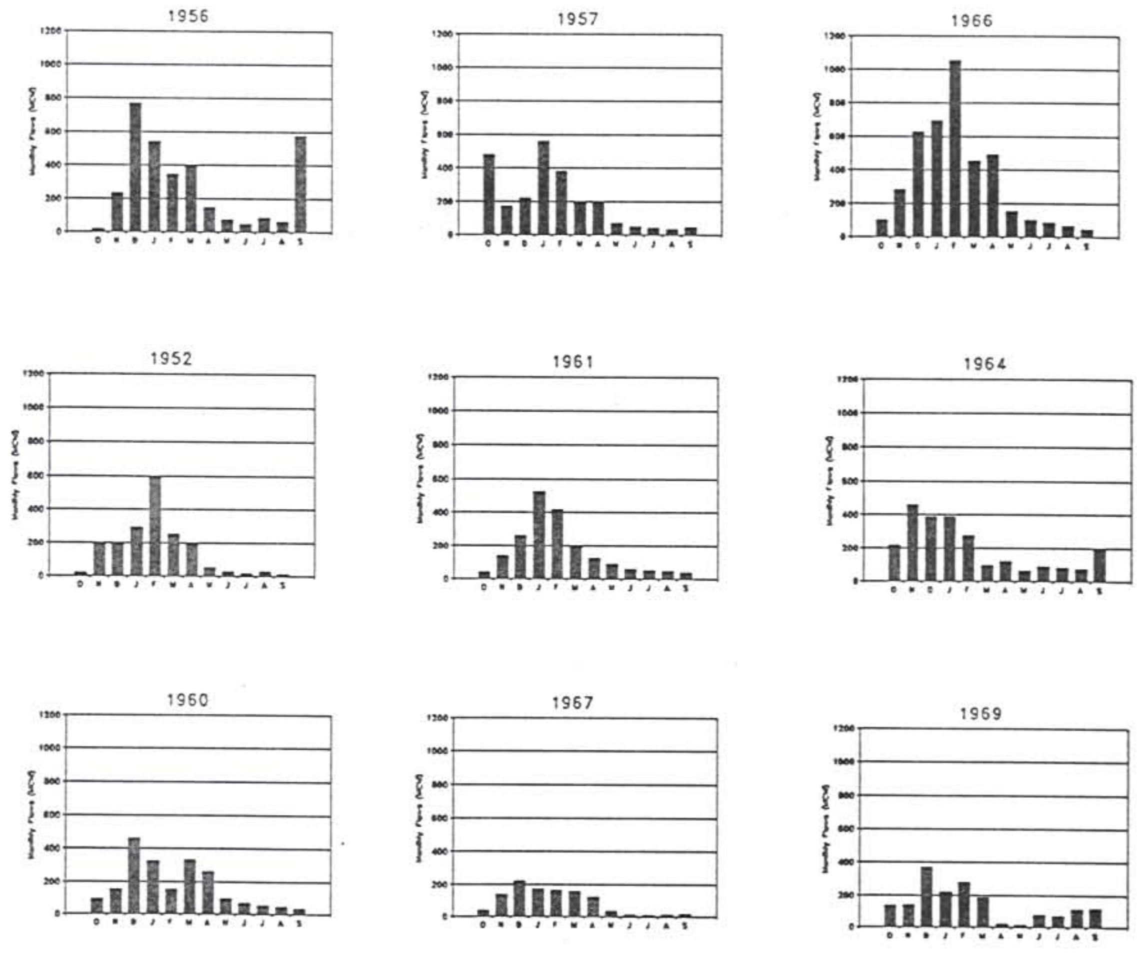

Figure 12 IFR5, Monthly flow volumes for present day and virgin conditions for three wet, three intermediate and three dry years

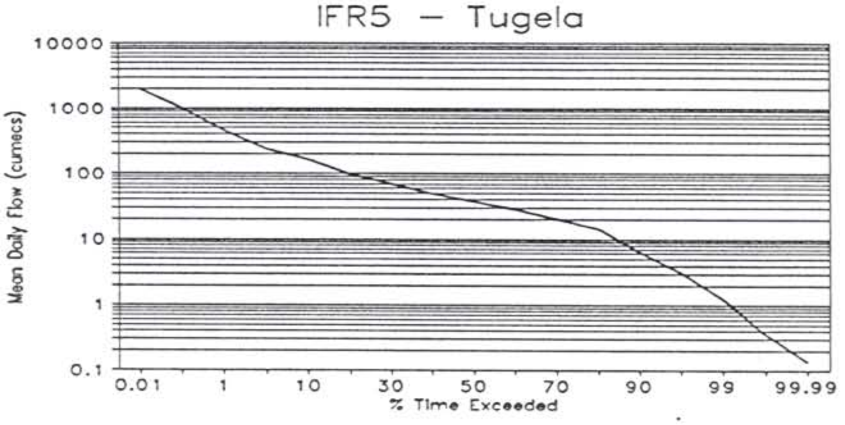

Figure 13 Annual 1-day duration curve for virgin condions, IFR site 5

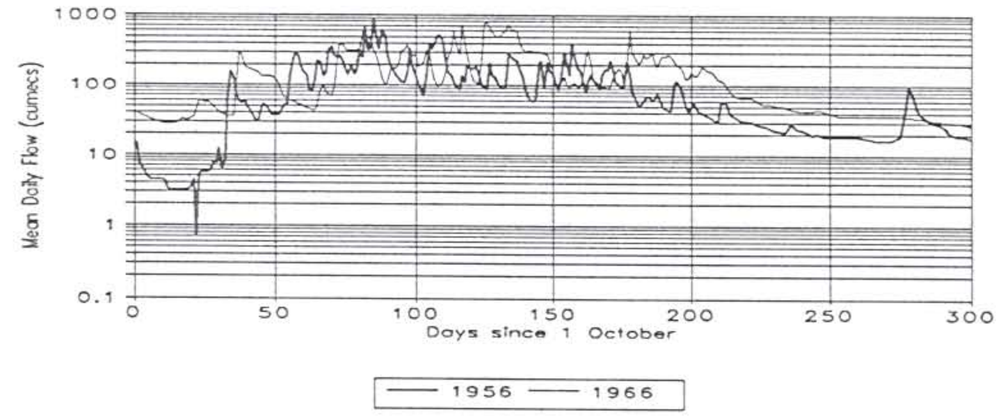

Figure 14 Daily time series for two wet years (1956 and 1966)

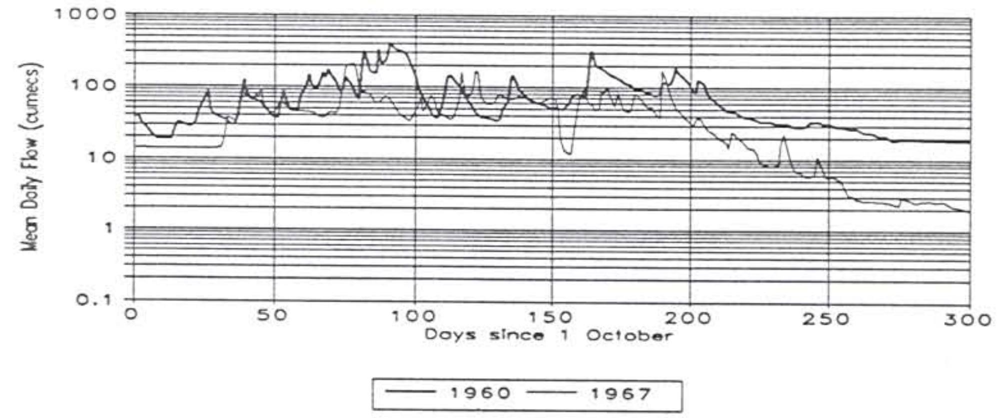

Figure 15 Daily time series for two dry years (1960 and 1967)

Table 2 Summary of flow data for virgin conditions at IFR sites 2, 3B and 5. Flows are in $m^3 s^{-1}$ and durations are in days.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.
IFR2 - Tugela (based on data for 1951 to 1971)												
Drought Baseflows	1.0 -1.5	3 - 5	8 - 10	8 - 9	10	10	10	4 - 5	3 - 4	2 - 3	1.5 - 2	1 - 2
Normal Baseflows	1.5 - 2.0	7 - 10	15 - 20	15 - 25	30 - 40	25 - 35	15 - 25	7 - 9	5 - 7	4 - 5	3 - 3.5	2 - 3
No. of Events	> 1	1 - 2	> 2	> 2	> 2	> 2	> 1	< 1	< 1	< 1	< 1	1
Range of peaks	15 - 30	30 - 50	50 - 100	50 - 100	50 - 100	50 - 100	50 - 100	20 - 40	15 - 20	± 15	10 - 30	> 15
Main duration	3	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3	3	3	3	3
IFR 3B - Bushman's (based on data for 1963 to 1994)												
Drought Baseflows	0.9 - 1.0	1.0 - 1.5	1.0 - 1.5	1.0 - 1.5	2 - 3	2 - 3	2 - 3	± 1.5	0.9	0.6 - 0.7	0.7 - 0.8	0.6 - 0.7
Normal Baseflows	1.5	2.0 - 2.5	3 - 5	3 - 5	4 - 6	4 - 6	3 - 5	2 - 3	1.0 - 1.5	0.8 - 1.0	1.0	0.8 - 1.0
No. of Events	1	> 1	> 1	> 2	> 2	> 1	1	< 1	< 1	< 1	< 1	1
Range of peaks	5 - 30	10 - 35	12 - 35	15 - 50	<15 - 50	<15 - 50	<10 - 25	4 - 8	2.5 - 10	2 - 6	3 - 15	4 - 15
Main duration	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6
IFR 5 - Tugela (based on data for 1951 to 1971)												
Drought Baseflows	0.6 - 1.0	1.0 - 1.5	10 - 15	10 - 15	15 - 20	20 - 25	15	7 - 8	2 - 3	<2 - 2.5	1.5 - 2.0	1.0 - 2.0
Normal Baseflows	3 - 5	10 - 20	± 40	30 - 40	± 50	± 40	20 - 25	15 - 20	± 14	± 12	± 10	4 - 6
No. of Events	± 1	> 1	> 2	> 2	> 2	± 2	> 1	Rare	Rare	Rare	< 1	< 1
Range of peaks	40 - 150	50 - 150	50 - 200	80 - 200	60 - 200	60 - 200	60 - 150	N/A	N/A	N/A	15 - 70	< 150
Main duration	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6	3 - 6				3 - 6	3 - 6

7. Tukhela and Bushmans Rivers Rivers Water Resource Development Feasibility Study Instream Flow Requirement Hydraulics

Tukhela and Bushmans Rivers Water Resource Development Feasibility Study
Instream Flow Requirement Hydraulics

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CONTENTS

1 Background

River flow hydraulic studies at the original instream flow requirement (IFR) sites were conducted during the pre-feasibility phase of the study. On-site data collection for the initial hydraulics study was however limited to a single set of stage and discharge measurements, and the cross-sectional profiles were surveyed with limited detail. Consequently, the synthesized rating curves for the pre-feasibility study were shown to be unreliable when compared with observations during the workshop site visits.

For the IFR refinement, it was therefore decided to reselect and resurvey the sites in order to obtain more reliable hydraulics information. The study was initiated in August 1996.

2 Objective

The main aim of this study is to provide reliable relationships between discharge rate, stage, average velocity, channel perimeter and width, for selected cross-sections at the four IFR sites.

3 Methodology

3.1 Data Collection

3.1.1 Cross-Sectional Profile Surveys

IFR sites 2 (Tukhela River in the Gorge), 3A (Bushmans River in the Weenen Nature Reserve), and 3B (Bushmans River at Darkest Africa) were reselected and surveyed following the recommendations of the pre-feasibility study as well as geomorphological changes resulting from the recent flood events. IFR 5 (Tukhela River downstream of Tukhela Ferry) was resurveyed to provide more detailed cross-sectional profiles. Three cross-sections were surveyed at each of the sites, upstream (cross-section 1) and downstream (cross-section 3) of the cross-section (2) selected for ecological purposes. An exception is IFR 3B, where the ecological cross-sections are 1 (fish) and 3 (riparian vegetation). The profile surveys were carried out by DWAF, Natal Region (Midmar Dam).

3.1.2 Discharge Rate and Stage Levels

Five recordings of the discharge rates and stage levels were undertaken over the period 26 August 1996 to 6 December 1996 (Table 6). The velocities were measured using an A OTT current meter. Considering the short period available for data collection, a satisfactory range of discharge rates were monitored (Table 6). Manual gauging was undertaken to obtain the most reliable estimates of discharge rate.

3.2 *Analysis*

3.2.1 *Synthesis of Rating Data*

The Manning's total flow resistance coefficient has been calibrated between the cross-sections at the IFR sites using a backwaters non-uniform flow profile computational procedure. These values, together with the friction slopes between cross-sections are given in Table 1. The data in Table 1 clearly reflect a reducing resistance coefficient with increasing discharge rate as is expected, with the energy slope data remaining relatively constant and not showing any significant variations with change in discharge rate. In order to extrapolate the observed rating data, the value of the resistance coefficient and friction slope terms in a resistance type equation must be determined. Manning's resistance relationship is applied here, and is given by:

$$Q = \frac{A^{5/3}}{P^{2/3}} \frac{\sqrt{S_f}}{n} \qquad 1$$

where

Q is the discharge rate (m^3/s)

A is the cross-sectional flow area (m^2)

P is the wetted perimeter (m)

S_f is the friction slope

n is the Manning resistance coefficient

The "resistance - friction slope" term in equation 1 may be combined into a single term, given by

$$k = Q \frac{P^{2/3}}{A^{5/3}} \qquad 2$$

This term is computed using the data recorded at each of the cross-sections, and the results are given in Table 3. The rating data may be extrapolated beyond the range of field measurements if the values of the "friction slope - resistance" term may be estimated. Since the change in friction slope with discharge rate has been shown to be small, constant values may be assumed with an acceptable degree of reliability. The friction coefficient varies significantly, however, and using a constant value will introduce significant errors. For this reason, it is advisable to determine the resistance - friction slope term for a range of discharge rates. Indications are that the resistance coefficient reduces to an asymptotic value with increasing discharge, but increases almost exponentially with reducing discharge as the flow depth becomes comparable with the height of the resistance elements. For IFR sites 2 and 3B, the k values computed (Table 3) at the highest discharges recorded

(28.9 m³/s and 20.1 m³/s respectively) were assumed to be the asymptotic values. For IFR sites 3A and 5, however, the k value determined at the highest recorded discharges (8.2 m³/s and 29.0 m³/s) resulted in unreasonably high average velocities for flood flows (1000 m³/s), and therefore the *k* values were increased according to a power relationship.

Table 1 Manning's Resistance Coefficient and Energy Slopes between Cross-Sections

Site	Cross-Section	Manning's Resistance, *n* Energy Slope, S_f				
IFR 2		Discharge Rate, Q (m³/s)				
		2.2	3.4	9.6	28.9	
	1 - 2	0.36 0.0070	0.29 0.0063	0.20 0.0070	0.13 0.0092	
	2 - 3	0.19 0.0020	0.20 0.0029	0.12 0.0028	0.070 0.0023	
IFR 3A		Discharge Rate, Q (m³/s)				
		0.9	2.0	6.5	8.2	
	1 - 2	0.22 0.0055	0.11 0.0040	0.072 0.0041	0.068 0.0035	
	2 - 3	0.23 0.0089	0.20 0.011	0.16 0.010	0.18 0.011	
IFR 3B		Discharge Rate, Q (m³/s)				
		1.3	2.2	2.6	5.9	20.1
	1 - 2	0.51 0.025	0.33 0.025	0.28 0.025	0.22 0.023	0.15 0.021
	2 - 3	0.20 0.0017	0.13 0.0021	0.10 0.0014	0.080 0.0015	0.052 0.0025
IFR 5		Discharge Rate, Q (m³/s)				
		5.7	9.2	11.5	18.2	29.0
	1 - 2	0.17	0.15 0.0080	0.12 0.0070	0.11 0.0093	0.080 0.0075
	2 - 3	0.34	0.29 0.014	0.27 0.015	0.18 0.012	0.15 0.014

Table 2 Regional Site Slopes

Site	Slope, S_o
IFR 2	0.0047
IFR 3A	0.010
IFR 3B	0.0061
IFR 5	0.0040

Table 3 Computed k values According to Equation 2, and Extrapolated Values

Site	Cross-Section	$k = Q \frac{P^{2/3}}{A^{5/3}}$						
IFR 2		Discharge Rate, Q (m^3/s)						
		< 2.2	2.2	3.4	9.6	28.9		> 28.9
	2	0.56	0.56	0.56	0.88	1.27		1.27
IFR 3A		Discharge Rate, Q (m^3/s)						
		< 0.9	0.9	2.0	6.5	8.2		> 8.2
	2	0.45	0.48	0.43	0.68	0.59		0.7 to 1.0
IFR 3B		Discharge Rate, Q (m^3/s)						
		< 1.3	1.3	2.2	2.6	5.9	20.1	> 20.1
	1	0.46	0.46	0.71	0.83	0.95	1.34	1.34
	3	0.33	0.33	0.56	0.58	0.71	1.16	1.16
IFR 5		Discharge Rate, Q (m^3/s)						
		< 5.7	5.7	9.2	11.5	18.2	29.0	> 29.0
	2	0.45	0.48	0.46	0.55	0.74	0.88	0.9 to 1.3

Applying the Manning's resistance coefficient for extreme low-flow conditions is problematic, since the flow depth is of the same order as the height of the resistance elements, and large coefficients result. In the absence of any field observations, however, the highest determined k value is applied. This is somewhat set-off by the fact that if the flow depth reduces to zero at a zero discharge rate, the synthesis is an interpolation and not an extrapolation. The rating relationship is assumed to pass through the origin at all cross-sections.

3.2.2 *Regression Relationships*

Regression relationships of the general form given in equation 3 have been fitted to the measured and synthesized rating data. The regression coefficients and ranges of applicability of the resultant equations are listed in Table 4.

$$y = a\ Q^{b} + c \qquad (3)$$

where
y is the maximum flow depth (m)
a,b,c are the coefficients given in Table 4

Table 4 Coefficients to Equation 3 from a Regression Analysis, and Ranges of Applicability

Site	Cross-Section	Coefficient			Range	
		a	b	c	Q (m^3/s)	y (m)
IFR 2	2	0.573	0.309	0.000	< 3.6	< 0.85
		0.217	0.442	0.468	> 3.6	> 0.85
	Backwater	0.284	0.439	0.623		
IFR 3A	2	0.457	0.308	0.000	< 8.9	< 0.90
		0.187	0.498	0.346	> 8.9	> 0.90
IFR 3B	1	0.523	0.356	0.000	< 1.3	< 0.58
		0.103	0.563	0.457	> 1.3	> 0.58
	3	0.801	0.419	0.000	< 1.2	< 0.85
		0.202	0.493	0.630	> 1.2	> 0.85
IFR 5	2	0.454	0.363	0.000	< 7.0	< 0.92
		0.175	0.458	0.495	> 7.0	> 0.92

3.2.3 *Accuracy*

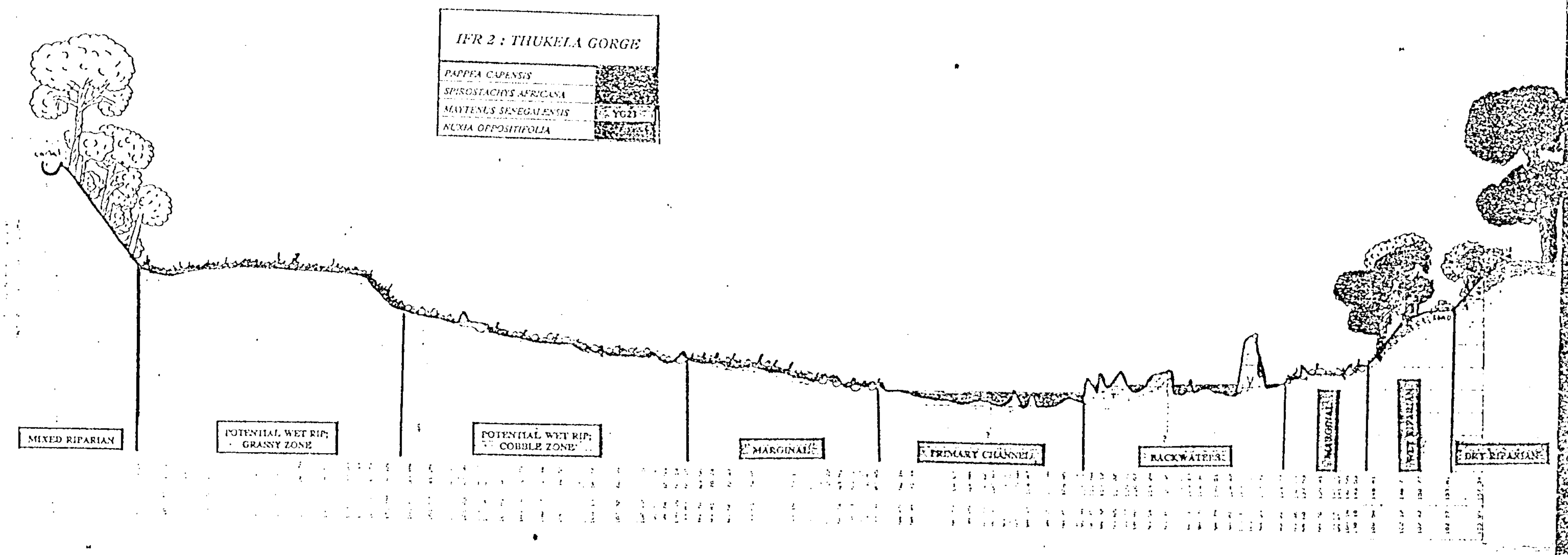
The measured and synthesized data are plotted together with the fitted relationship (log. discharge scale) to allow an assessment of the data base and also the accuracy with which the assumed regression relationships fit the data. The average errors between measured/synthesized and regression data are provided by the PC presentation.

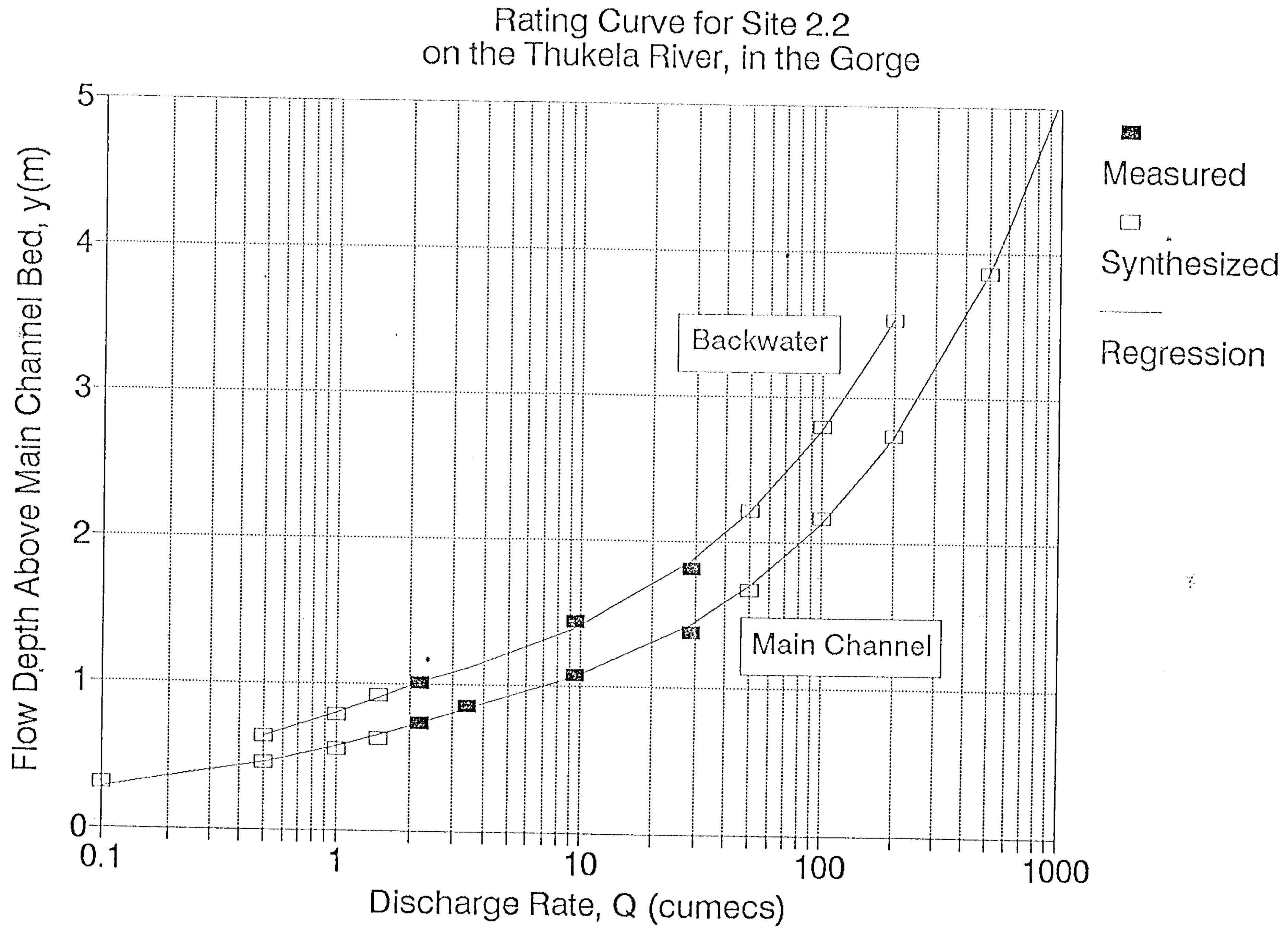
4 Presentation of Hydraulic Data

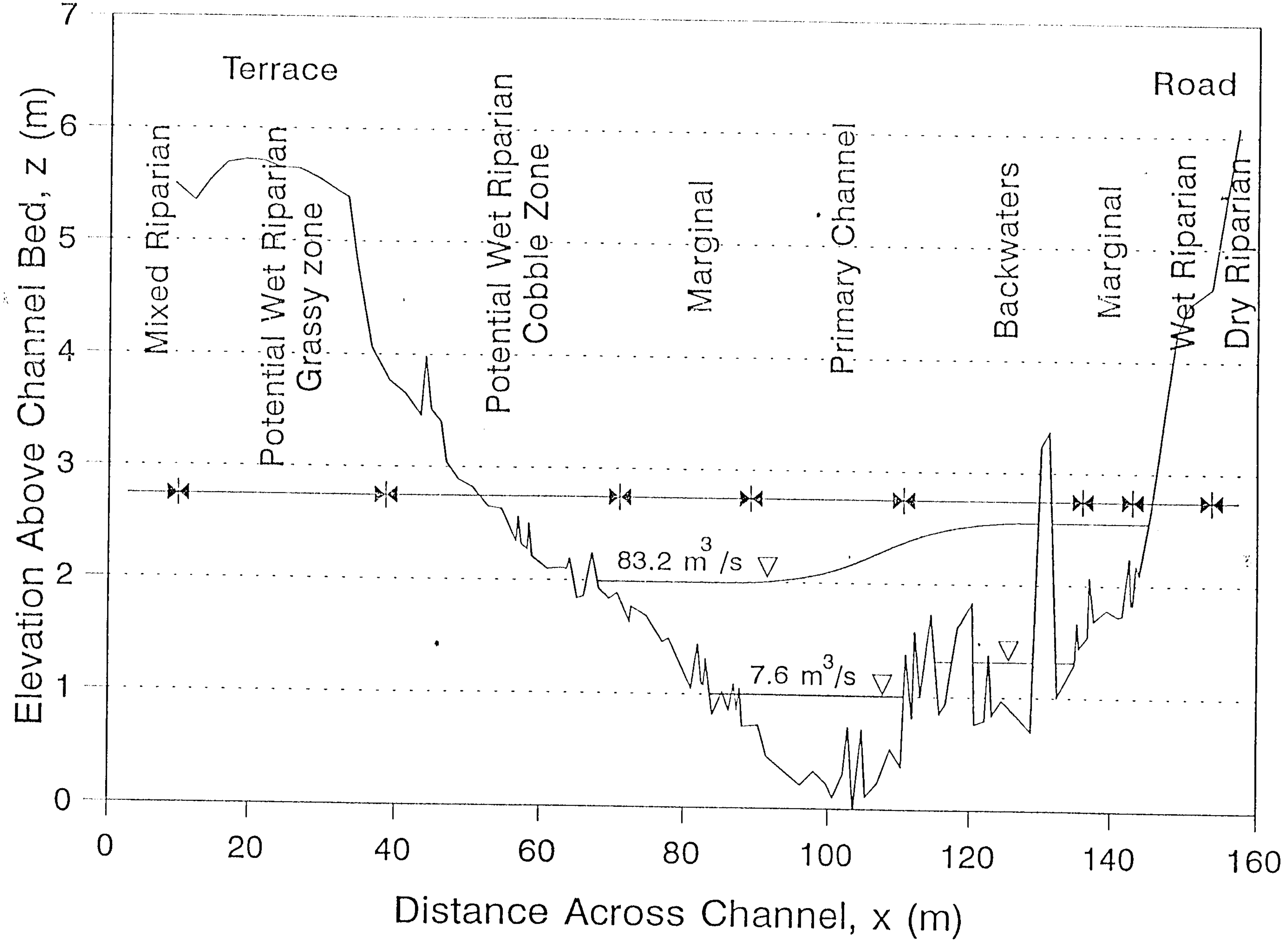
The data are presented in the form of cross-sectional profiles and plots of relevant hydraulics variables (maximum water depth, average velocity, channel width and channel wetted perimeter) against discharge rate. In addition software is provided to assist with the visualisation of the water levels at the cross-sections.

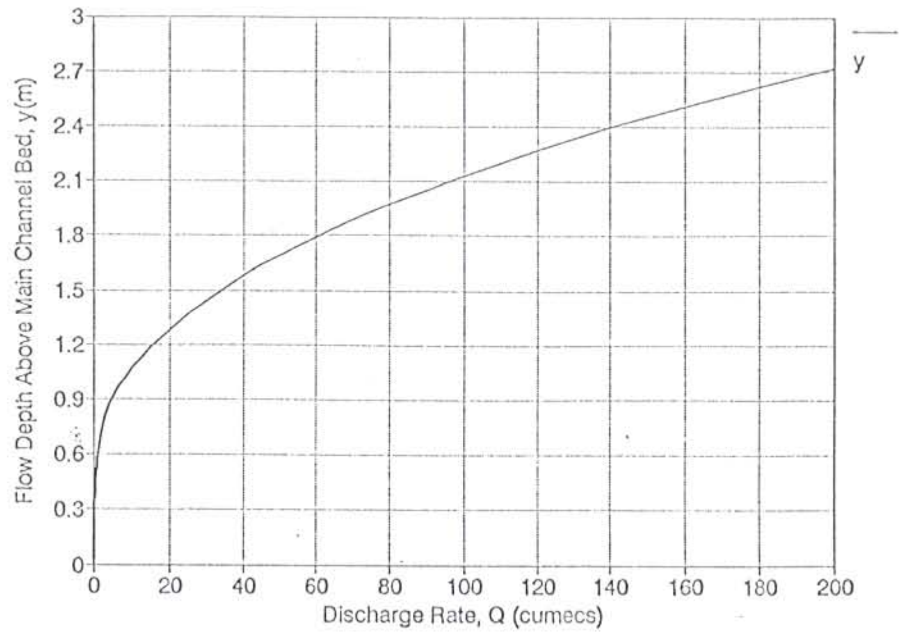
Table 6 Measured Maximum Water Depths at the Cross-Sections

Site	Cross-Section	Maximum Water Depth, y (m)				
IFR 2		Discharge Rate, Q (m^3/s)				
		2.2	3.4	9.6	28.9	
	1	1.05	1.13	1.43	1.83	
	2	0.73	0.86	1.07	1.38	
	3	1.47	1.54	1.76	2.09	
	Backwater @ 2	1.01		1.44	1.81	
IFR 3A		Discharge Rate, Q (m^3/s)				
		0.9	2.0	6.5	8.2	
	1	0.57	0.59	0.77	0.82	
	2	0.44	0.61	0.78	0.89	
	3	0.52	0.53	0.76	0.80	
	Seasonal Channel @ 2			0.44		
IFR 3B		Discharge Rate, Q (m^3/s)				
		1.3	2.2	2.6	5.9	20.1
	1	0.58	0.60	0.60	0.76	1.03
	2	1.35	1.37	1.39	1.63	2.01
	3	0.88	0.88	0.93	1.17	1.50
IFR 5		Discharge Rate, Q (m^3/s)				
		5.7	9.2	11.5	18.2	29.0
	1	0.67	0.81	0.84	0.96	1.02
	2	0.85	1.02	1.09	1.12	1.25
	3	0.99	1.20	1.21	1.36	1.41

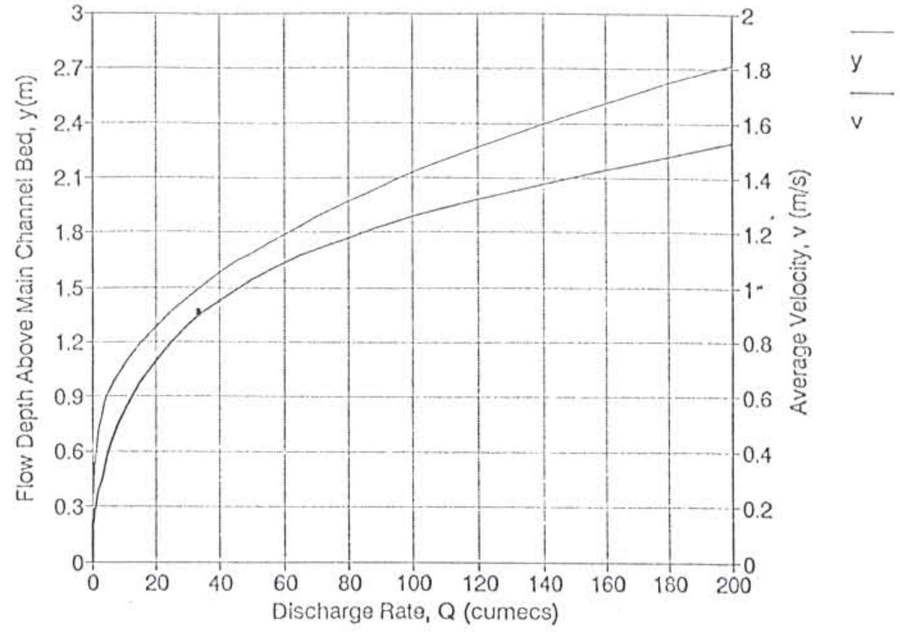

IFR 2 : THUKELA GORGE
PAPPEA CAPENSIS
SPIROSTACHYS AFRICANA
MAYTENUS SENEGALENSIS
NUXIA OPPOSITIFOLIA
MIXED RIPARIAN
POTENTIAL WET RIP; GRASSY ZONE
POTENTIAL WET RIP; COBBLE ZONE
MARGINAL
PRIMARY CHANNEL
BACKWATERS
MARGINAL
WET RIPARIAN
DRY RIPARIAN


Rating Curve for Site 2.2
on the Thukela River, in the Gorge
Flow Depth Above Main Channel Bed, y(m)
Discharge Rate, Q (cumecs)
0
1
2
3
4
5
0.1
1
10
100
1000
Backwater
Main Channel
Measured
Synthesized
Regression

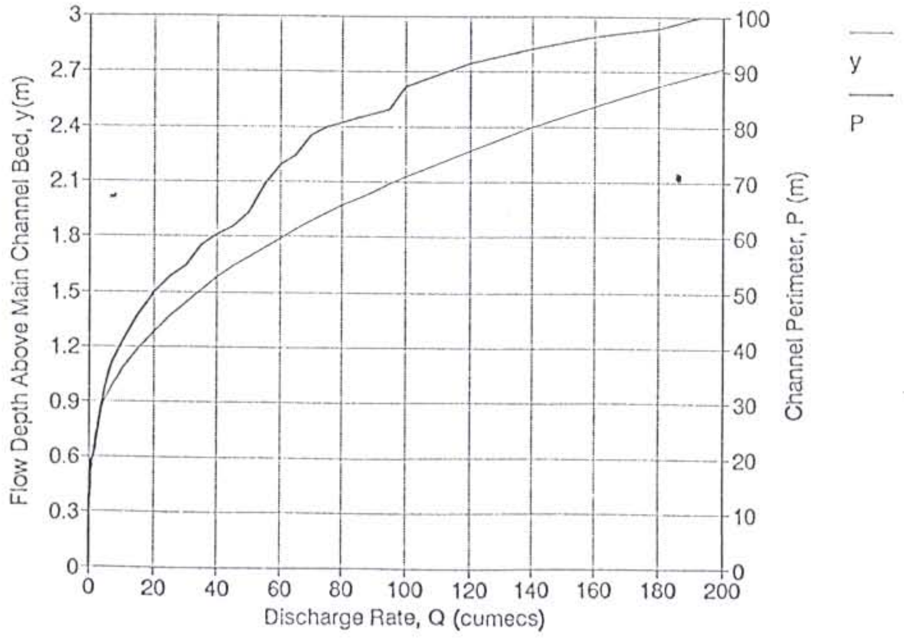

Elevation Above Channel Bed, z (m)
Distance Across Channel, x (m)
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
Terrace
Road
Mixed Riparian
Potential Wet Riparian
Grassy zone
Potential Wet Riparian
Cobble Zone
Marginal
Primary Channel
Backwaters
Marginal
Wet Riparian
Dry Riparian
83.2 m3/s
7.6 m3/s



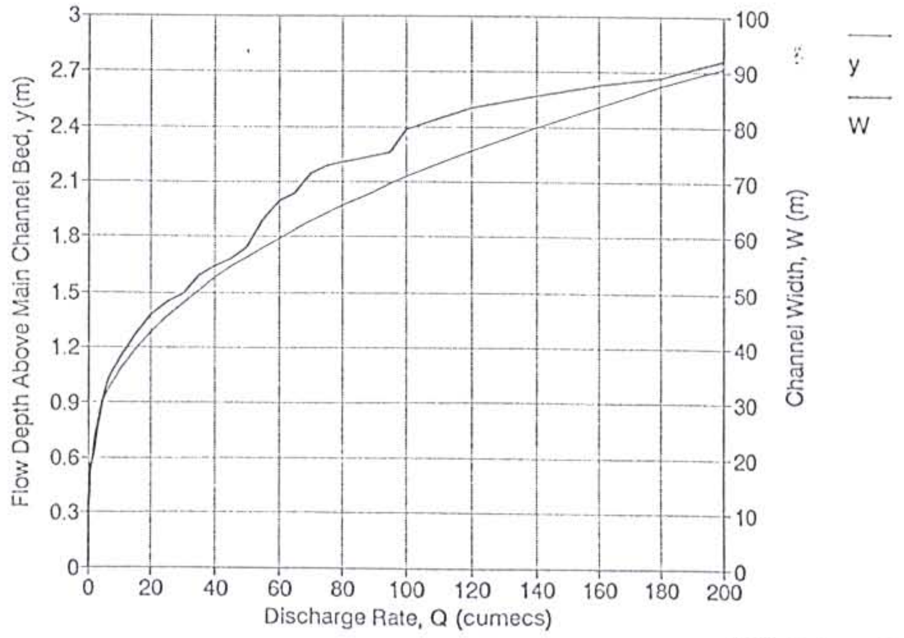
Flow Depth Above Main Channel Bed, y(m)
Discharge Rate, Q (cumecs)
y



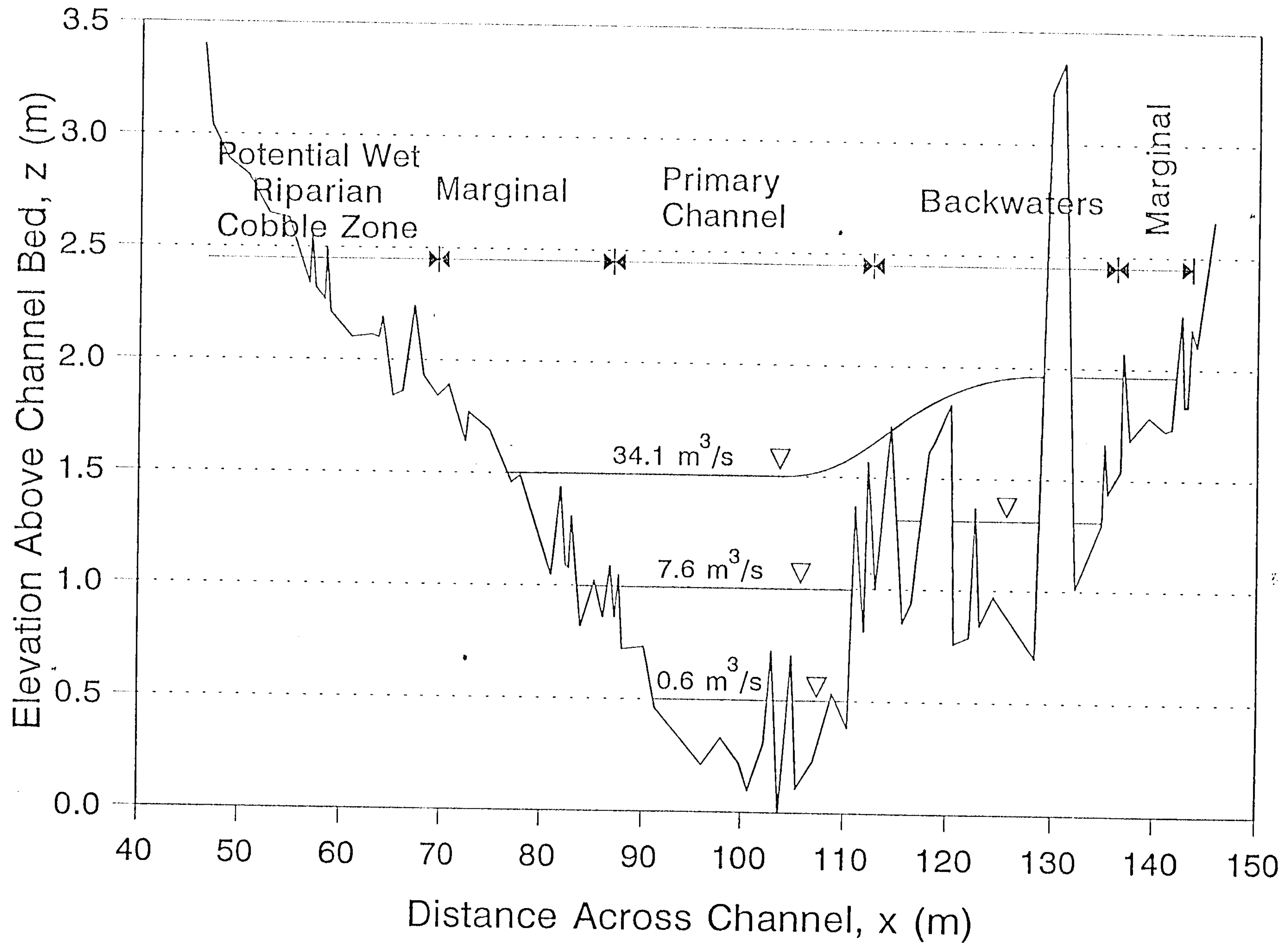
Flow Depth Above Main Channel Bed, y(m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

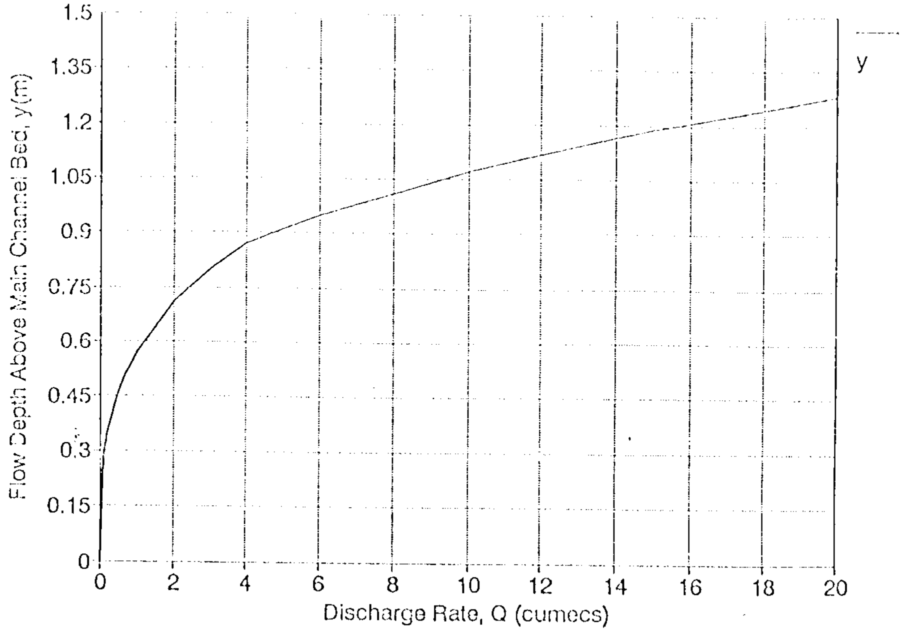


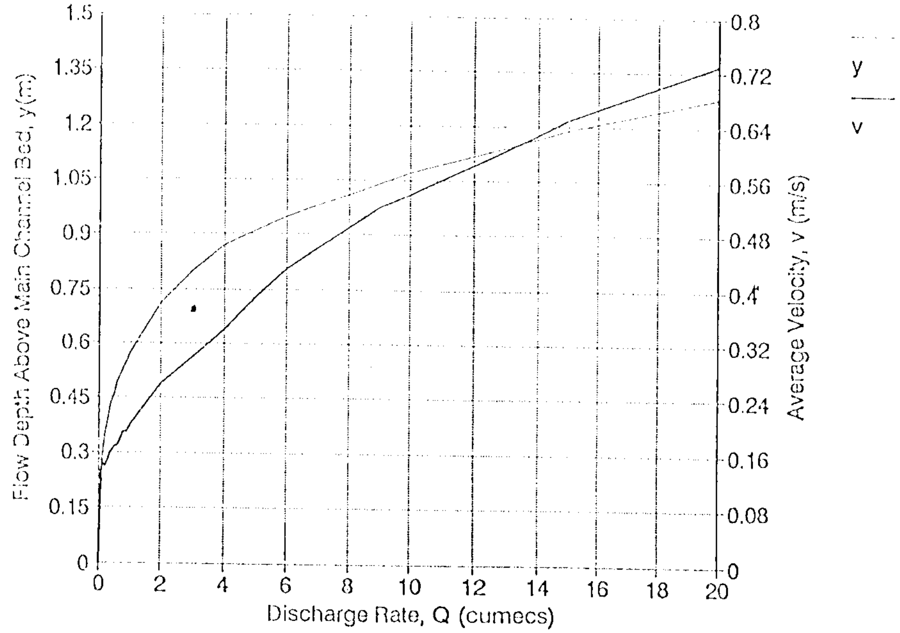
Flow Depth Above Main Channel Bed, y(m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

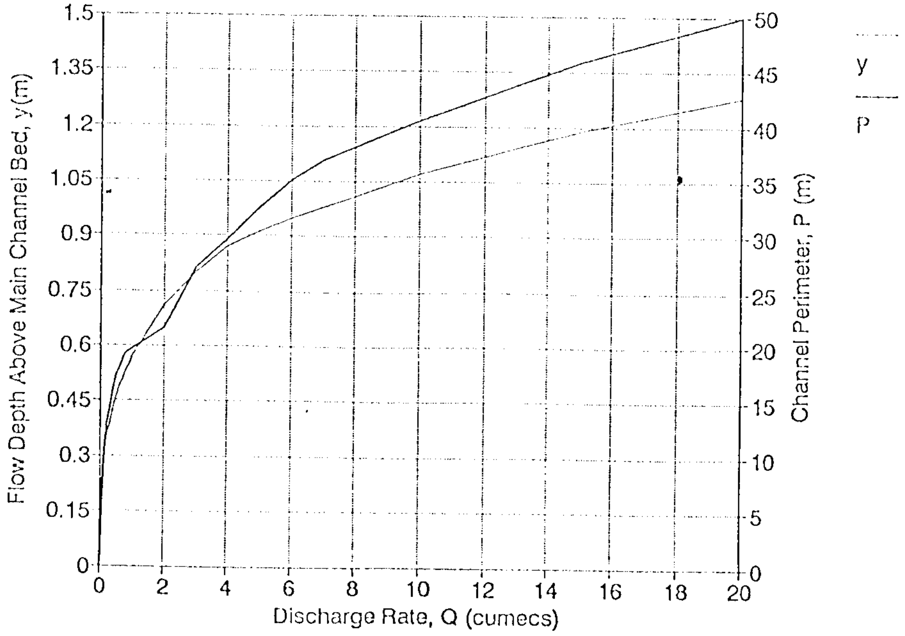


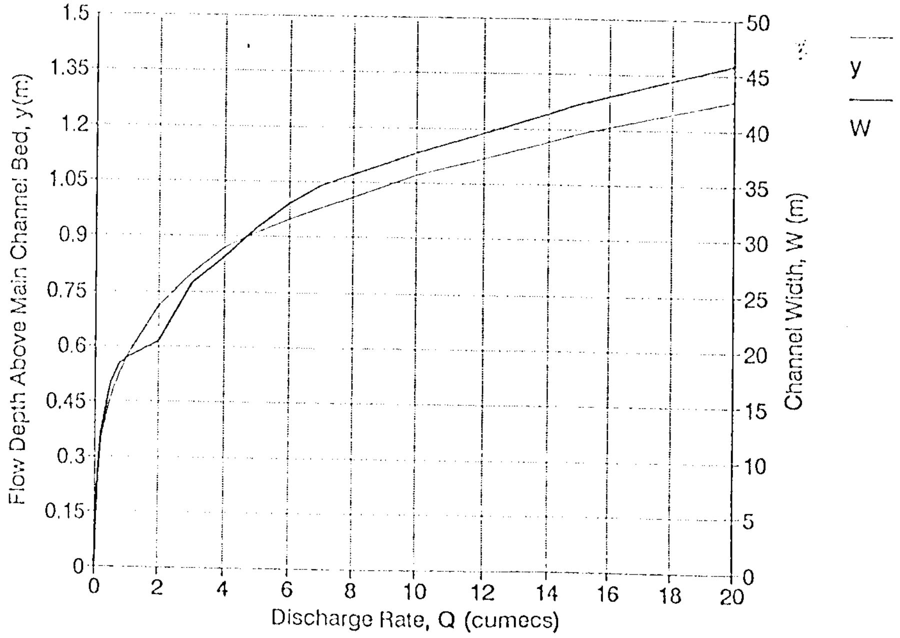
Flow Depth Above Main Channel Bed, y(m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

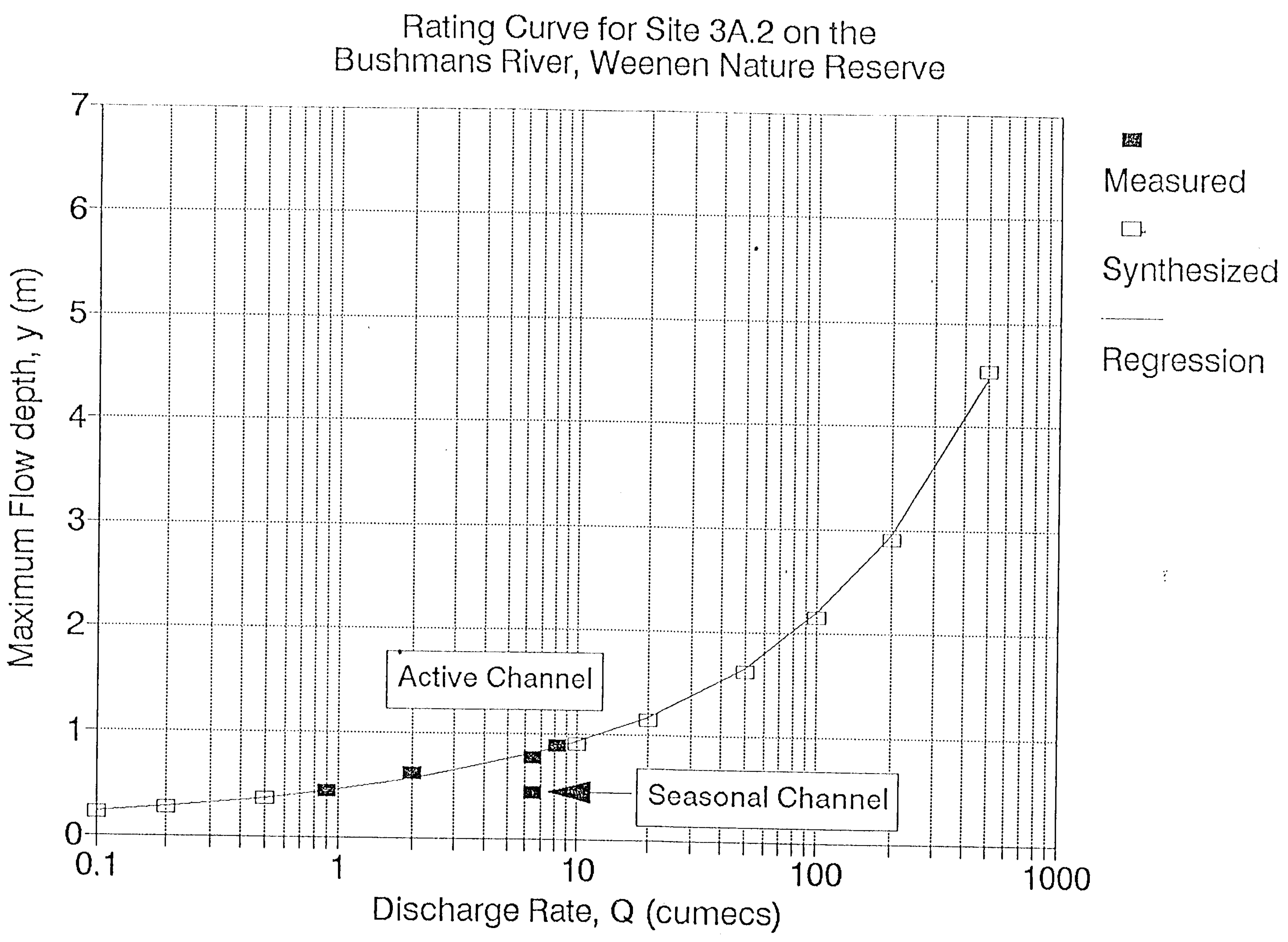

Elevation Above Channel Bed, z (m)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
40
50
60
70
80
90
100
110
120
130
140
150
Distance Across Channel, x (m)
Potential Wet Riparian Cobble Zone
Marginal
Primary Channel
Backwaters
Marginal
34.1 m3/s
7.6 m3/s
0.6 m3/s


Flow Depth Above Main Channel Bed, y(m)
Discharge Rate, Q (cumecs)
y


Flow Depth Above Main Channel Bed, y(m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

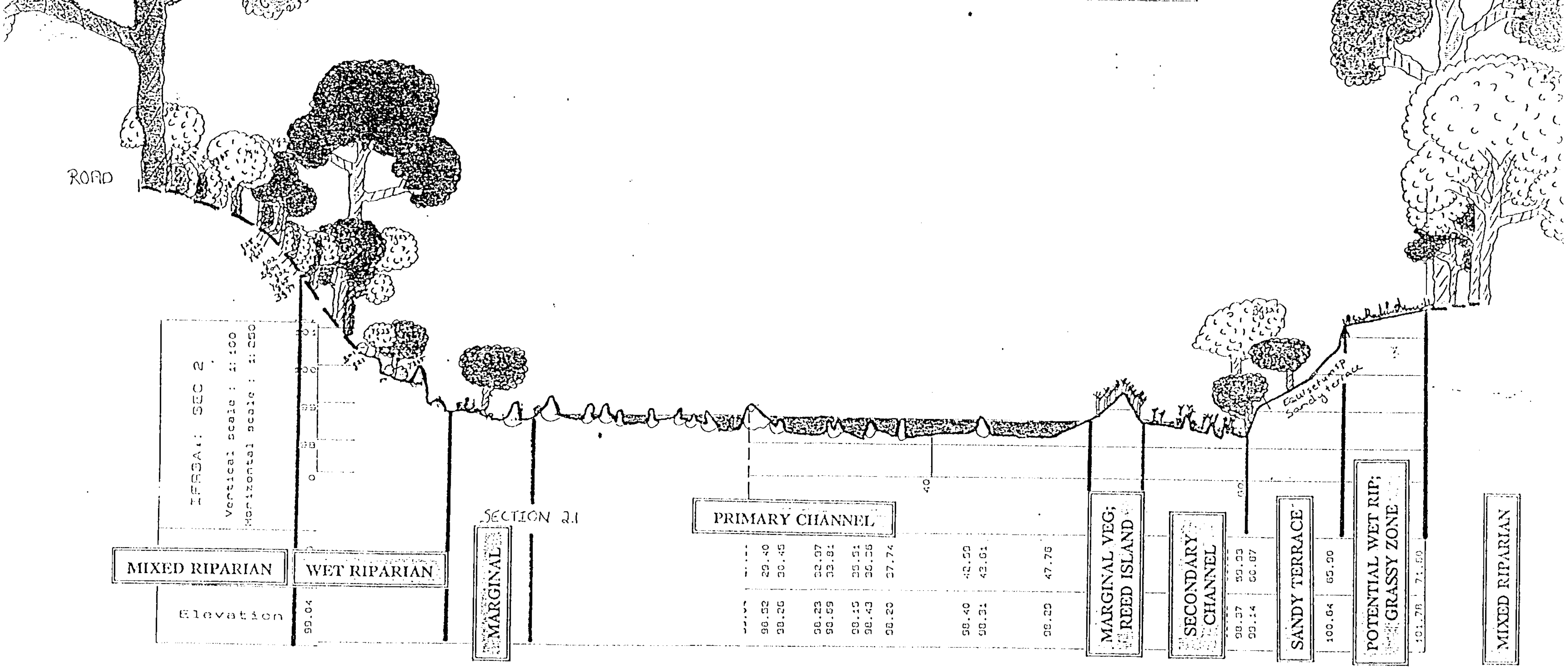

Flow Depth Above Main Channel Bed, y(m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

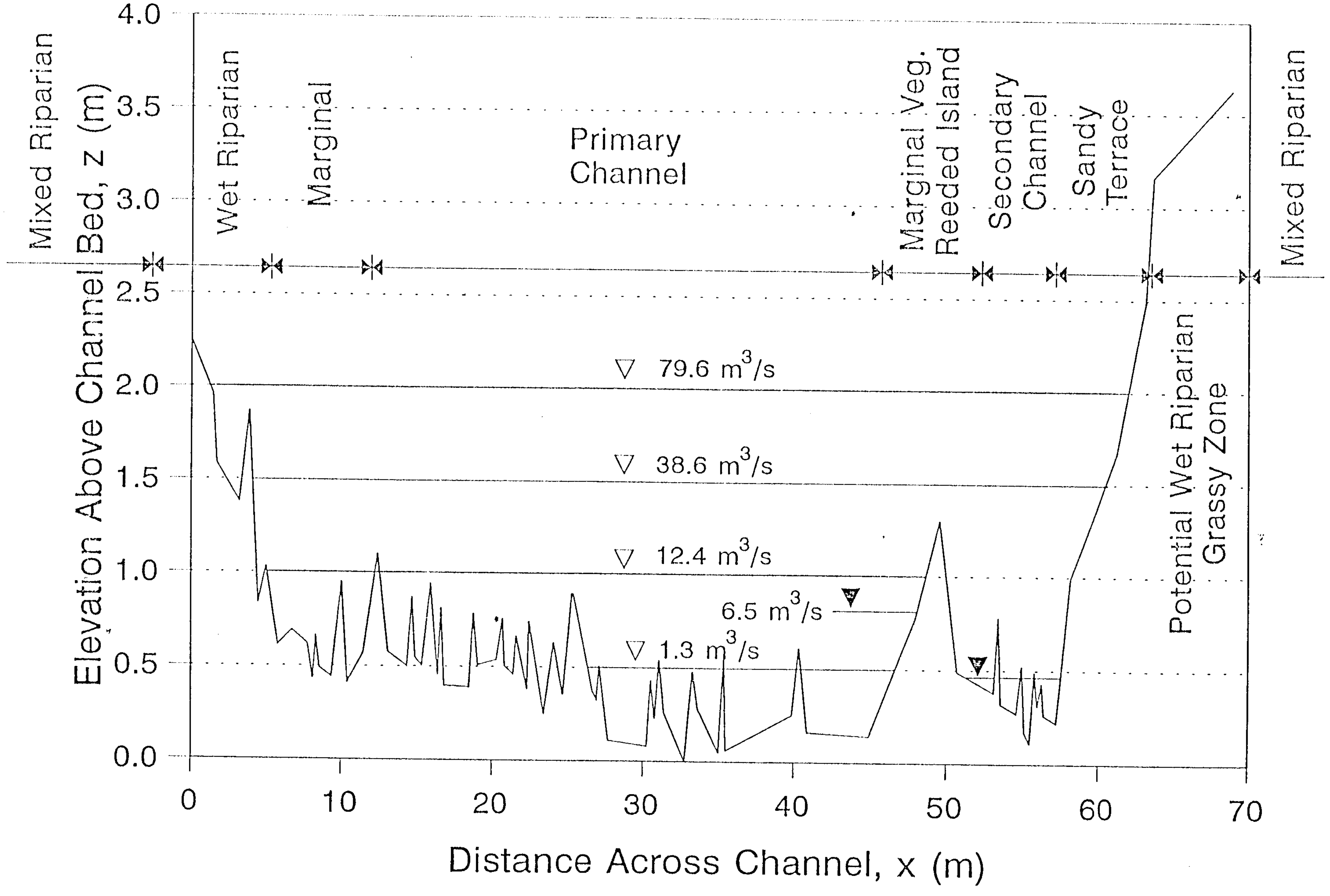

Flow Depth Above Main Channel Bed, y(m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

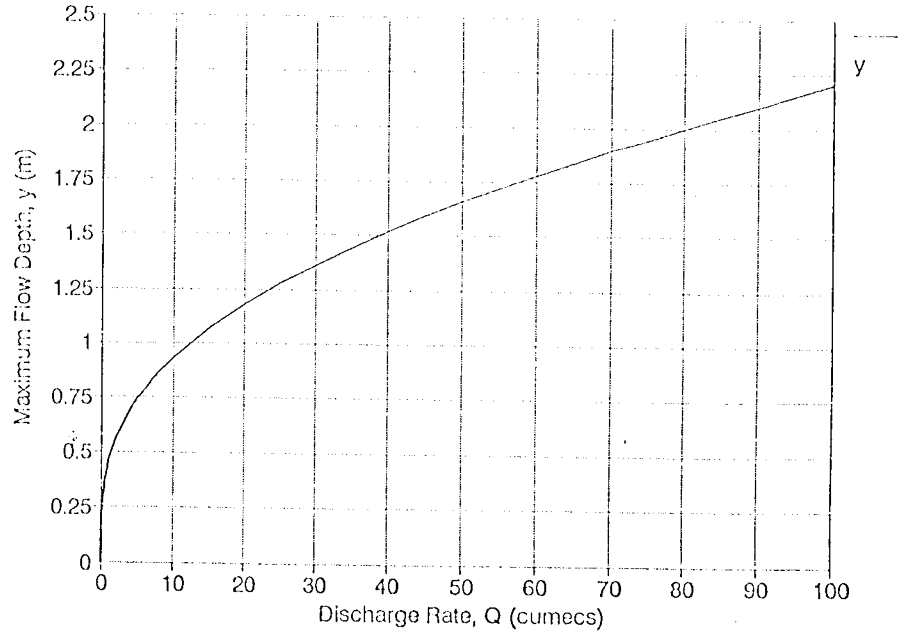

Rating Curve for Site 3A.2 on the
Bushmans River, Weenen Nature Reserve
Maximum Flow depth, y (m)
0
1
2
3
4
5
6
7
0.1
1
10
100
1000
Discharge Rate, Q (cumecs)
Active Channel
Seasonal Channel
Measured
Synthesized
Regression

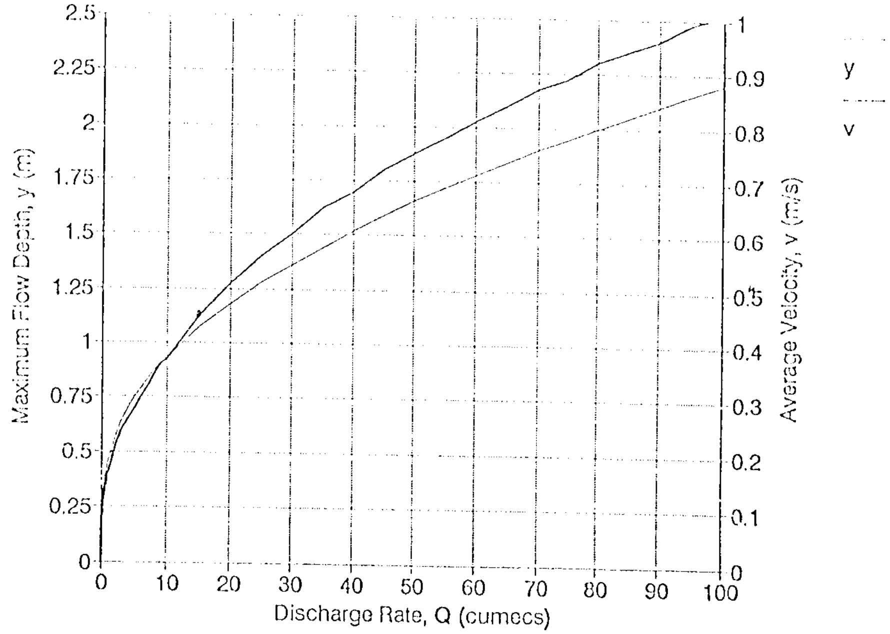
IFR 3A : WEENEN NATURE RESERVE : BUSHMENS RIVER

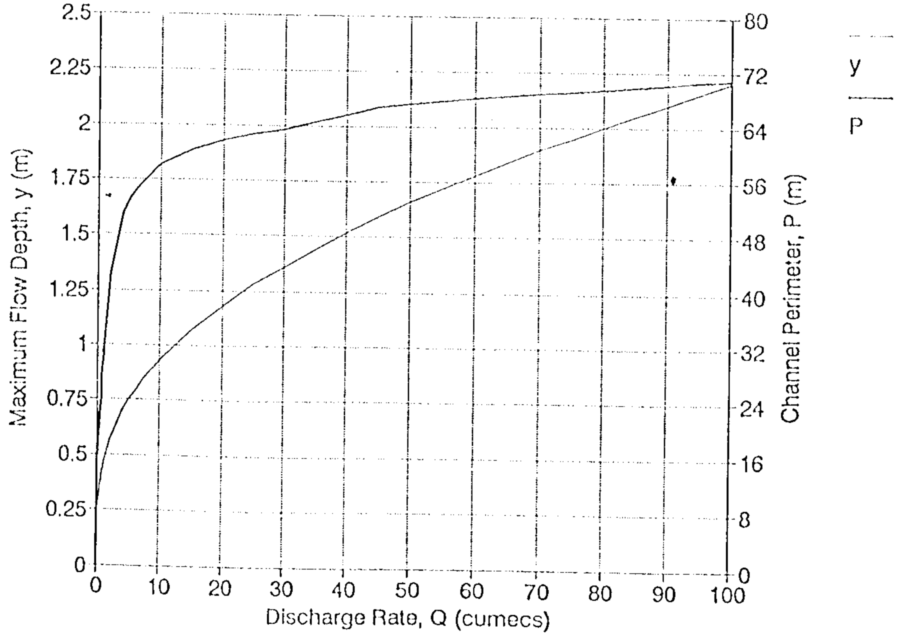
SCHOTIA BRACHYPETALA	G05	*CLAUSENA ANISATA*	[illegible]
SCOLOPIA MUNDII	G02	*CELTIS AFRICANA*	[illegible]
OLEA AFRICANA	YG67	*ACOKANTHERA OPPOSITIFOLIA*	G21
EHRETIA RIGIDA	YG45	*BUDDLEJA SALVIFOLIA*	OH
ACACIA ATAXACANTHA	[illegible]	*DOVYALIS CAFFRA*	B01
RHUS DENTATA	YG11	*SALIX MUCRONATA (WOODII)*	G17
SCUTIA MYRTINA	YG23	*ACACIA SIEBERANA*	P370
RHUS TRANSVAALENSIS		*COMBRETUM ERYTHROPHYLLUM*	BG32

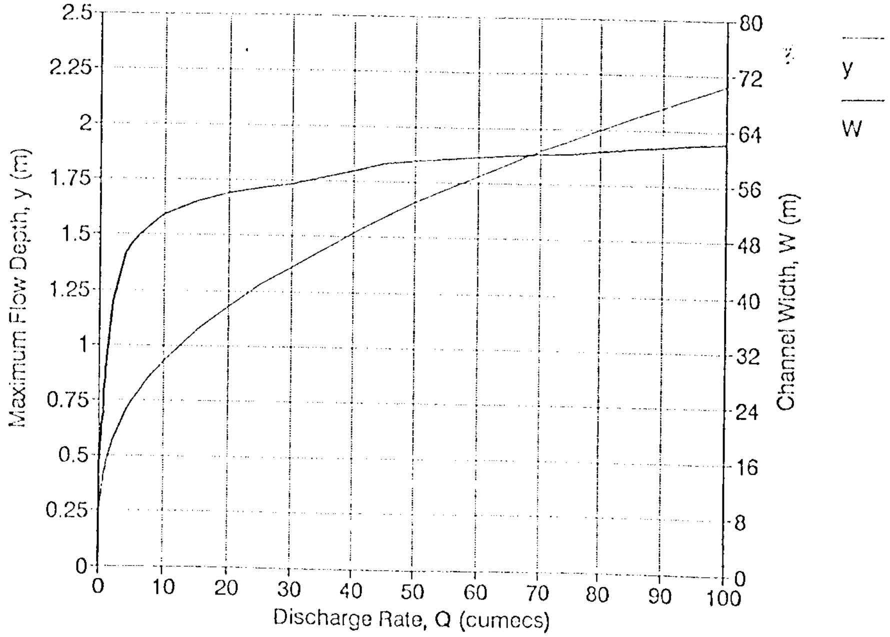


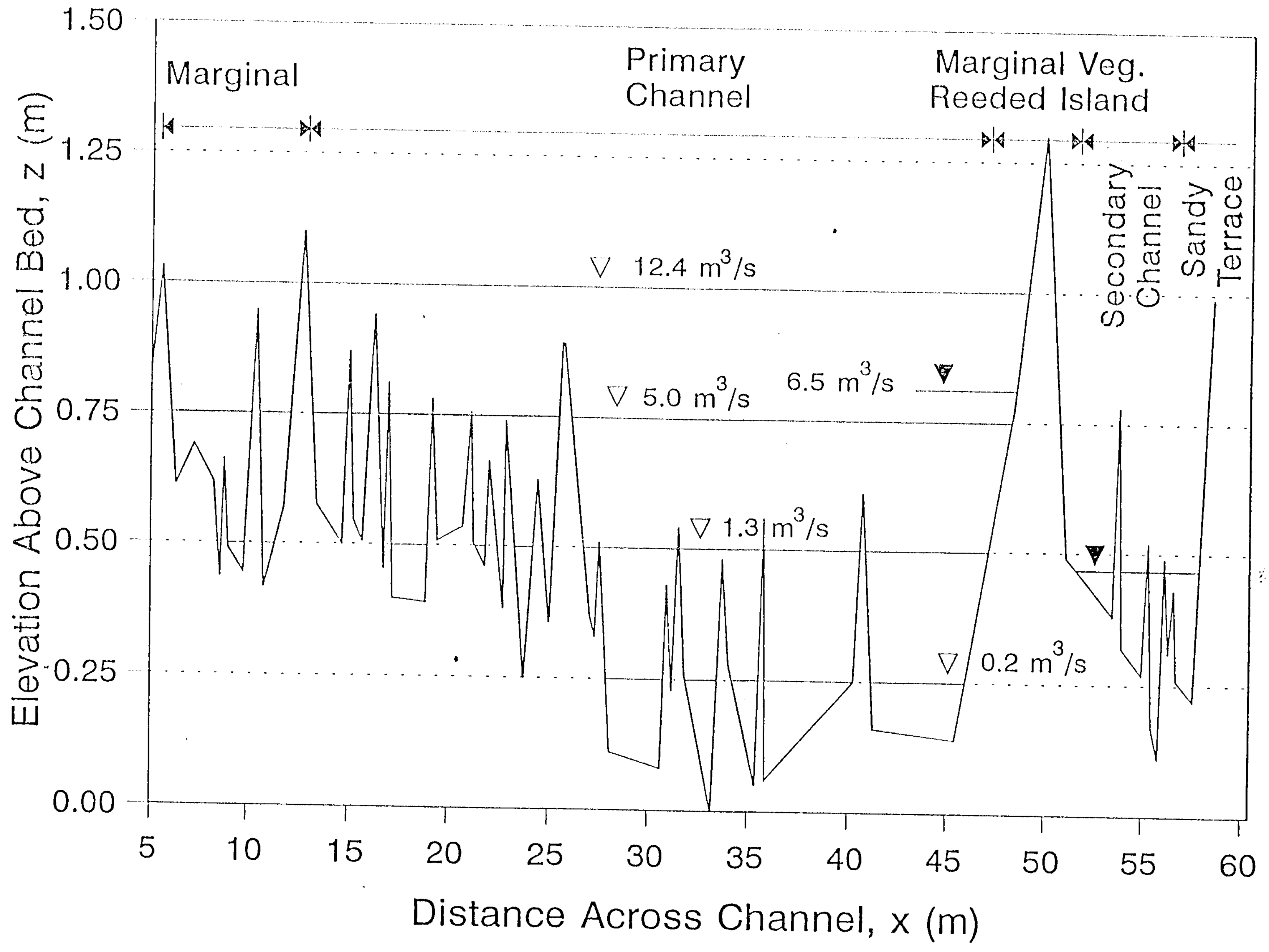

Mixed Riparian
Wet Riparian
Marginal
Primary Channel
Marginal Veg. Reeded Island
Secondary Channel
Sandy Terrace
Mixed Riparian
Potential Wet Riparian Grassy Zone
79.6 m3/s
38.6 m3/s
12.4 m3/s
6.5 m3/s
1.3 m3/s
Elevation Above Channel Bed, z (m)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
Distance Across Channel, x (m)

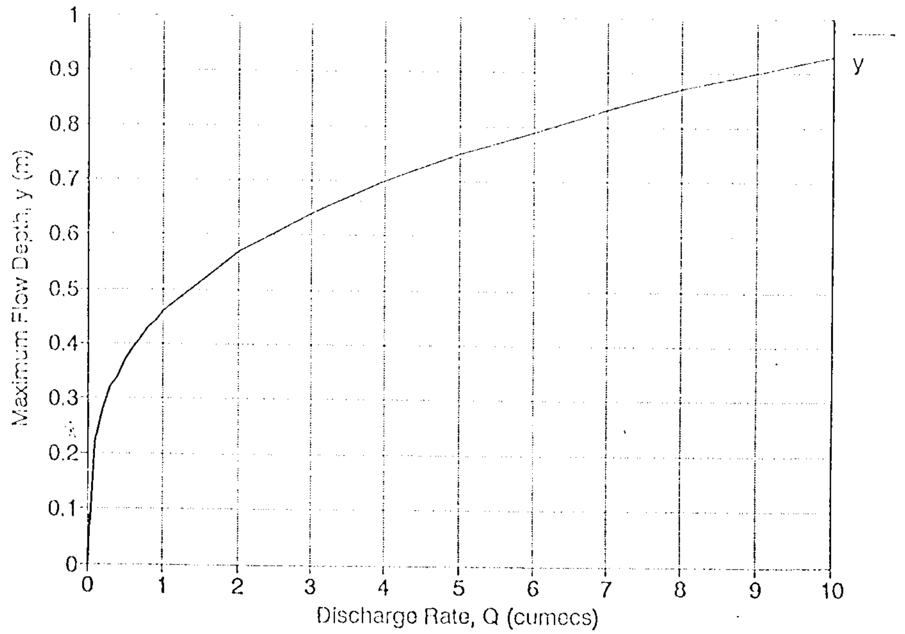

Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y

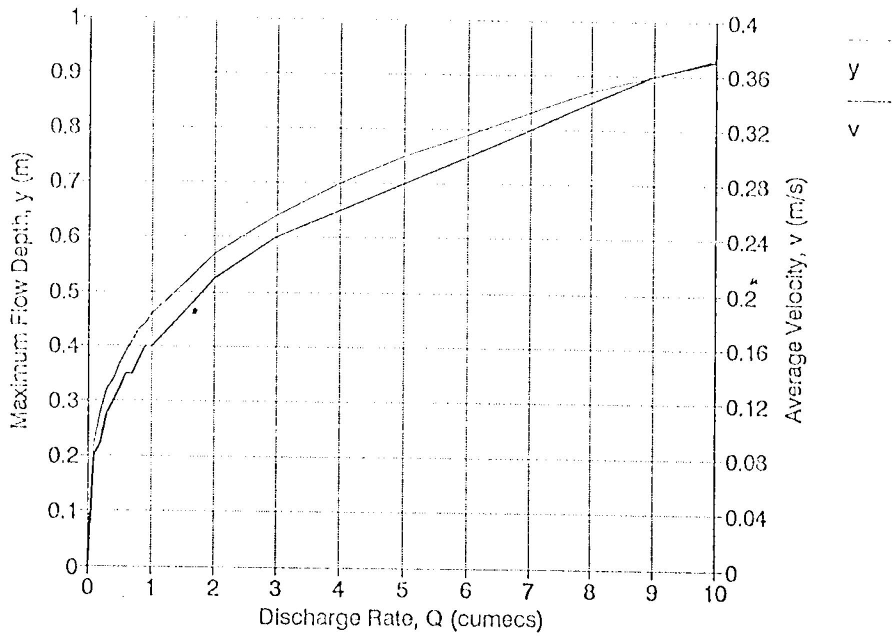

Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

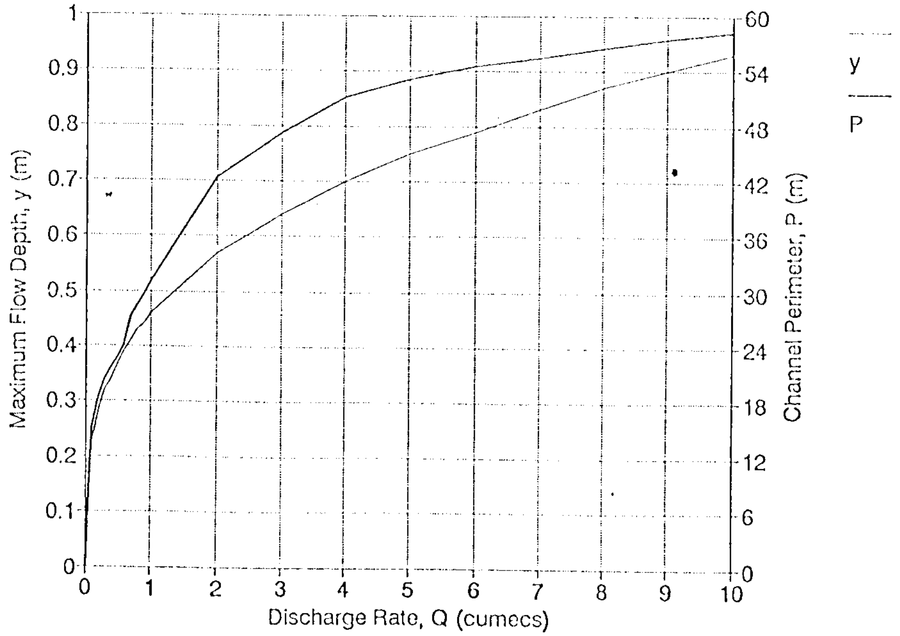

Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

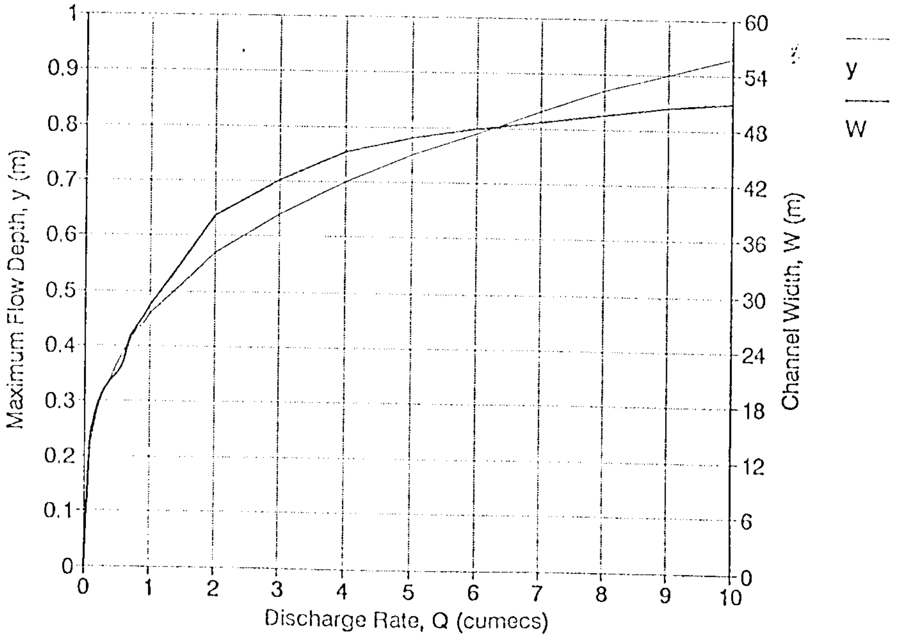

Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

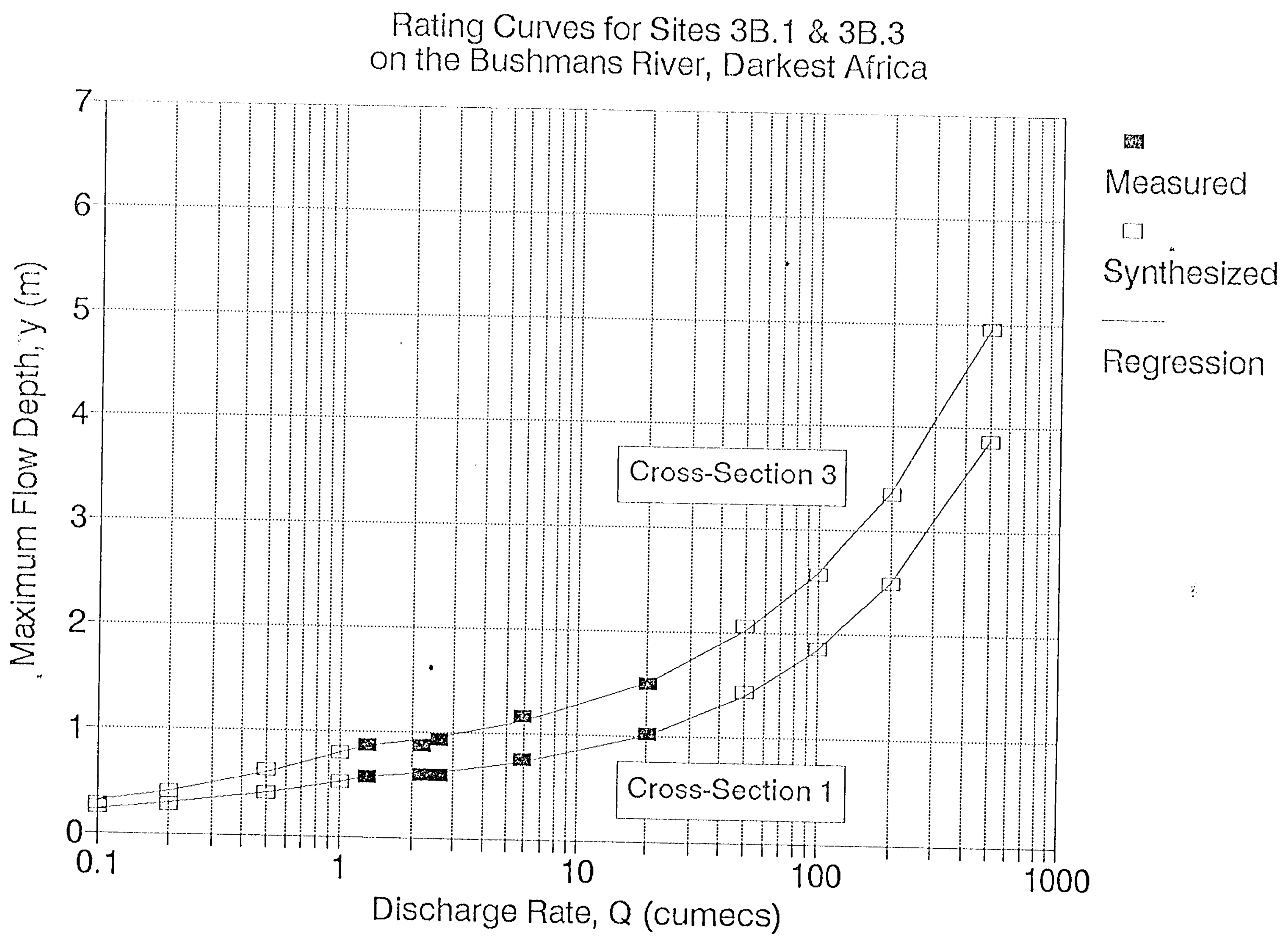

Marginal
Primary Channel
Marginal Veg. Reeded Island
Secondary Channel
Sandy Terrace
12.4 m3/s
5.0 m3/s
6.5 m3/s
1.3 m3/s
0.2 m3/s
Elevation Above Channel Bed, z (m)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
5
10
15
20
25
30
35
40
45
50
55
60
Distance Across Channel, x (m)


Maximum Flow Depth, y (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Discharge Rate, Q (cumecs)
0
1
2
3
4
5
6
7
8
9
10
y


Maximum Flow Depth, y (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Average Velocity, v (m/s)
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
0.36
0.4
Discharge Rate, Q (cumecs)
0
1
2
3
4
5
6
7
8
9
10
y
v

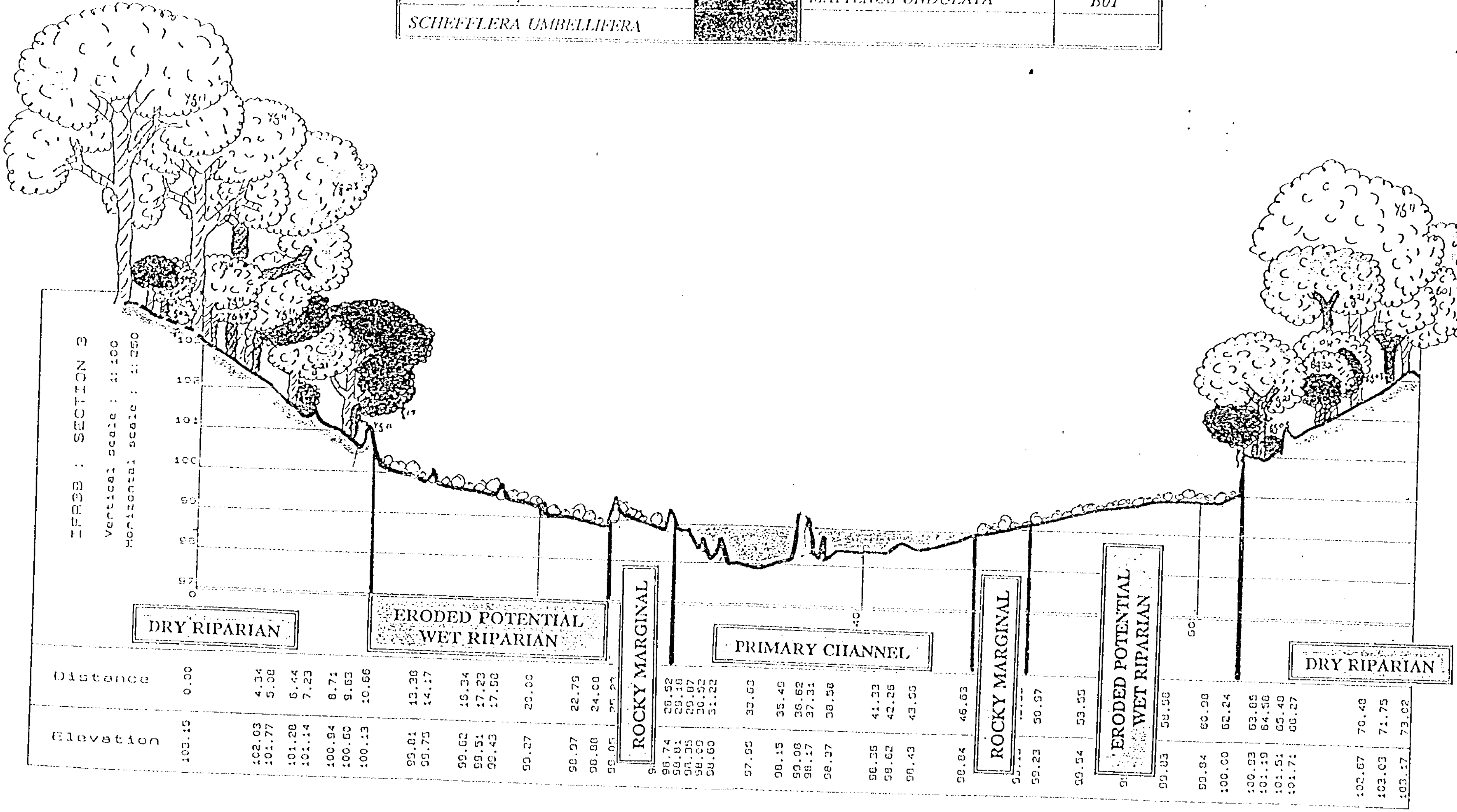

Maximum Flow Depth, y (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Channel Perimeter, P (m)
0
6
12
18
24
30
36
42
48
54
60
Discharge Rate, Q (cumecs)
0
1
2
3
4
5
6
7
8
9
10
y
P

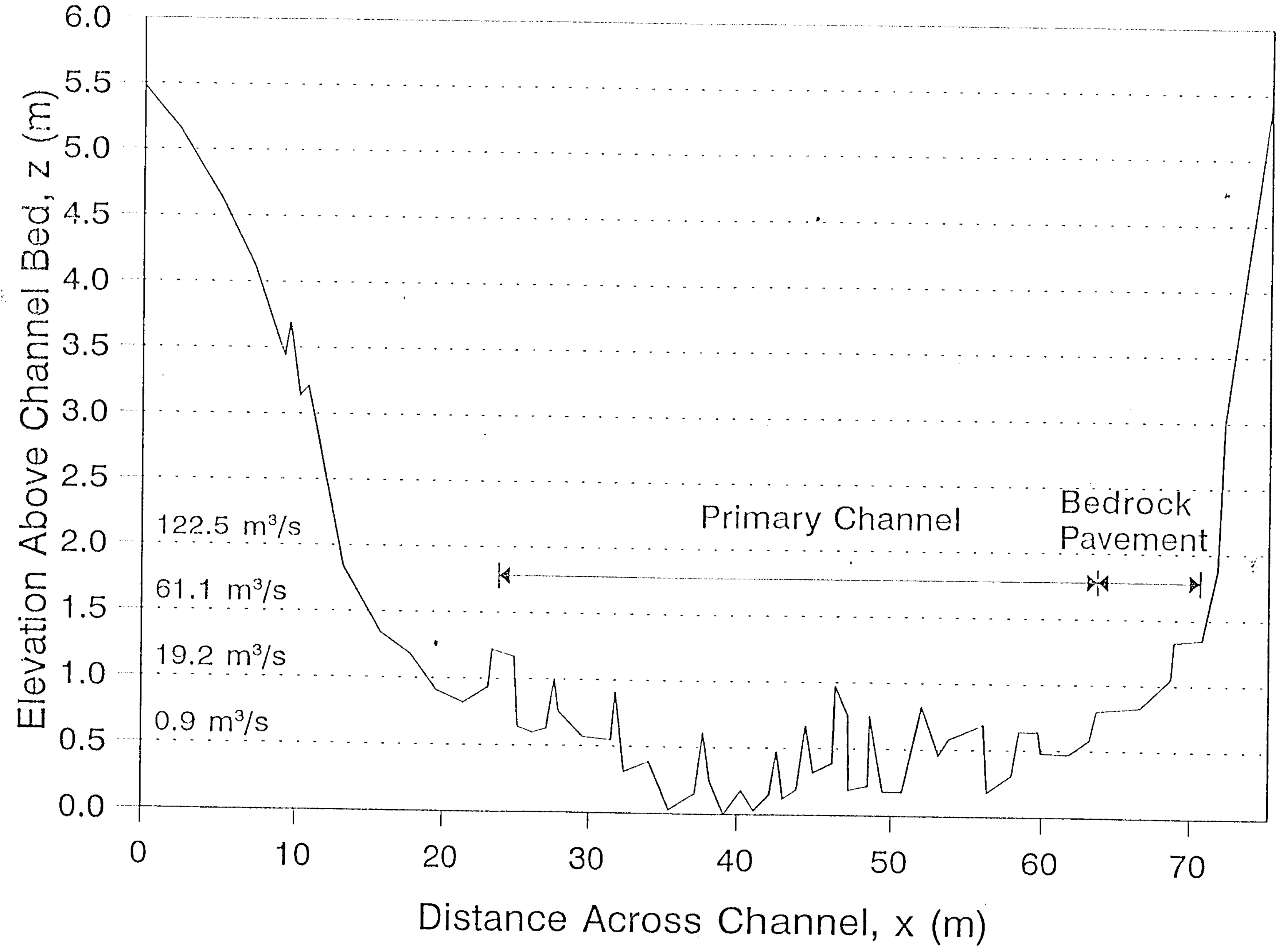

Maximum Flow Depth, y (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Channel Width, W (m)
0
6
12
18
24
30
36
42
48
54
60
Discharge Rate, Q (cumecs)
0
1
2
3
4
5
6
7
8
9
10
y
W


Rating Curves for Sites 3B.1 & 3B.3
on the Bushmans River, Darkest Africa
Maximum Flow Depth, y (m)
0
1
2
3
4
5
6
7
0.1
1
10
100
1000
Discharge Rate, Q (cumecs)
Cross-Section 3
Cross-Section 1
Measured
Synthesized
Regression

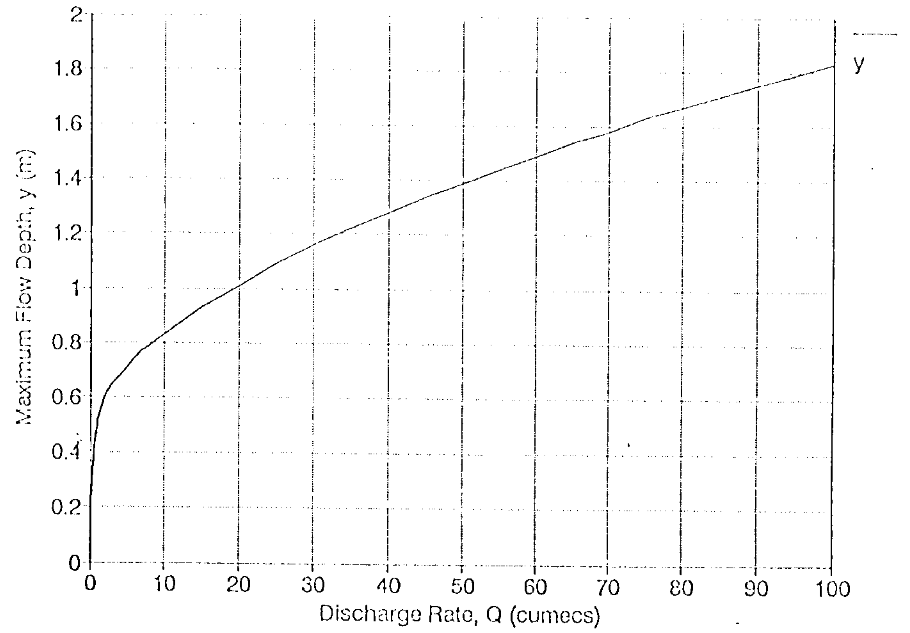
IFR 3B : DARKEST AFRICA, BUSHMENS RIVER

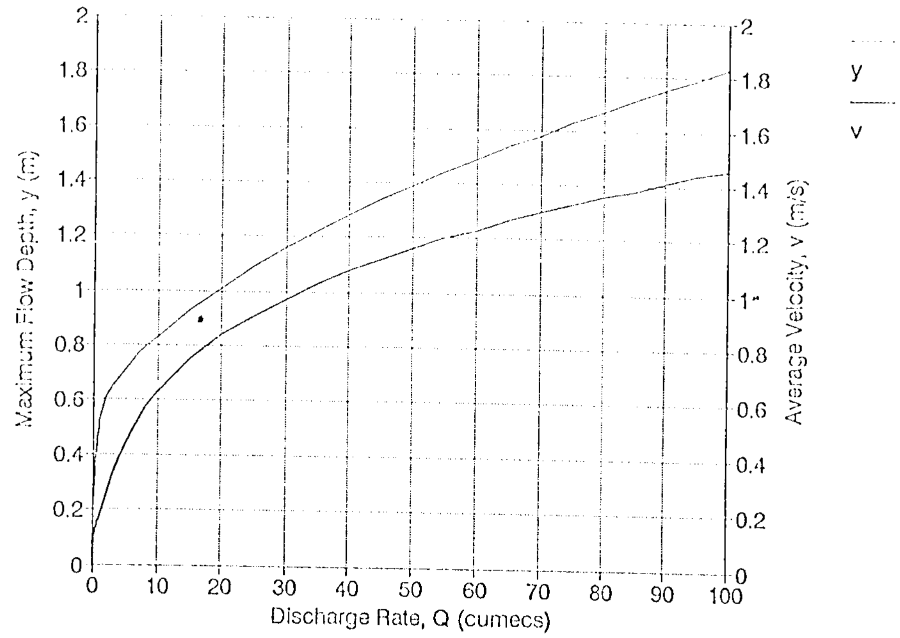
? Terrestrial sp	YG 11	OLEA AFRICANA	G21
CROTON GRATISSIMUS	YG 07	SPIROSTACHYS AFRICANA	G17
CAPPARIS FASCICULARIS	G05	RHUS TRANSVAALENSIS	[illegible]
EUPHORBIA TIRUCALLI	G02	TARKONANATHUS TRILOBUS	[illegible]
PAPPEA CAPENSIS	YG23	DOVYALIS CAFFRA	BG32
ACOKANTHERA OPPOSITIFOLIA	YG45	ACACIA ATAXACANTHA	OH
? Terrestrial sp	[illegible]	MAYTENUS UNDULATA	B01
SCHEFFLERA UMBELLIFERA	[illegible]		

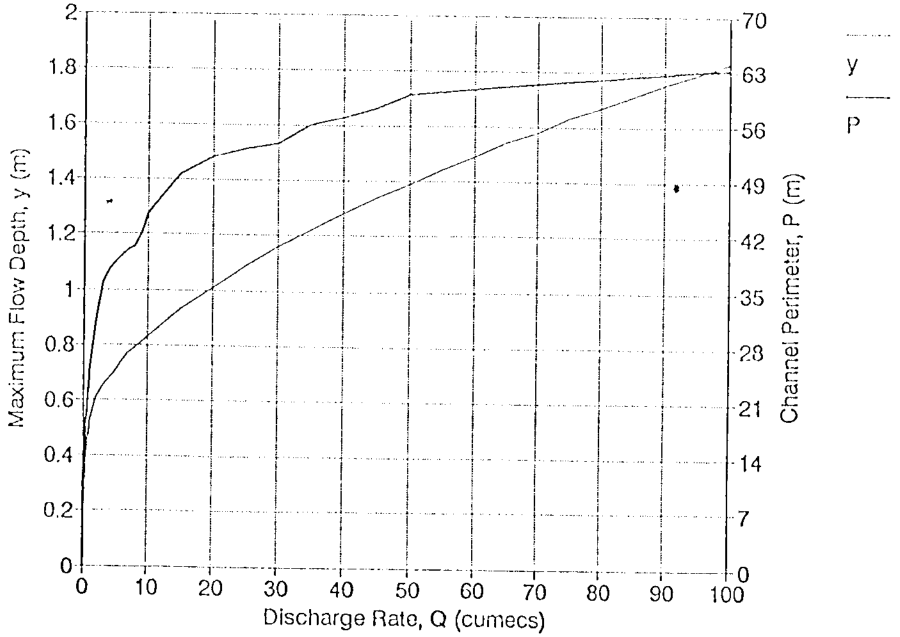


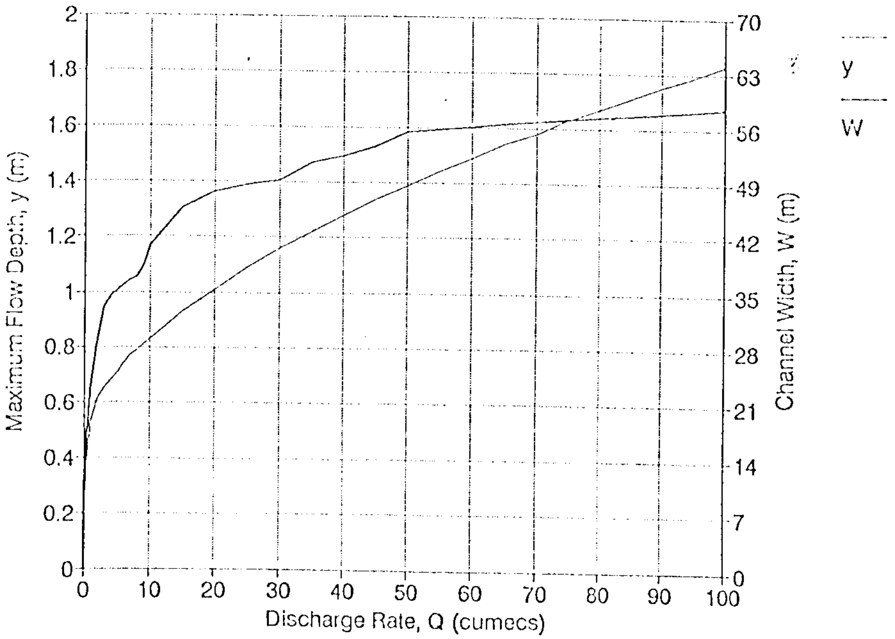


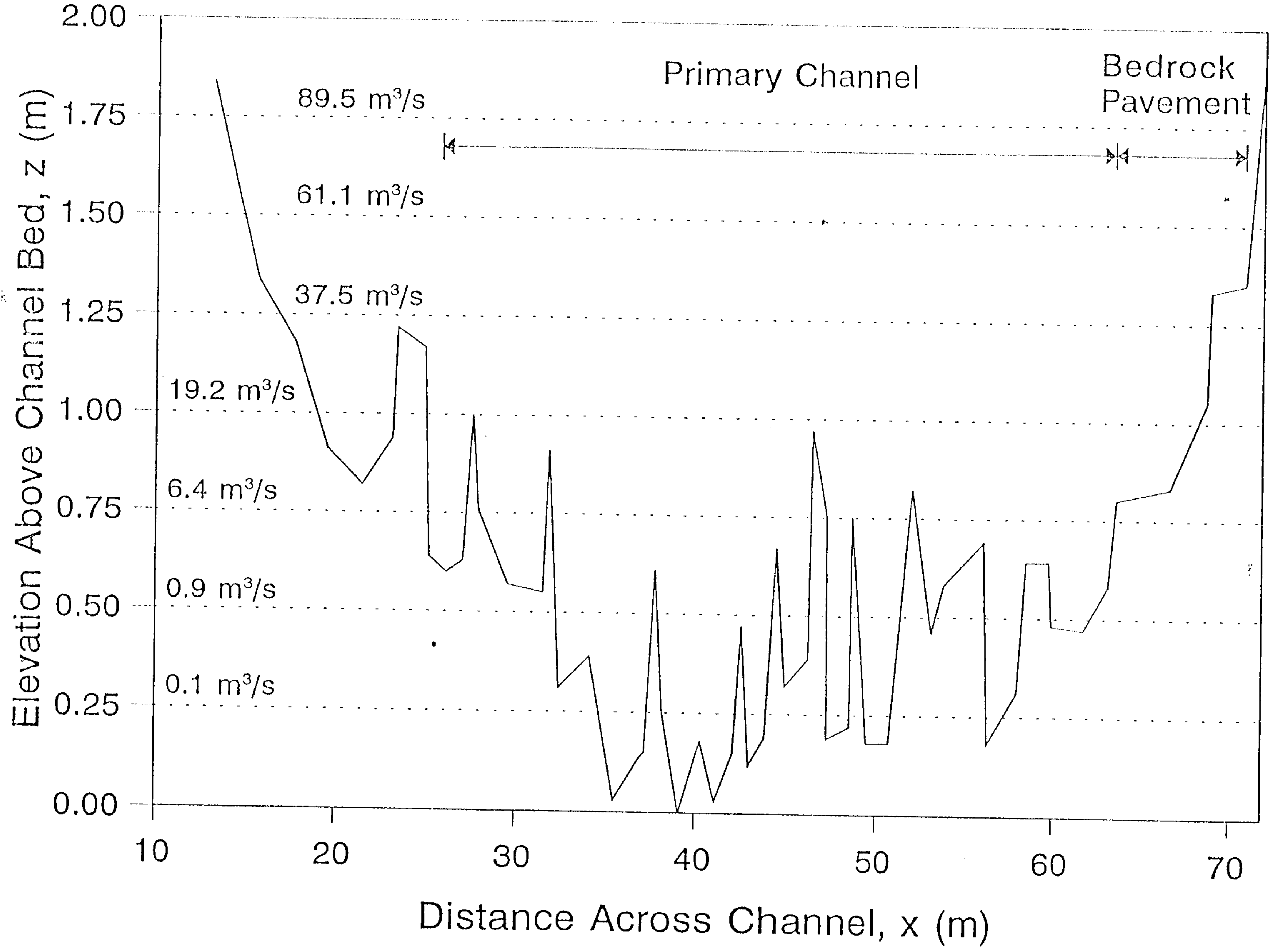
Elevation Above Channel Bed, z (m)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
122.5 m³/s
61.1 m³/s
19.2 m³/s
0.9 m³/s
Primary Channel
Bedrock Pavement
0
10
20
30
40
50
60
70
Distance Across Channel, x (m)

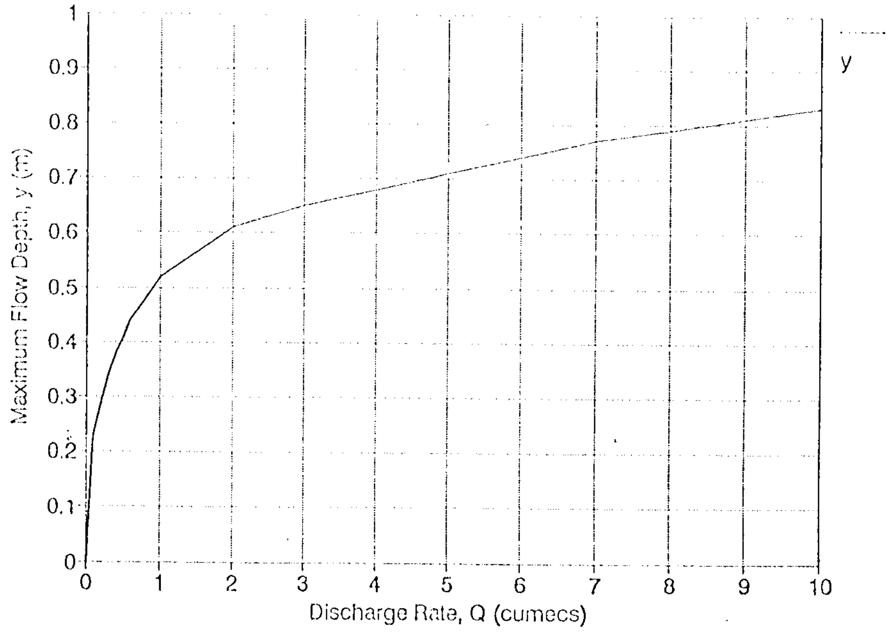

Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y

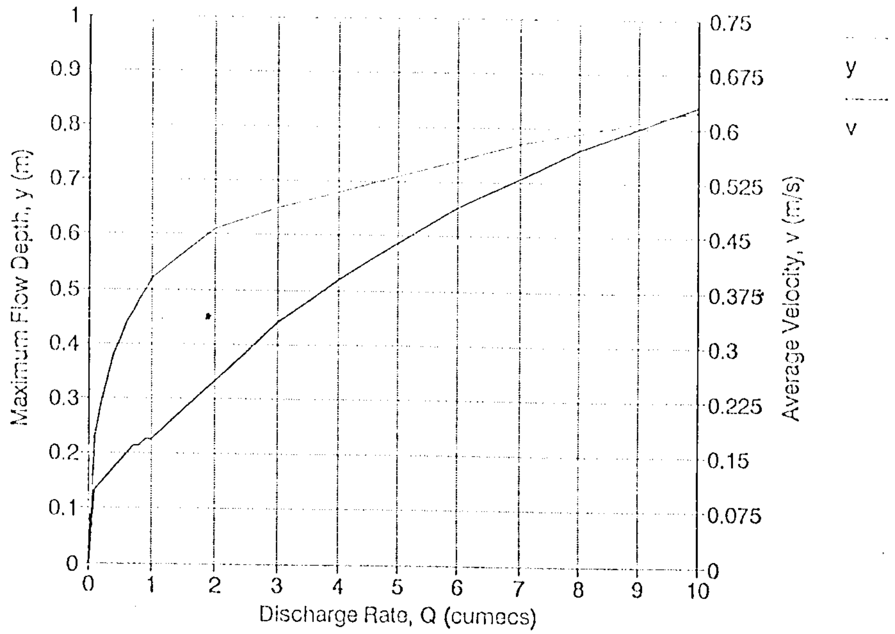

Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

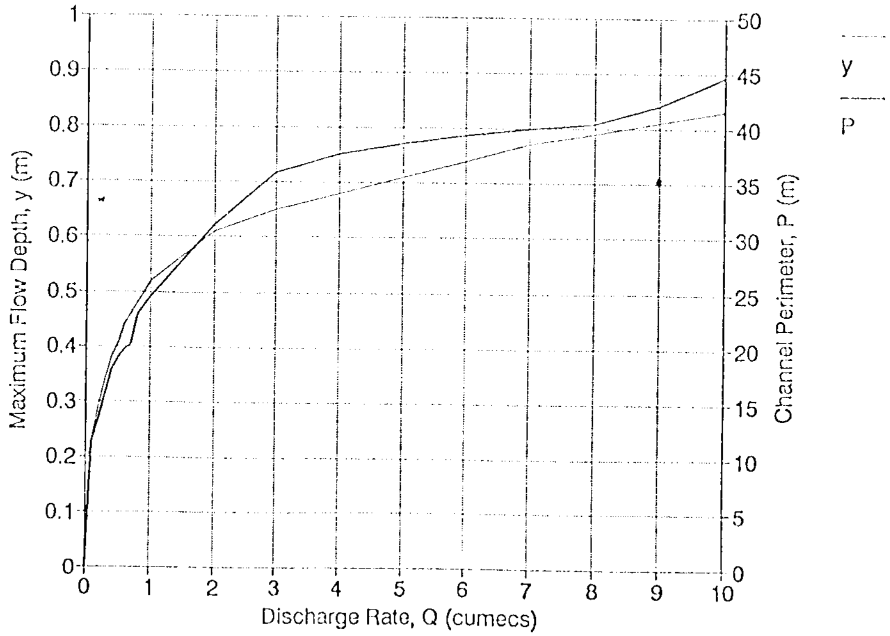

Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

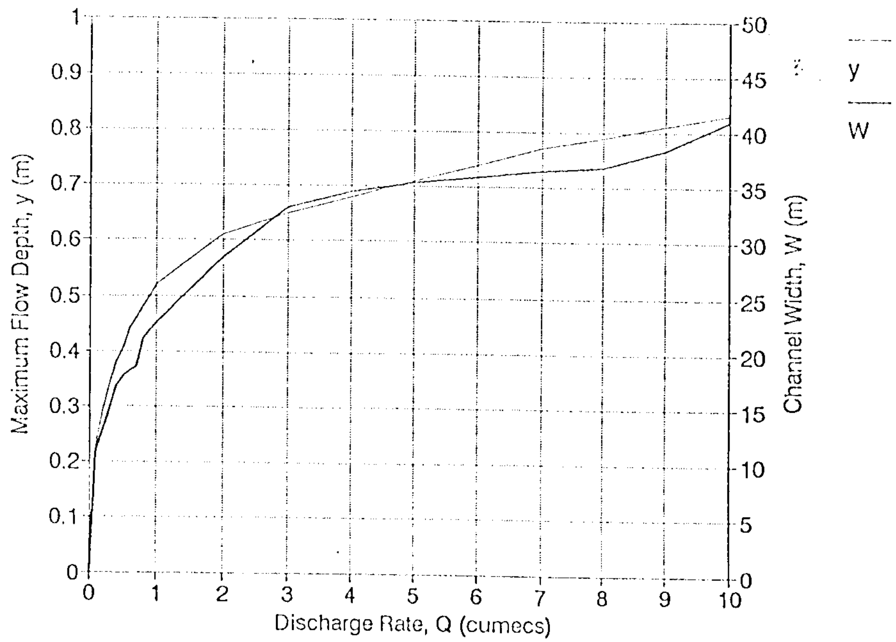

Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W


Primary Channel
Bedrock Pavement
89.5 m³/s
61.1 m³/s
37.5 m³/s
19.2 m³/s
6.4 m³/s
0.9 m³/s
0.1 m³/s
Elevation Above Channel Bed, z (m)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
10
20
30
40
50
60
70
Distance Across Channel, x (m)

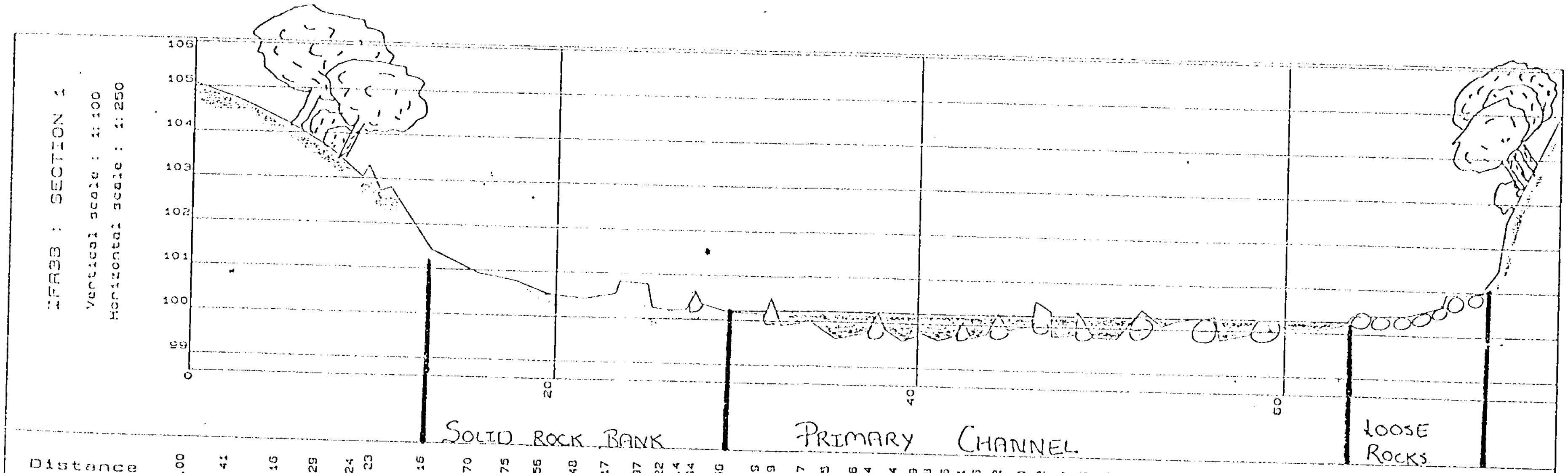

Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y


Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

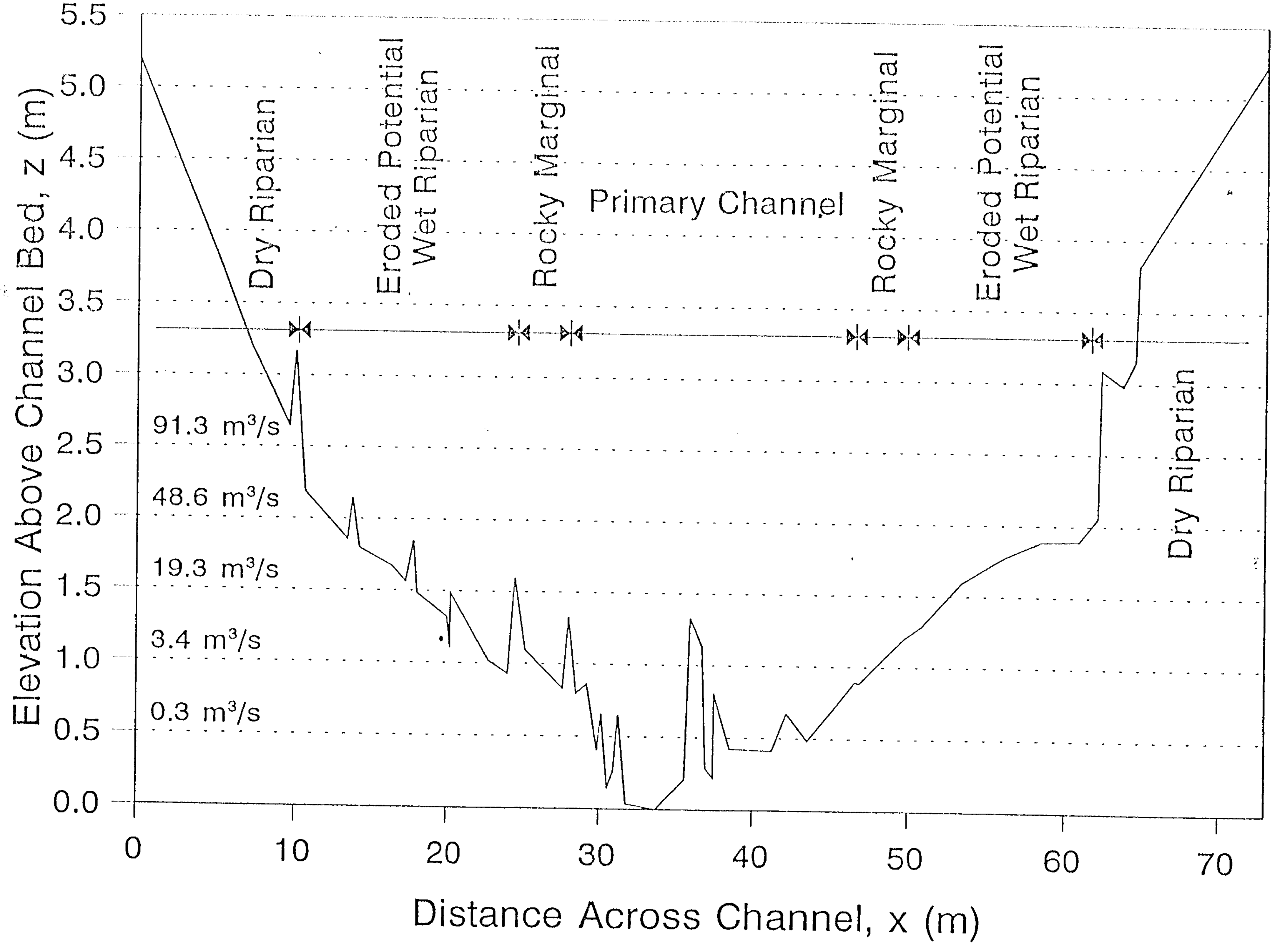

Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

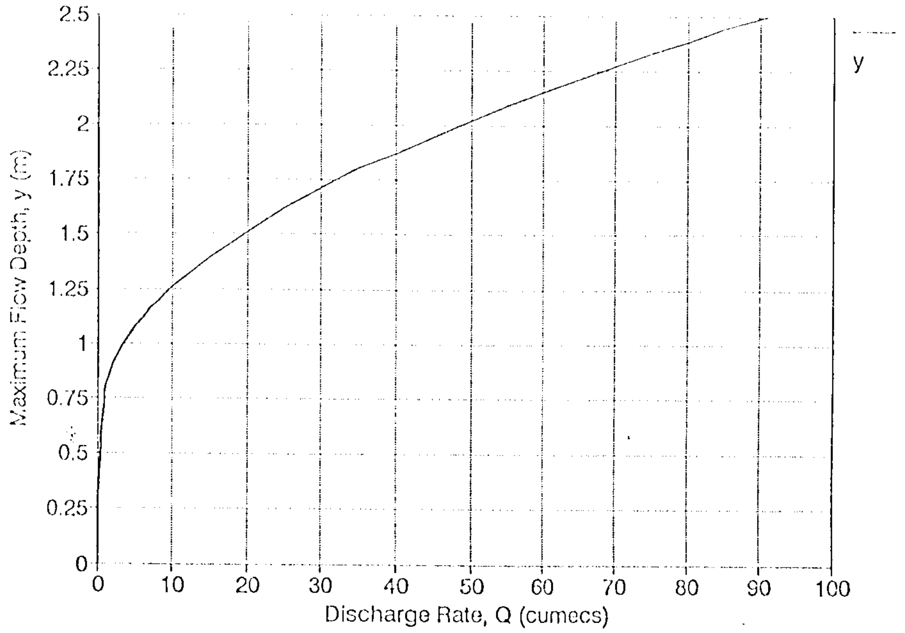

Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

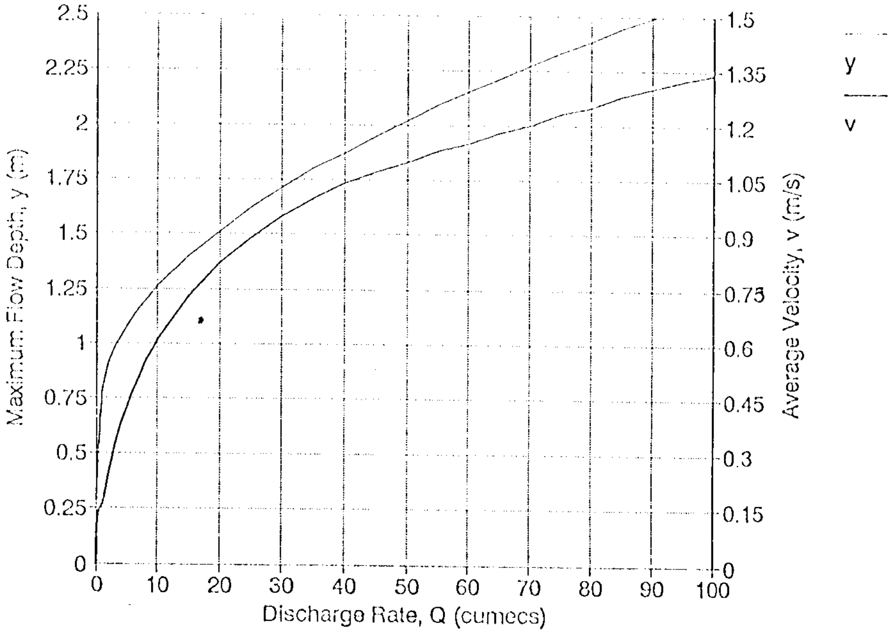
IFR 3B: RIFFLE
DARKEST AFRICA

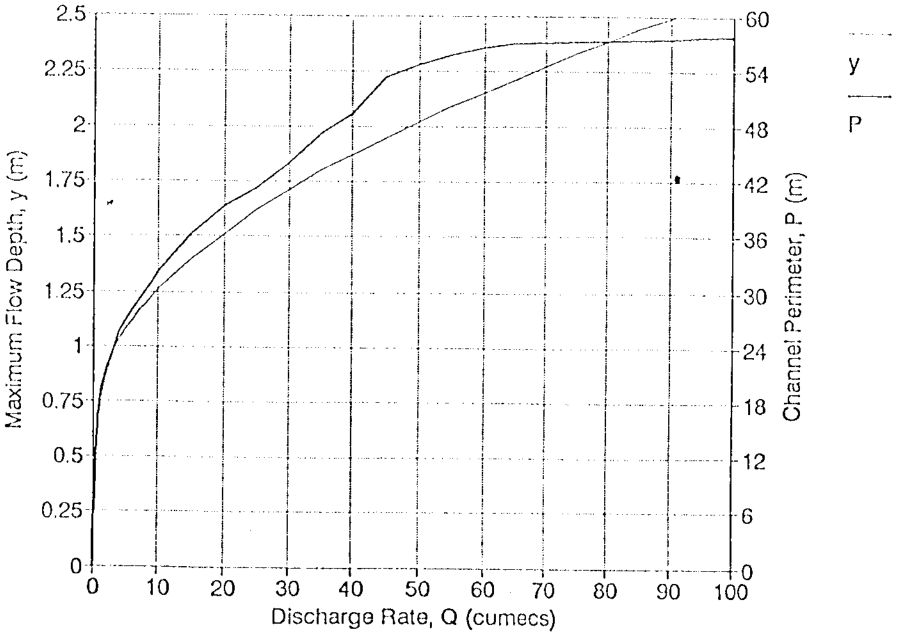


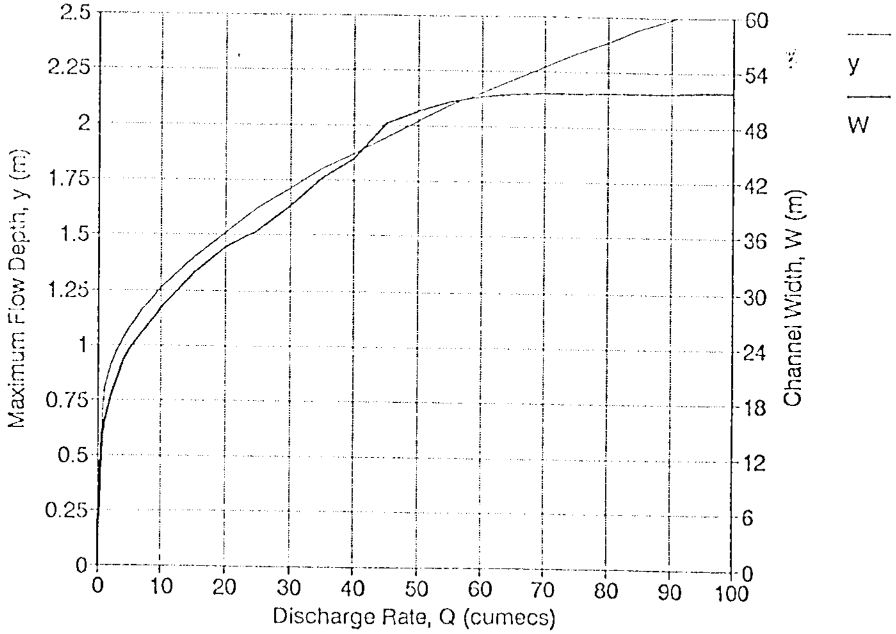
Distance	Elevation
0.00	105.07
2.41	104.75
5.16	104.22
7.29	103.71
9.24	103.03
10.23	102.73
13.16	101.43
15.70	100.93
17.75	100.77
19.56	100.50
21.48	100.41
23.17	100.53
24.97	100.76
25.22	100.19
27.14	100.22
27.94	100.35
29.56	100.16
31.49	100.14
32.39	99.90
34.07	99.98
35.45	99.61
36.96	99.73
37.74	100.20
39.14	99.59
40.29	99.77
41.08	99.62
42.06	99.74
42.91	99.71
43.76	99.78
44.82	99.91
46.10	99.98
47.12	100.34
48.47	99.81
49.49	99.77
50.75	99.77
52.03	100.41
53.16	100.05
53.85	100.17
56.11	100.28
58.00	99.90
59.76	100.23
61.77	100.06
63.23	100.17
65.66	100.42
68.69	100.54
70.80	100.94
71.78	101.47
75.12	105.00

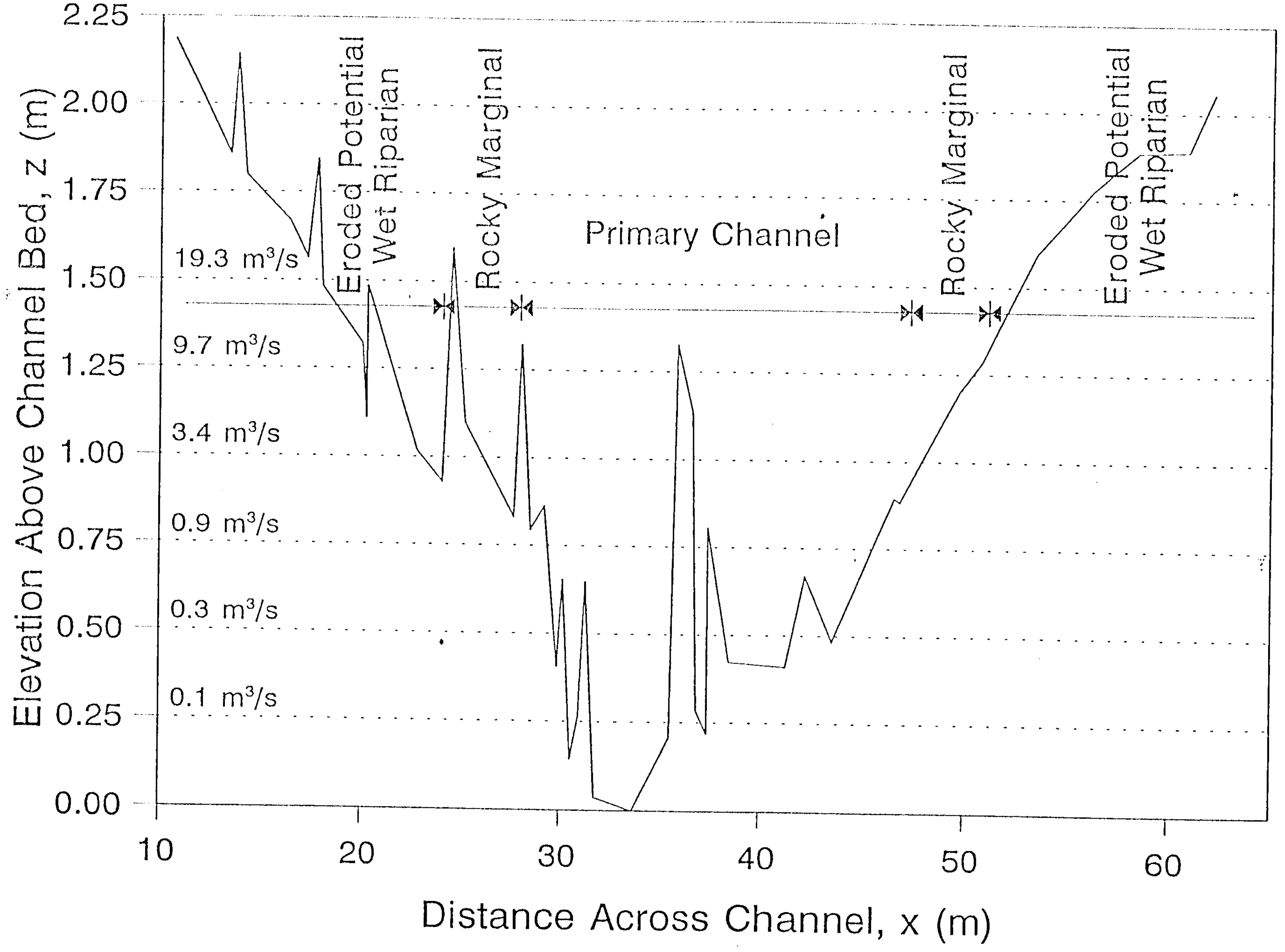

Elevation Above Channel Bed, z (m)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dry Riparian
Eroded Potential Wet Riparian
Rocky Marginal
Primary Channel
Rocky Marginal
Eroded Potential Wet Riparian
Dry Riparian
91.3 m³/s
48.6 m³/s
19.3 m³/s
3.4 m³/s
0.3 m³/s
0
10
20
30
40
50
60
70
Distance Across Channel, x (m)

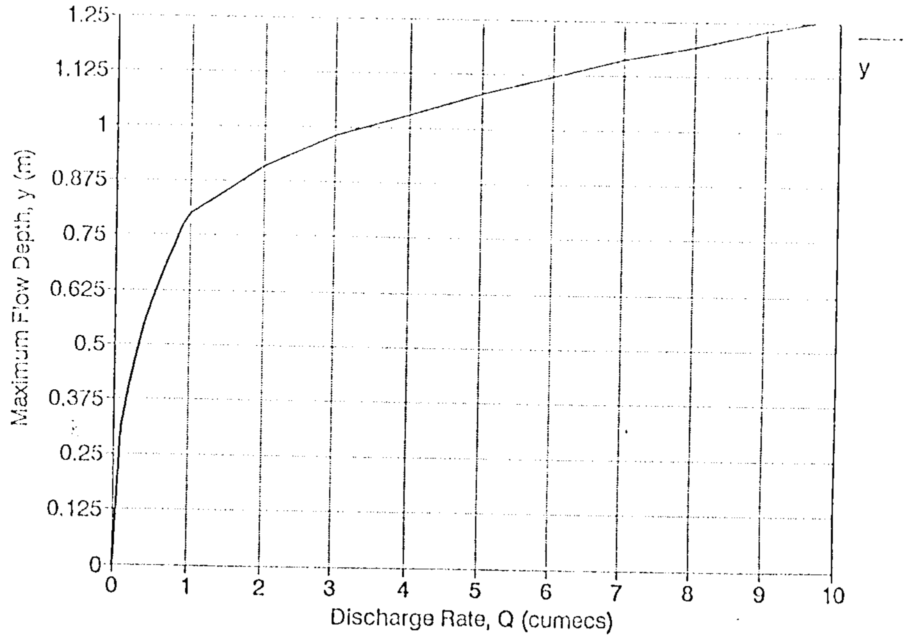

Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y


Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

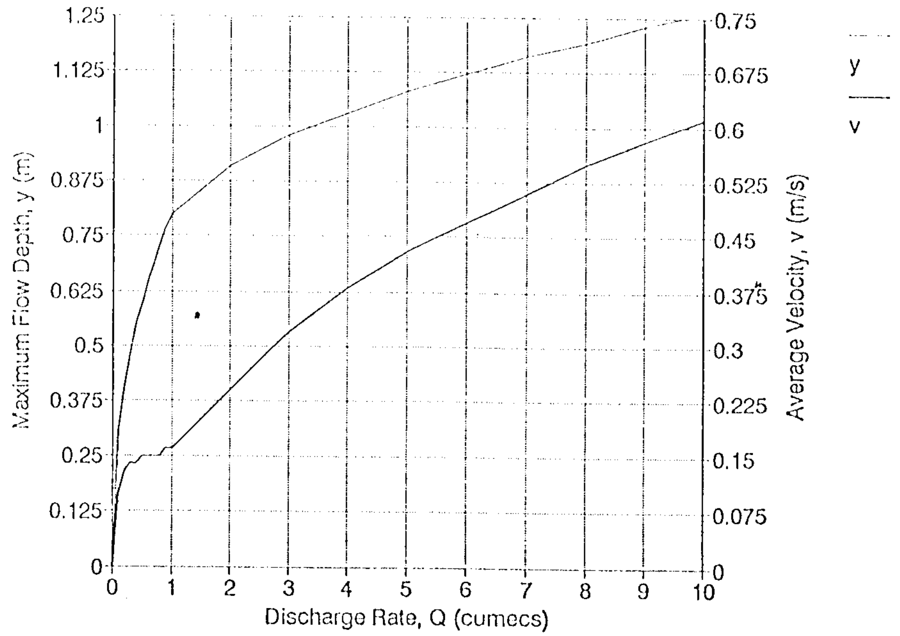

Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P


Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

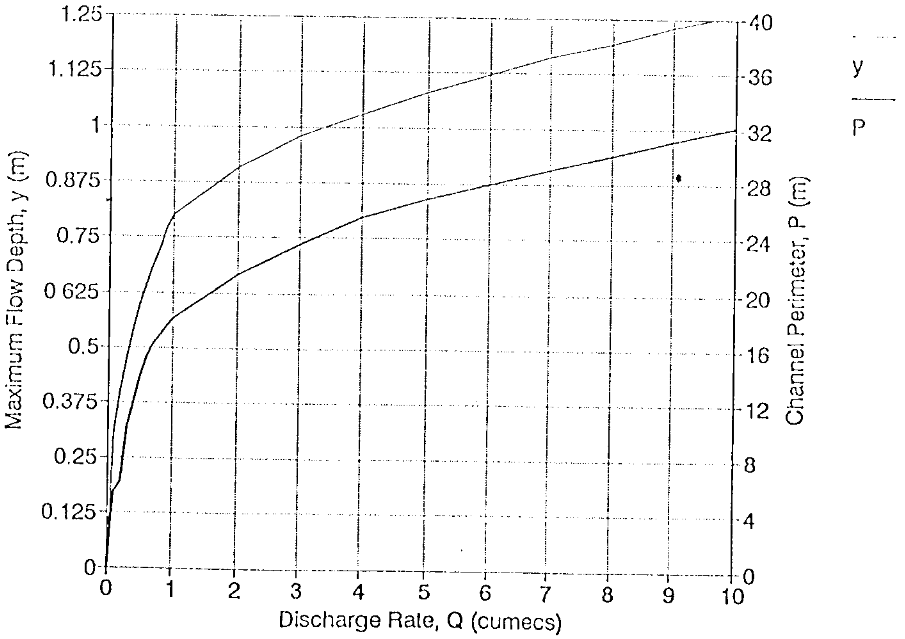

Elevation Above Channel Bed, z (m)
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
19.3 m³/s
9.7 m³/s
3.4 m³/s
0.9 m³/s
0.3 m³/s
0.1 m³/s
Eroded Potential Wet Riparian
Rocky Marginal
Primary Channel
Rocky Marginal
Eroded Potential Wet Riparian
10
20
30
40
50
60
Distance Across Channel, x (m)



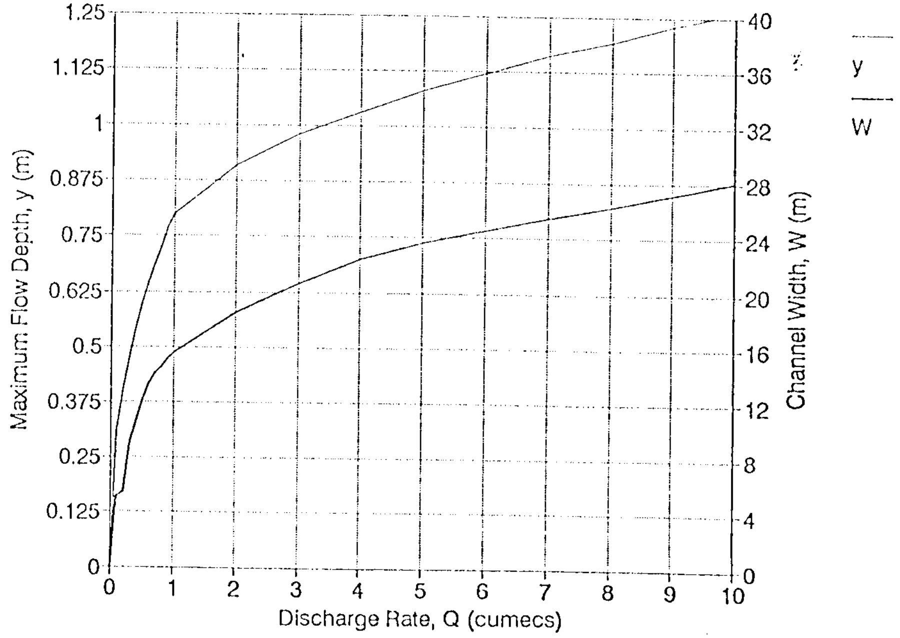
Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y



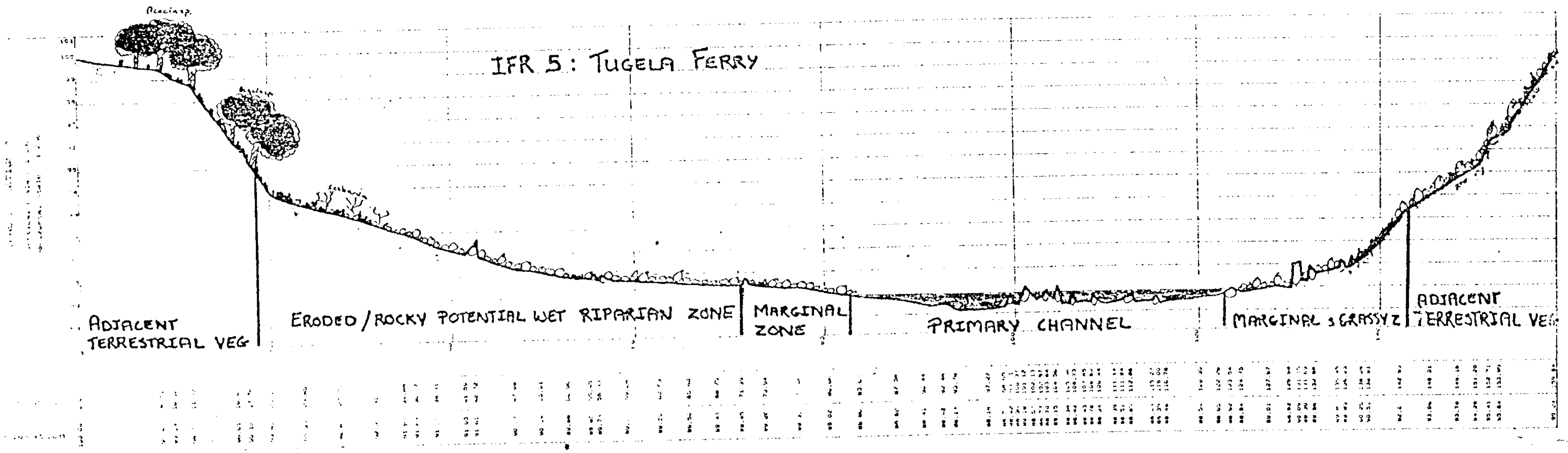
Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

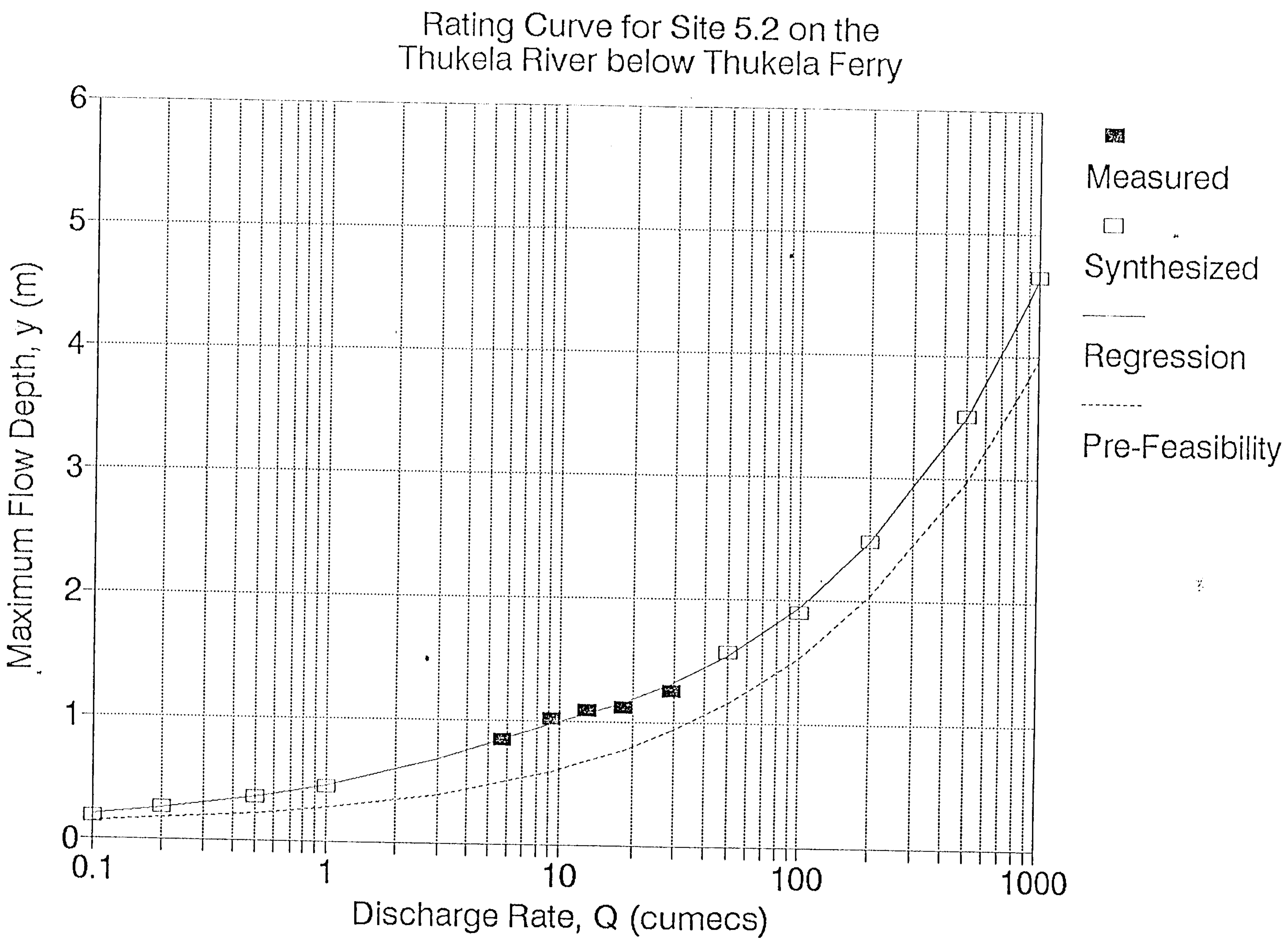


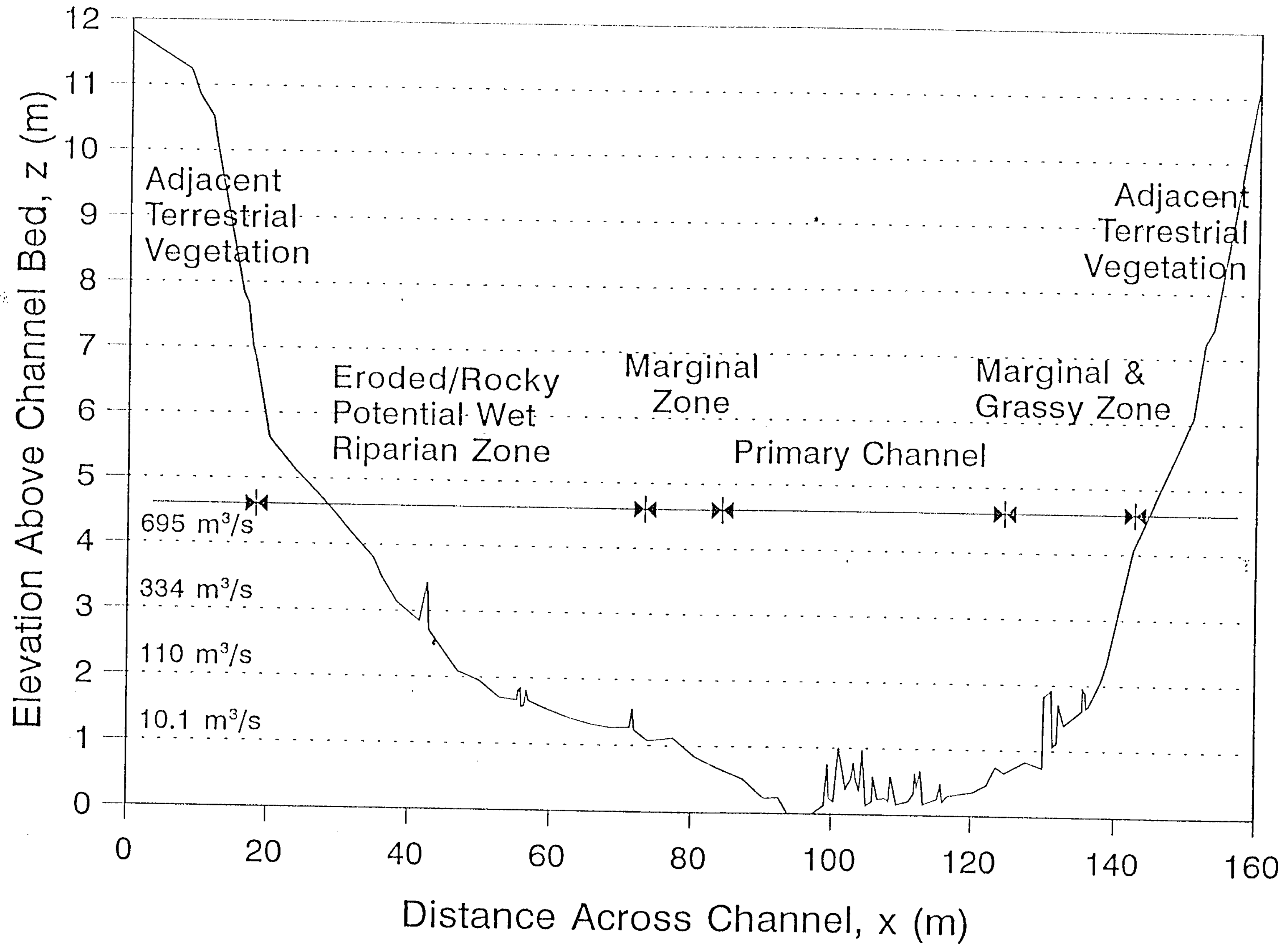
Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

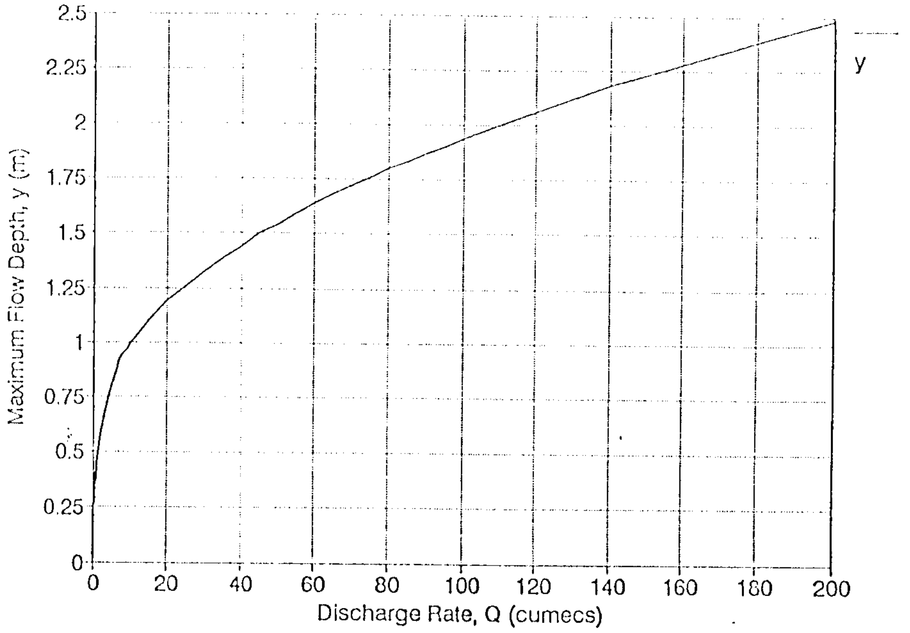


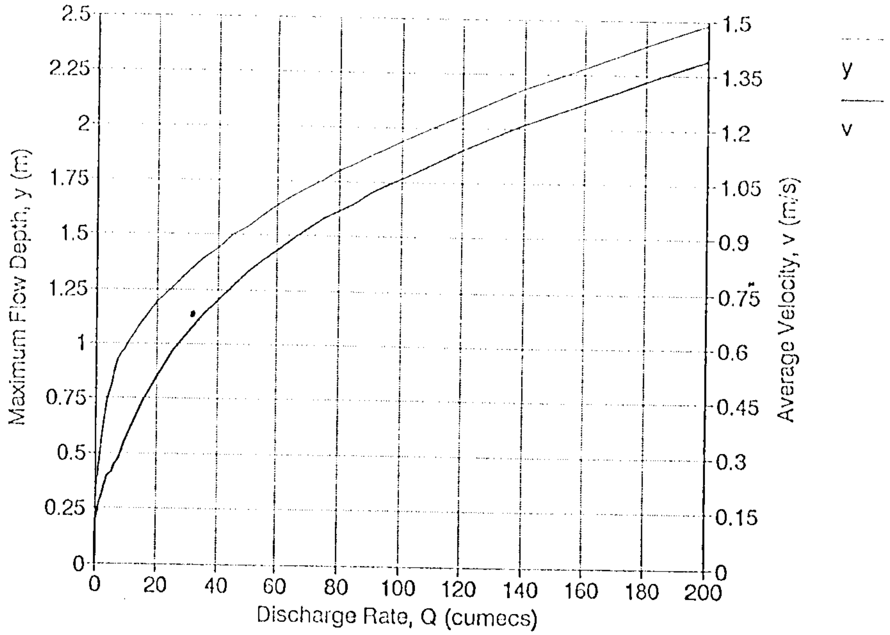
Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

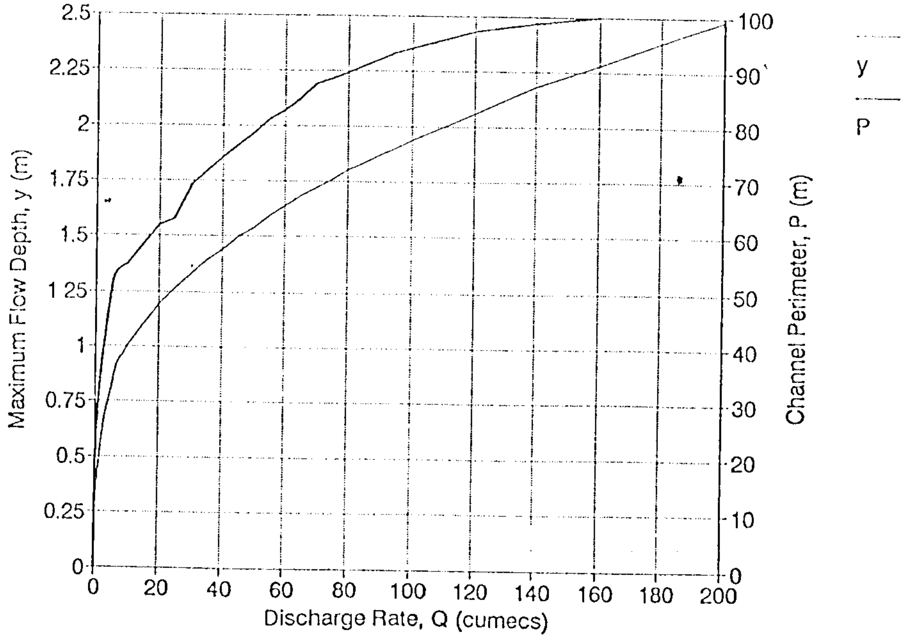

IFR 5: TUGELA FERRY
ADJACENT TERRESTRIAL VEG
ERODED / ROCKY POTENTIAL WET RIPARIAN ZONE
MARGINAL ZONE
PRIMARY CHANNEL
MARGINAL & GRASSY Z
ADJACENT TERRESTRIAL VEG

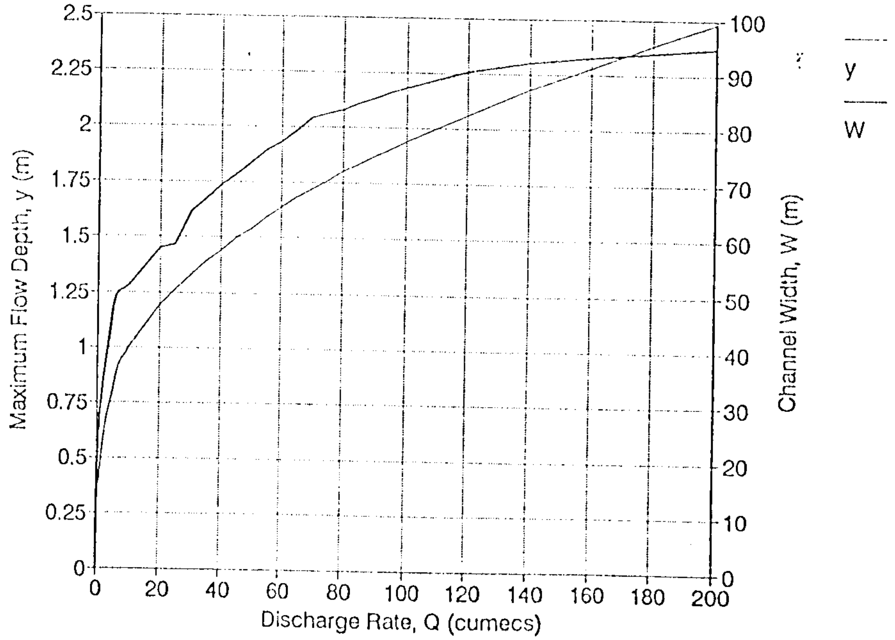

Rating Curve for Site 5.2 on the
Thukela River below Thukela Ferry
Maximum Flow Depth, y (m)
0
1
2
3
4
5
6
0.1
1
10
100
1000
Discharge Rate, Q (cumecs)
Measured
Synthesized
Regression
Pre-Feasibility

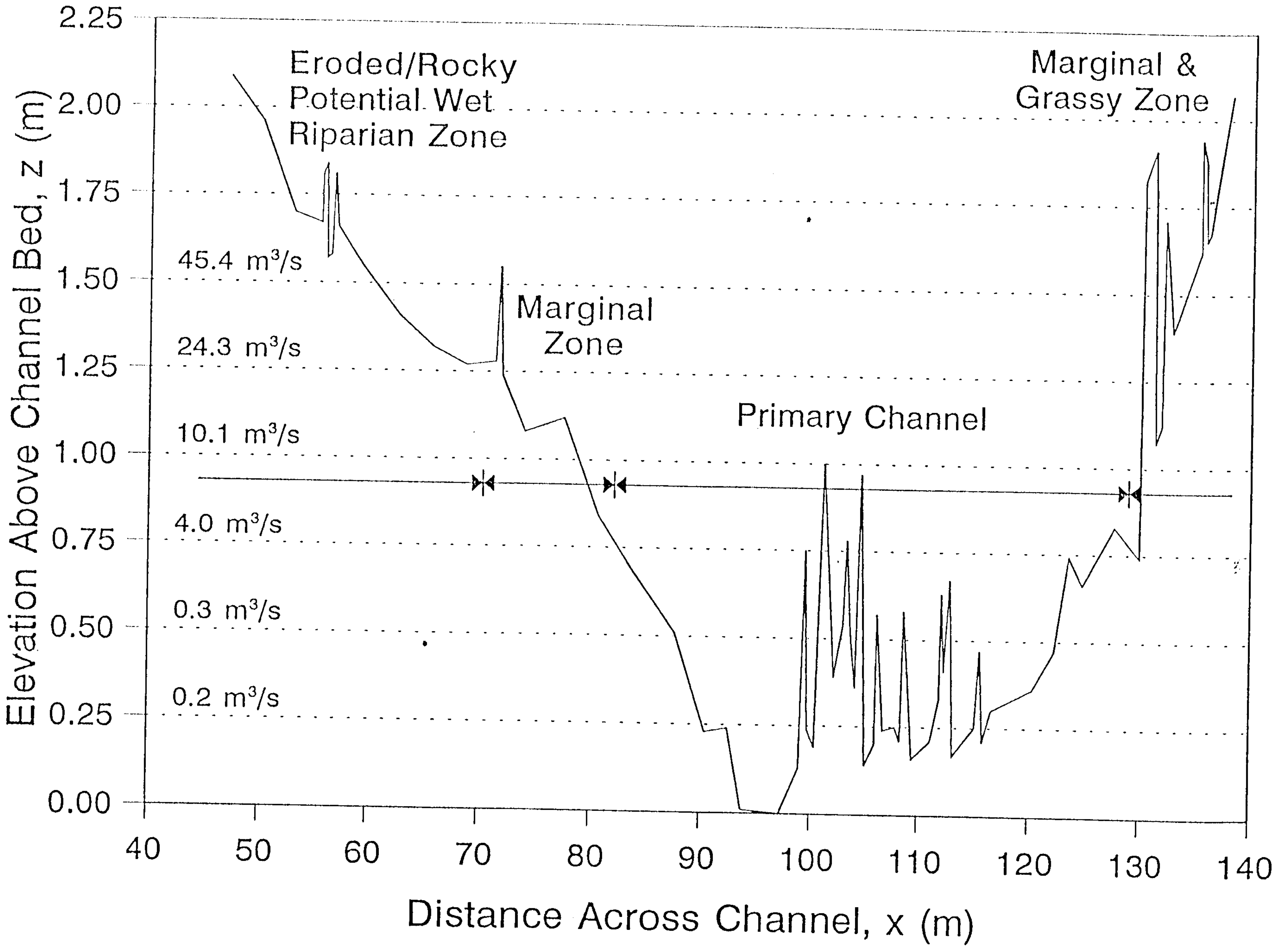

Elevation Above Channel Bed, z (m)
0
1
2
3
4
5
6
7
8
9
10
11
12
Adjacent Terrestrial Vegetation
Eroded/Rocky Potential Wet Riparian Zone
Marginal Zone
Primary Channel
Marginal & Grassy Zone
Adjacent Terrestrial Vegetation
695 m³/s
334 m³/s
110 m³/s
10.1 m³/s
0
20
40
60
80
100
120
140
160
Distance Across Channel, x (m)

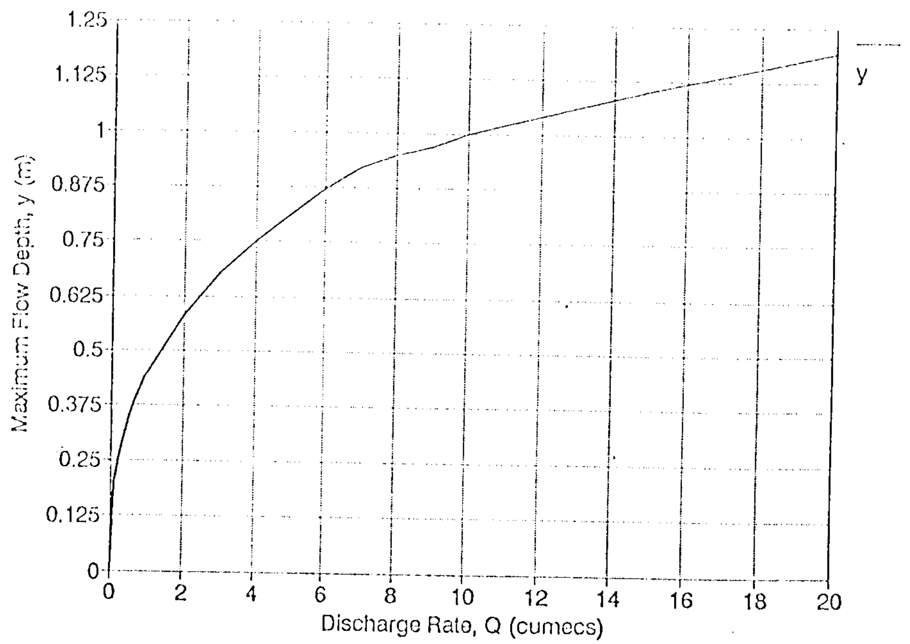

Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y

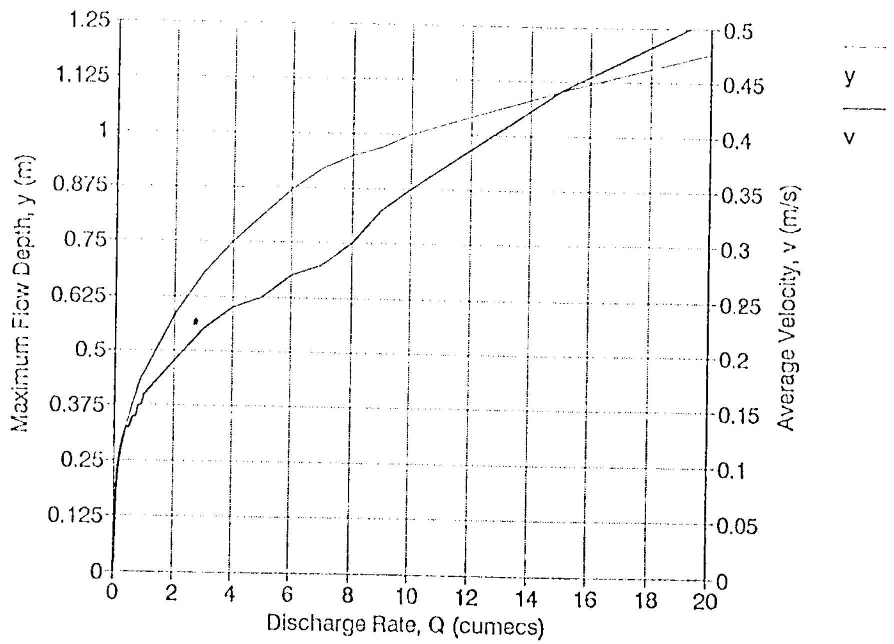

Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v

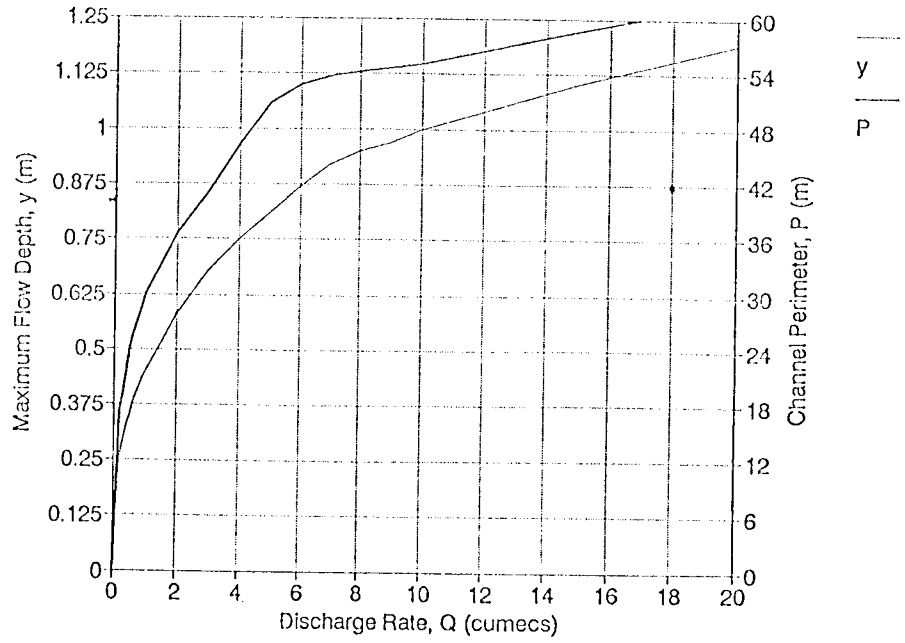

Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P

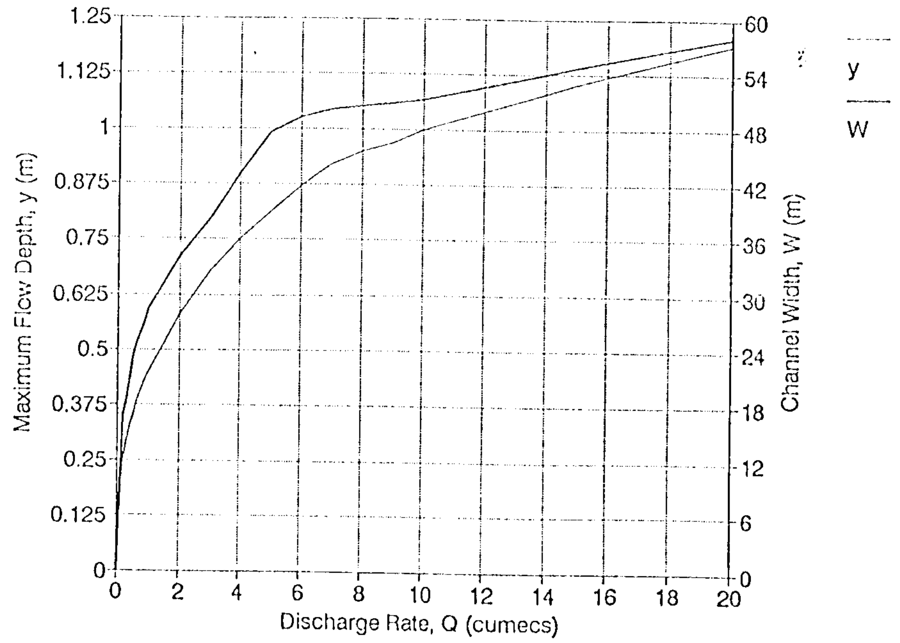

Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W


Elevation Above Channel Bed, z (m)
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
40
50
60
70
80
90
100
110
120
130
140
Distance Across Channel, x (m)
Eroded/Rocky
Potential Wet
Riparian Zone
Marginal
Zone
Primary Channel
Marginal &
Grassy Zone
45.4 m³/s
24.3 m³/s
10.1 m³/s
4.0 m³/s
0.3 m³/s
0.2 m³/s


Maximum Flow Depth, y (m)
Discharge Rate, Q (cumecs)
y


Maximum Flow Depth, y (m)
Average Velocity, v (m/s)
Discharge Rate, Q (cumecs)
y
v


Maximum Flow Depth, y (m)
Channel Perimeter, P (m)
Discharge Rate, Q (cumecs)
y
P


Maximum Flow Depth, y (m)
Channel Width, W (m)
Discharge Rate, Q (cumecs)
y
W

8. Geomorphology

GEOMORPHOLOGY

Kate Rowntree, Department of Geography, Rhodes University

1. INTRODUCTION

As part of the Tugela Vaal Transfer Scheme, a dam is proposed on the Bushmans River at the Mielietuin site, above Weenen, and the Jana Gorge site has been proposed for a dam on the Tugela. A field investigation was undertaken on the Tugela and Bushmans Rivers to assess the geomorphological component of the Instream Flow Requirement. This report presents the data collected during these field surveys and examines some of the possible consequences of upstream flow regulation on the rivers in question.

Three IFR sites were investigated on the Tugela and Bushmans Rivers. One site (IFR2) was located in the gorge downstream of the site of the proposed Jana Dam, two sites (IFR 3A and IFR3B) on the Bushmans River. IFR3A was located a short way below the proposed Mielietuin Dam, just upstream of the entrance to the gorge. The second site, IFR3B, was located at Darkest Africa some way upstream of the original site which had been significantly altered during recent flooding. Detailed site investigations were carried out for sites IFR2 and IFR3A, but insufficient time was budgeted to allow Site 3B to be investigated. A short visit was made to the original site to investigate the extent of the flood damage. In addition to the IFR sites themselves, observations were also made on the low gradient length of channel lying downstream of IFR3A in the vicinity of Weenen. This stretch of river was deemed to be particularly sensitive to impoundment impacts due to the low gradient and high sediment inputs from tributaries. As this stretch of river passes through an intensively farmed area it has suffered considerable disturbance so is less suitable for an actual IFR site.

2. IFR SITES

2.1 IFR2 Tugela Estates

Lat. 28° 44' 586" S
Long. 30° 08' 369" E
Reach gradient 0.005

2.1.1 General Site Description

This site is located on the Tugela River downstream of the proposed Upper Jana Dam. The site is upstream of the confluences of the Tugela with the Bloukrantz River and the Bushmans River. At this point the River is laterally confined by valley side walls. There is evidence of a macro-channel as well as some terracing. The width of the macro-channel is approximately 120m, with a depth of 5 - 6 m. The active channel had a width of 70 m- 80 m and a depth of 2.5 to 3 m. The channel follows a single thread pattern of low sinuosity.

The channel is alluvial, with boulders and cobbles being dominant. The reach is a pool-rapid sequence, with the dominant hydraulic control being a rapid containing large to very large boulders. Lateral bars covered approximately 30% of the active channel, 40% consisted of pools, 20 % of rapids and 5% each of backwater and bench. Water depth in the rapid was between 50 and 80 cm. Pools varied in depth, with maximum depths of 155 cm being recorded downstream of the rapid and approximately 230 cm upstream of the rapid. The bed composition varies depending on the morphological unit: pools consisted of equal proportions of cobbles and gravels, bars consisted largely of boulders with a great deal of other material of varying size being present, and the rapids consisted of boulders (50%), with cobbles (30%) and gravel (20%) making up the majority of rest of the material.

Both the macro-channel and the active channel have concave banks, with the macro-channel banks ranging from 30° to 60° and the active channel banks being in the 10° to 30° range. The bank composition of both the macro-channel and the active channel consist of almost equal proportions of sand, gravel and cobbles. The banks were generally well vegetated and stable. However, there were some signs of subaerial erosion associated with the road and livestock trampling. Bank vegetation consisted of moderately dense trees, grass, shrubs and some reeds. Instream vegetation consisted of a moderate amount of shrubs, grass and reeds (with lateral bars being consolidated by grass, and a berm being formed along the right bank by the consolidatory action of reeds and some shrubs).

Evidence of aggradation was present in the form of extensive bar deposits which are being consolidated by vegetation. In addition, a berm is forming along the right bank. Backwaters and slackwaters show signs of silt deposition. There may already have been some adjustment due to the influence of Spioenkop Dam which is a distance upstream

2.1.2. Hydraulic transects and discharge measurement

Two transects were set up across the rapid and the downstream pool on the line of the survey transects in order to estimate the variability of flow depth, velocity, substrates and hydraulic biotopes. Points were taken at one metre intervals across the rapid and at 5 metre intervals across the pool. One further transect was taken in the transition area between the rapid and pool in order to measure discharge. The results are given in Table 1. Flow discharge was estimated at 3.2 $m^3 s^{-1}$. Evidence of a recent high flood was available from flood debris present at 2.5 m above the macro-channel.

Characteristic hydraulic biotopes

The hydraulic biotopes of the site were generally not very diverse. The hydraulic control (in this case a rapid) was characterised by 70% run and glide, 10% rapid and chute, with the remaining 20% consisting of marginal backwater, slackwater and pool. The pools, which made up a large proportion of the reach, consisted of 40% pool, 40% glide, 10 % run and 10% slackwater or backwater.

Evidence exists for deposition of fine material within slow flowing sections of the reach. It is likely that these areas will become smothered with silt and sand if flows are reduced. This would result in a loss of habitat quality as well as a reduction in diversity.

Within the hydraulic control, any reduction in flow is likely to result in accelerated deposition in the slack water and backwater areas (a process which is already in evidence). However, due to the steep gradient across the hydraulic control, it is unlikely that aggradation would take place there.

The pools are likely to be more effected by a reduction in flows. The high proportion of glides are likely to be reduced in favour of pool biotopes, with deposition and habitat loss associated with the reduced velocity. Existing backwaters and slackwaters are likely to be infilled, and these areas will tend to migrate towards the main channel.

2.1.3 Assessment of geomorphologically effective flows

Flows of different velocities are required to perform various geomorphological tasks within the river. A certain minimum flow is required to ensure that fines are scoured out of the bed and that there is no smothering of the bed by deposition of fine material. Higher flows are required to entrain the dominant particles in the bed material. Bankfull discharges are required to maintain the general channel form (Gordon *et al.*, 1992).

The flows required to prevent fine material from being deposited within the IFR site can be deduced from Hjulström curves. For small particles of fine sand size and smaller, a velocity of approximately 0.2 m/s would be required. Wherever this flow rate was not maintained, deposition and aggradation would take place. Evidence of this occurring is present within the backwaters and slackwaters.

The bed in the IFR site was dominated by coarse material. The rapids consisted of 45% boulders, 30% cobbles and 20% gravels. The bars consisted of 40% boulders, 30% cobbles, 20% gravel and 10% sand. The pools consisted of equal proportions of gravel and cobbles. Thus the dominant bed materials tended to be coarse. The Hjulström curve can be used to give an approximate mean velocity required to move this material. However, these curves are based on uniform materials. To move the material of cobble size and larger a mean velocity of at least 2 to 2.5 $m.s^{-1}$ would be necessary. It is unlikely that any but the most extreme events would move the large boulders present within the hydraulic control.

The channel forming discharge is generally considered to be the bankfull discharge. The active channel is approximately 3 m deep at this site. It should be noted that flood debris was present 2.5m above bankfull level. This represents a flood of almost 8 m depth.

2.2 IRF3A Weenen Nature Reserve

Lat. 28° 53' 39" S

Long. 30° 01' 03" E

Reach gradient 0.009

2.2.1 General description of site:

The site is located on the Bushmans River immediately downstream of the proposed Mielietuin Dam. At this point the river is moderately confined, with the presence of a floodplain on right bank, but the channel is confined on the left by the hillslope. The river consists of a single thread channel of low sinuosity, and can be described as a mixed pool-riffle/ plain bed reach. The site was located on a plane bed section immediately downstream of a weir, from which most of Weenen's irrigation requirements are abstracted. The abstraction rate at the time of the field visit approximated to half of the total stream flow.

No clear distinction could be made between a macro and active channel. The main channel banks were about 2 m to 3 m in height, an indistinct bench which may represent the level of an active channel was present at the foot of the main banks. The channel width was approximately 60 m wide. In the vicinity of the study site, lateral bars made up a large proportion of the active channel covering approximately 25% of the area, with a plane bed making up another 55%. Pools covered 15% of the area, with riffles, rapids and backwaters making up the rest. The bed consists of mixed materials, with cobbles and boulders being prominent, but significant amounts of bedrock were present. The plane bed consisted of boulders (40%), cobbles (30%), gravel 20% and 10% sand. Bars consisted largely of cobbles and boulders (40% each), with sand and gravel making up 10% each. The bed composition in the pool upstream of the main study area was made up of 40% bedrock, with silt and clays making up 20%, sand 20% and gravels 20%. Evidence of aggradation on the bed existed in the form of extensive bar deposits, embedded cobbles and encroaching vegetation.

The left bank consisted of equal proportions of sand, gravel, cobbles, boulders and bedrock. The right bank consisted of sand (80%), silt and clay (10%) and gravel (10%). Vegetation on the right bank was moderately dense, with trees, shrubs, grass and reeds being present. The left bank was more sparsely vegetated with a moderate amount of grass and sparse trees, shrubs and reeds. Instream vegetation consisted mostly of moderately dense reeds, with some trees, shrubs and grass. The banks were generally stable, with a small amount of subaerial erosion present. The left bank was significantly influenced by human activity. It was concave, with a gradient of 10° to 30° in most places. The right bank was relatively undisturbed with a more convex profile and a range in gradients from 10° to 60°.

2.2.2 Hydraulic transects and discharge measurement

Two transects were set up across the plane bed section on the line of the two most downstream survey transects in order to estimate the variability of flow depth, velocity, substrates and hydraulic biotopes. Points were taken at 1.5 metre intervals.. A third transect was taken through a pool which had a smooth bedrock controlled bed and was considered a good site for measuring discharge. Discharge was measured as 1.4 m^3s^{-1}. The results for the two hydraulic transects are given in are given in Table 2.

The amount of water being extracted for irrigation purposes was gauged at 1.065 cubic metres per second. This represents 43% of the total water in the river just upstream of this site

Characteristic hydraulic biotopes

The hydraulic habitats were relatively diverse. Pools consisted mostly of glide (80%), with pool (10%), backwater (5%) and run (5%) making up the rest. The hydraulic control (in this case mostly the plane bed), consisted of 40% run, 20% glide, 20% riffle, 10% rapid, chute and cascade, 4% pool, 3% slack water and 3% backwater.

Reductions in flow are likely to cause a similar aggradation and channel reduction process. The pools are likely to experience a reduction in glide in favour of pool hydraulic biotope. Slow flowing areas are likely to experience aggradation as the river is no longer competent to carry its sediment load. The site is located below a section of relatively steep gradients within a gorge. The reduction in gradient is likely to cause aggradation here.

The hydraulic control is likely to experience a reduction in fast flowing biotopes such as run and riffle. Aggradation could result in a decrease in habitat variety and channel width and depth.

2.2.3 Assessment of geomorphologically effective flows

The bed consists of mixed materials, with cobbles and boulders being prominent, but significant amounts of bedrock were present. The bed composition in the pools was made up of 40% bedrock, with silt and clays making up 20%, sand 20% and gravels 20%. Bars consisted largely of cobbles and boulders (40% each), with sand and gravel making up 10% each. The thalweg bed consisted of boulders (40%), cobbles (30%), gravel (20%) and 10% sand. Thus the bed material is very varied, with no particle size being dominant.

There was evidence of deposition of fine material within the pools. From the Hjulström curve, flows of 0.3 m/s would be required to entrain these particles (Gordon *et al.*, 1992).

The main channel is three metres deep. This flood depth would correspond to the bankfull discharge.

2.3 IFR3B Darkest Africa

Lat. 30° 10' 07" S
Long. 28° 48' 09" E
Reach gradient 0.009

The new IFR site in the gorge was not visited due to lack of time. A general description was made of the channel at the original site and a discharge measurement was taken. No hydraulic transects were measured at this site.

2.3.1 General Description of site:

This site is located on the Bushmans River upstream of its confluence with the Tugela River. The site is approximately 30 km downstream of the proposed Mielietuin Dam.

The channel is laterally confined by valley side walls. There is a terrace present along sections of the right bank. The active channel was approximately 70m wide with a depth of 2m. The channel was classified as mixed, with some bedrock controls being present within what is essentially an alluvial plane bed channel. The river consists of a plane bed dominated by boulders and cobbles, with an island being present in mid-stream. Erosion during the recent flood event had removed large sections of a lateral bar that had existed along the right hand bank. Further downstream there was evidence of major depositionary activity to form lateral cobble bars.

The study site consisted of approximately 70% plane bed, 20% island, 8% backwater and 2% rapid. The bed consisted of 50% boulders, 20% cobble, 20% gravel and 10% sand. There was significant evidence of aggradation including the presence of a vegetated island and the encroachment of vegetation. The site is located just below a steep gorge section, and is thus likely to experience deposition due to the change in gradient.

The left bank of the channel consisted of bedrock, with the right bank consisting mostly of sand. The right bank was relatively densely vegetated with trees, shrubs and grass, while the left bank consisted of exposed bedrock. The banks appeared to be relatively stable with few signs of active erosion. However, disturbances due to cultivation and the artificial building up of parts of the right bank may lead to instability under flood conditions. The right bank varied in steepness from 30°- 60° and was concave, while the left bank varied from 60°- 80° with a relatively straight bank form.

2.3.2 Flow Discharge
Discharge was measured downstream of the original IFR3 site as 1.687 m3 s-1.

2.3.3 Hydraulic Habitat
The site consists of a large variety of hydraulic biotopes, which provide significant habitat diversity. 20% of the area consisted of glides, 20% of runs, 38% of riffle, 10% of slack water, 5% of pool, 5% of rapid, with chutes making up the remaining 2%.

Reduction in discharge of the river due to flow regulation would result in the reduction in the depth and width of the channel due to aggradation of fine material. Slack water areas along the channel margins would be likely to be infilled, accompanied by the encroachment of vegetation into the channel. A reduction in riffle, rapids and runs could be expected.

Aggradation is likely to be a major problem at this site due to the reduction in gradient as the river leaves the gorge. Floods of sufficient magnitude are required to ensure that fine material is flushed out of the system.

2.3.4 Assessment of geomorphologically effective flows
It is important that flows of sufficient magnitude to prevent the deposition of fine material over the plane bed are maintained. The bed was dominated by boulders (50%), with cobbles (20%), gravel (20%) and sand (10%) making up the rest. Velocities of above 0.2 metres per second would be necessary to ensure that smaller particles were entrained and not allowed to aggrade. Within this system, this velocity is associated with a relatively low discharge.

Bankfull levels are around 2 metres. A velocity in excess of 2 $m.s^{-1}$ cobbles would be required to move cobbles of up to 10cm diameter. A very severe flood would be necessary to move the dominant boulders of the plane bed.

2.4 Non-IFR sites Bushmans River above Weenen (including uMngwenya confluence)

Lat. 28° 51' 45" S
Long. 34° 04' 51" E
Reach gradient 0.0036

2.4.1 General description of site:

This area is located on the Bushmans River upstream of Weenen. Two sites were examined within this reach. The sites are downstream of the proposed Mielietuin Dam. Descriptions refer to the main study site unless the uMngwenya confluence is specifically mentioned. The single thread channel is non-confined and of low sinuosity. There is a floodplain present and some terracing. The channel is laterally mobile. The channel gradient is lower than the reaches up and downstream of the site, with a gradient of 0.0036.

The reach is an alluvial pool-riffle sequence, with cobbles being dominant. The active channel had a width of 70 m, and a maximum depth of 3.5 m. 60% of the active channel consisted of side bars. 30% consisted of pools, 7% of riffles and 3% of backwater. The bed material varied according to location. The beds of pools consisted of 50% silt and clay, 20% gravel, 20% cobble and 10% sand. Two sorts of bars were present. An upstream bar lateral to the pool consisted of 70% silt and clay, and 30% sand. The downstream bar in the vicinity of the riffle consisted of 30% cobble, 25% gravel, 20% boulder, 15 % sand and 10% silt and clay. The riffle was dominated by cobble (70 %) with gravel (20 %), sand (5 %) and boulder (5 %). There was significant evidence of aggradation, with extensive bar deposits of cobbles and boulders mixed with finer material, embedded cobbles and encroaching vegetation.

The banks consisted of stratified material. The lower layer consisted of 45 % each of cobbles and gravel, and the upper layer consisted of 90% sand and 10% gravel. The banks were relatively densely vegetated. The right bank had dense trees, with some shrubs, grass and reeds. The left bank was covered with dense patches of grass and reeds. Instream vegetation consisted of some herbaceous plants, shrubs and reeds. The right bank was vertical or concave, and was steeper than 60°. The left bank tended to be convex and was generally under 30° in angle, although some undercutting was taking place. The banks were generally stable, with localised active basal erosion especially on the meander bends, as well as subaerial erosion due to livestock trampling.

There is a significant amount of local catchment disturbance and upstream channel disturbance. Floodplain irrigation is taking place and there is evidence of the construction of artificial levees.

Although the channel is superficially disturbed, it unlikely that the channel's geomorphological characteristics are very different from a more natural situation.

2.4.2 Hydraulic Biotopes

Hydraulic biotopes were relatively diverse, with a number of different habitats being present. Within the pools, 35% consisted of pool, 57% of glide, 5% of slack water and 3% of run. Hydraulic biotopes within the riffle consisted of 55% riffle, 25% run, 10% slack water, 5% glide and 5% chute.

A reduction in discharge is likely to reduce the amount of glide within the pools and result in deposition of fine material within the slow flowing areas. The hydraulic controls may tend to get buried by sand and gravel deposits, with almost complete loss of habitat. This would result in the river looking like the uMngwenya River with a slow flowing stream flowing over a uniform gravel bed. This could be associated with encroachment by vegetation.

Upstream of this site was the confluence of the uMngwenya River with the Bushmans River. The uMngwenya River catchment is relatively arid and although it contribute insignificant amounts of base flow to the Bushmans River, the catchment generates significant amounts of sediment, specifically in the coarse sand and gravel range. The catchment is densely populated and is relatively degraded.

The area immediately downstream of the confluence of the two rivers is marked by extensive deposits of coarse sand and gravel. There is little evidence of aggradation immediately upstream where a bedrock controlled channel is present. In input of sediment from the uMngwenya River will become especially significant if the Mielietuin Dam is built , causing a significantly reduction in high flows in the Bushmans River. In the absence of flows sufficient to entrain and transport the sediment, extensive aggradation and associated habitat loss can be expected below the confluence of the uMngwenya River as well as a number of other smaller tributaries from similar areas such as the iMotane River. It is possible that the extensive aggradation that is already present could be attributed to the presence of the Wagendrift Dam further upstream on the Bushmans River.

3. GENERAL ASSESSMENT OF THE POSSIBLE EFFECTS OF FLOW REGULATION ON THE GEOMORPHOLOGY OF DOWNSTREAM REACHES

The projected dams are likely to have a major effect on the flow regime of the Bushmans and Tugela rivers. This effect can be broken down into two components, ie the reduction in total discharge, and the alteration of the flow pattern (Petts, 1988). The dams at Mielietuin (on the Bushmans River) and at Upper Jana (on the Tugela) are likely to reduce the total flow within the systems. In addition, the dams are likely to significantly reduce the geomorphologically significant annual flood or bankfull flood frequencies (Petts, 1988). Bankfull discharges or, alternatively, the mean annual flood discharge, are widely considered to be the discharges which are responsible for determining the channel form and characteristics (Gordon *et al.*, 1992). It is specifically these small and medium scale floods which are effected by damming. The flood hydrograph tends to be flattened by upstream controls. Thus it is likely that in the long term there will be channel adjustment in response to reduced channel forming discharges.

Leopold and Maddock (1953) introduced the idea of channel hydraulic geometry. Essentially, depth, width, velocity and suspended load vary with discharge as a simple power function. A reduction in discharge will result in a decrease in an eventual decrease in depth, width and velocity. In addition, the ability of the river to carry suspended load is reduced. The net result is a tendency towards aggradation.
All of the sites visited already showed signs of aggradation in the form of bar deposits, encroaching vegetation, deposition of fine material over coarse material etc. This may be in part a response to upstream impoundments at Spioenkop on the Tugela and Wagendrift on the Bushmans, in part to increased degradation and soil erosion in the catchments. Thus the sections of the rivers analysed are prone to deposition and aggradation which will be exacerbated by river regulation.

Within the study region, tributaries such as the uMngwenya River, the iMotane River and the iBusane River are responsible for introducing heavy sediment loads into the main rivers. Because of the arid nature of their catchments, they do not contribute significant amounts of discharge. Under an undisturbed flow regime, discharge in the main rivers would be high enough to ensure that the sediment could be moved by the main river and would not build up downstream of confluences. However, reductions in total discharge and, more importantly, reductions in the frequency of small and medium scale floods, would reduce the competence and capacity of the river to move this sediment. The net result is likely to be large scale deposition of material downstream of confluences. Evidence of this occurring is already present at the confluence of the uMngwenya River with the Bushmans River..

Aggradation is most likely in areas of reduced gradient, ie where the river has a reduced ability to carry sediment. Within the study area, these areas coincide with where the Bushmans and Tugela Rivers leave gorges and enter flatter reaches. This occurs on the Bushmans River below IFR3A (in the stretch above Weenen, including the non-IFR study site described earlier) and below the Darkest Africa site at IFR3B. On the Tugela River this occurs below the Jana Gorge (at Tugela Estates below IFR2). These areas are likely to be most severely effected by aggradation and associated habitat loss.

Extensive aggradation has a number of serious consequences in terms of aquatic habitats. It tends to result in a reduction in both the diversity of habitats (as various hydraulic biotopes become aggraded) and their quality of the habitats (Petts, 1988).. Where the bed material previously consisted on boulders of cobbles, any smothering with significantly reduce the quality of habitat. Niches become inilled and destroyed. Aquatic invertebrates are especially prone to the destruction of habitat in this way. Instead of high quality cobble or boulder beds (which present a great variety of habitats), after aggradation channel beds often consist of relatively sterile gravel or sand beds. In addition, valuable slack water and backwater habitats will tend to be lost through aggradation.

Thus the net result of reduced discharge would be a shallower, narrower, and more sluggish river, with extensive loss of habitat quality and diversity due to aggradation.

4. CONCLUSIONS

The Bushmans and Tugela Rivers within the study area are characterised by coarse alluvial beds, though bedrock controls are sometimes present. Cobble bars and other signs of aggradation are common especially in low gradient sections of the rivers.

Impoundments are likely to result in further aggradation of low gradient reaches. Vegetation is likely to encroach on the channel, islands to be formed or extended and cobble bars to become silted up. Channels will thus become smaller and will tend to have a reduced amount of lateral habitat. Flow velocities will be especially reduced in the margins of the rivers.

Impoundments are likely to result in significant habitat loss and degradation if careful attention is not paid to ensuring that flows of sufficient magnitude are maintained to ensure the continued functioning of present channel processes.

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Table 1 Hydraulic characteristics at IFR2

RAPID

width	depth	velocity	substrate	h.biotope
0	0	0	boulder	
1	0.02	0	cobble	pool
2	0	0	boulder	
3	0	0	boulder	
4	0	0	boulder	
5	0	0	boulder	
6	0.07	0	boulder & silt	slackwater
7	0.24	0	boulder & silt	slackwater
8	0.08	0	boulder	slackwater
9	0.011	0.07	silt	pool
10	0.38	0.03	boulder & gravel	pool
11	0	0	boulder	
12	0.38	0.07	boulder & gravel	pool
13	0	0	boulder	
14	0	0	dry	
15	0	0	dry	
16	0	0	dry	
17	0.29	0	boulder	slackwater
18	0.37	0	boulder	
19	0	0	boulder	
20	0.21	0.01	boulder	pool
21	0	0	boulder	
21.8	0.19	0.06	boulder	run
23	0	0	boulder	
24	0	0	boulder	
25	0	0	boulder	
25.4	0.4	0.87	cobble & gravel	
26	0	0	boulder	
27	1	0.54	boulder	rapid
28	0.27	0.64	boulder	rapid
29	0.5	0.1	boulder & cobble	run
30	0.6	0.08	boulder	run
31	0.7	0.41	boulder & cobble	run
32	0.7	0.29	boulder & cobble	run
33	0.8	0.52	boulder & cobble	run

POOL

width	depth	velocity	substrate	h.biotope
0	0	0		
5	1.26	0.01	sand and gravel	pool
10	1.4	0.01		pool
15	0.95	0.09	gravel	pool
20	1.35	0.16	gravel	pool
25	1.55	0.05	boulder & cobble	pool
30	1.09	0.06	boulder & cobble	pool
35	0.8	0	boulder & cobble	pool
40	0.33	0		pool
41	0.41	0		pool
42	0	0	dry boulder	pool
43	0.16	0	slackwater	pool
44	0.03	0	slackwater	pool
45	0	0	dry boulder	pool
47	0	0		

RAPID (cont.)

34	0.72	0.69	boulder	run	42	0.2	0	dry boulder	run
35	0.65	0.75	boulder & cobble	run	43	0.25	0.09	boulder	run
36	0.7	0.66	boulder & cobble	run	44	0.25	0.03	boulder	run
37	0.65	0.63	boulder	run	45	0.25	0.01	boulder	run
38	0.6	0.19	boulder	run	46	0	0	dry boulder	
39	0.6	0.16	boulder	run	47	0	0	dry boulder	
40	0.5	0.36	boulder	run	48	0.07	0		slackwater
41	0.4	0.2	gravel & cobble	run	49	0	0	dry	

Table 2 Hydraulic characteristics at IFR3A

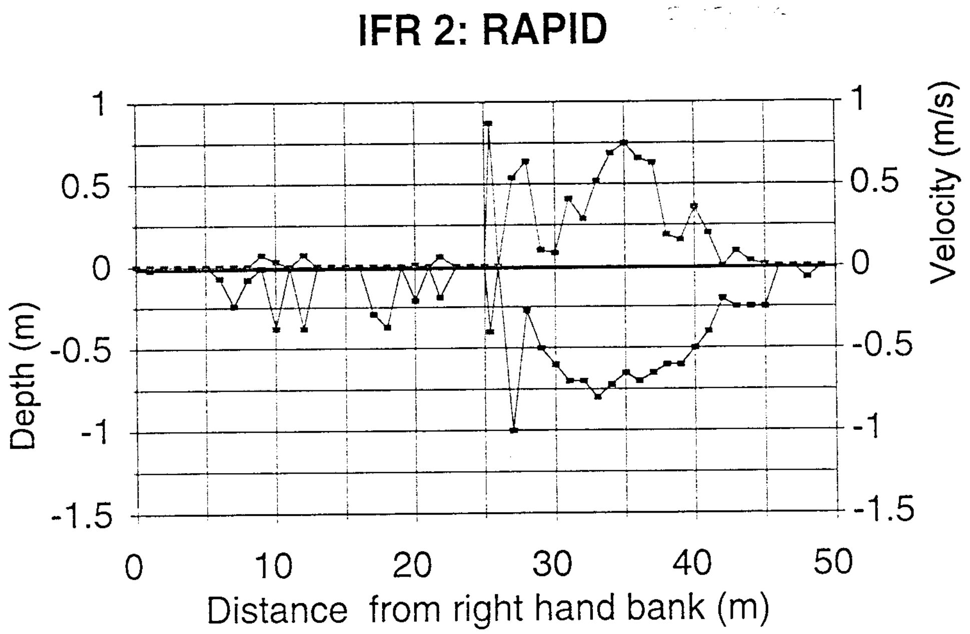
TRANSECT 2

width	depth	velocity	substrate	h.biotope
0	0	0		
5.5	0	0	dry boulder	
7	0	0	dry boulder	
8.5	0	0	dry boulder	
10	0.2	0.22	cobble	run
11.5	0.3	0.18	gravel & cobble	run
13	0	0	dry boulder	
14.5	0	0	dry boulder	
16	0.38	0.26		riffle
17.5	0.6	0.19	boulder	run
18.85	0.56	0.19	boulder	run
20.5	0.45	0.38	gravel & boulder	run
22	0.6	0.16	boulder	run
22.5	0.72	0.48	boulder	run
24	0.45	0.01	boulder	run
25.5	0.42	0.03	boulder	run
27	0.55	0.36	boulder	run
28.5	0.4	0.01	boulder	run
30	0.21	0.33	gravel	run
31.5	0.38	0.03	gravel & cobble	run
33	0.17	0.02	boulder	
34.5	0	0	dry boulder	

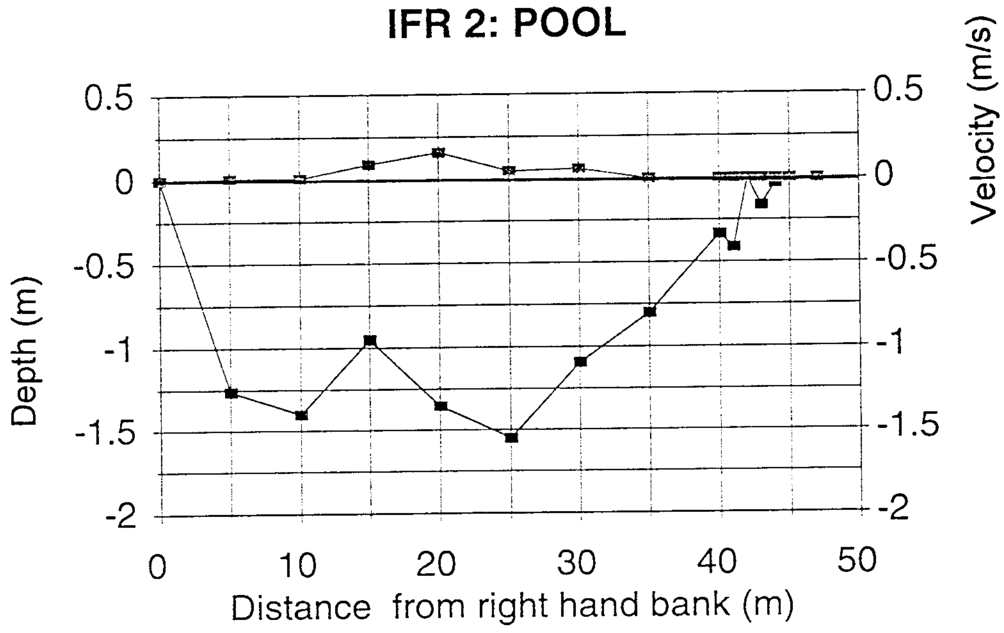
TRANSECT 3

width	depth	velocity	substrate	h. biotope
0	0	0	boulder	run
1.5	0.29	0	boulder/silt & cobble	run
3	0.17	0.12	boulder	run
4.5	0.18	0.02	cobble & silt	run
6	0.18	0.1	cobble & silt	run
7.5	0.2	0.12	gravel & cobble	riffle
9	0	0	dry boulder	
10.5	0	0	dry boulder	
12	0.05	0.24	boulder	
13.5	0.4	0.6	boulder	
15	0	0	dry boulder	
16.5	0.2	0.19	boulder	run
18	0.48	0.25	cobble	riffle
19.5	0.34	0.71		
21	0.6	0.61		
22.5	0.2	0.36	boulder	
24	0	0	dry boulder	
25.5	0.15	0.24	boulder & silt	
27	0	0	dry boulder	
28.5	0.29	0.27	boulder & gravel	
30	0.34	0.21	boulder	
31.5	0	0		

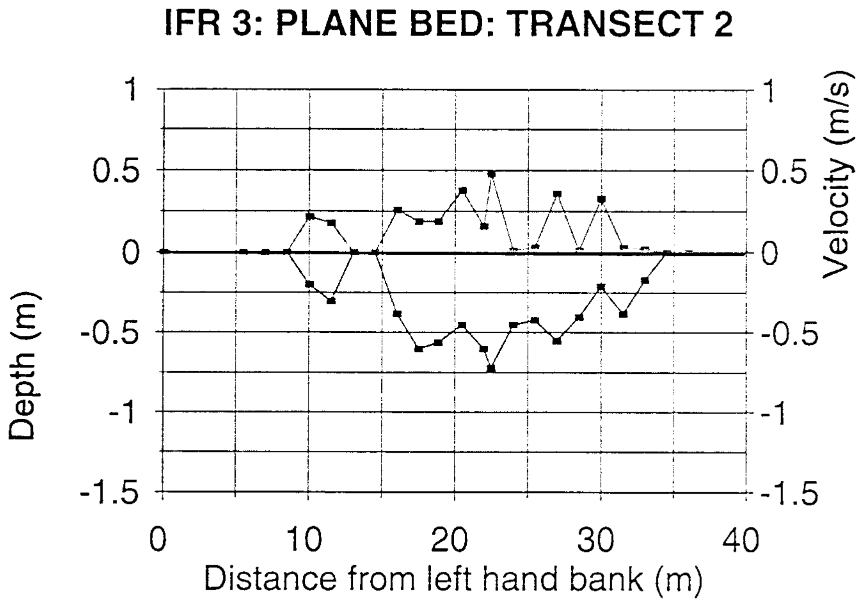
36	0	0



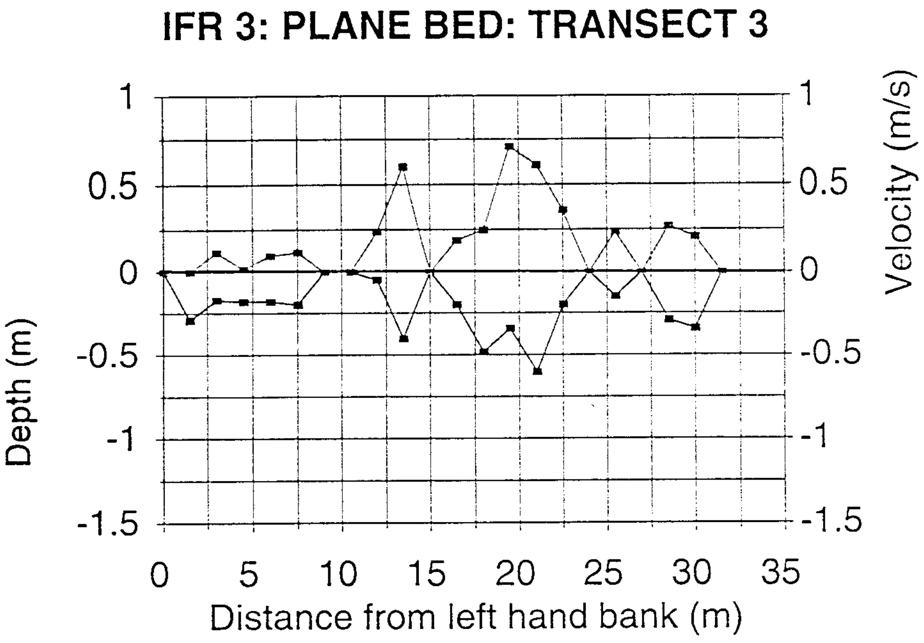
IFR 2: RAPID
Depth (m)
Velocity (m/s)
1
0.5
0
-0.5
-1
-1.5
0
10
20
30
40
50
Distance from right hand bank (m)



IFR 2: POOL
Depth (m)
Velocity (m/s)
0.5
0
-0.5
-1
-1.5
-2
0
10
20
30
40
50
Distance from right hand bank (m)



IFR 3: PLANE BED: TRANSECT 2
Depth (m)
Velocity (m/s)
1
0.5
0
-0.5
-1
-1.5
0
10
20
30
40
Distance from left hand bank (m)



IFR 3: PLANE BED: TRANSECT 3
Depth (m)
Velocity (m/s)
1
0.5
0
-0.5
-1
-1.5
0
5
10
15
20
25
30
35
Distance from left hand bank (m)

9. Riparian vegetation requirements - Thukela River

RIPARIAN VEGETATION REQUIREMENTS - THUKELA RIVER

N.P. Kemper

Ninham Shand - January 1997

1. INTRODUCTION

Still very evident at the IFR sites on the Thukela River and its tributaries is the significant degree of disturbance of the riparian zone by a large flood event such as that of Domoina (1984) and/or the 1987 floods. This disturbance is clearly evident by the distinct absence of riparian vegetation and the well defined flood line. Limited riparian vegetation still remains in small, isolated areas in close proximity to the river which was protected from the high energy flood waters and above the flood line in areas where the riparian zone is naturally wide. The Bushmans River site had been further disturbed significantly during the previous summer, with extensive scouring of the zone clearly evident.

2. DESCRIPTION OF IFR SITES AND FEATURES FOR IFR DETERMINATION

The points selected for the IFR process were visited during August 1996. During this visit, the vegetation present on the primary cross sections at each site was described and annotated on the cross section. The site was also extensively investigated for the sake of understanding the water requirements of the vegetation present on the basis of the criteria described above. The sites and the water requirements of the vegetation are described below.

- **SITE 2 - Thukela Gorge (Thukela River)**

  The right bank of this site still sports evidence of a once extensive riparian zone.The trees which remain on this bank include large fig trees and Tamboties. The transect line itself does not include these species, and displays more extensive levels of disturbance. Maytenus senegalensis and Nuxia oppositifolia are common in the highly disturbed patches which are still overlain with soils. A clear terrace is evident on which the road is built. It is important that this terrace is fed with water to ensure the lateral movement of water and to feed the higher riparian zone. The zone below this is characterised by a rocky zone interspersed with sedges and other hydromorphic plants. It is believed that this area once constituted the riparian zone which has subsequently been eroded away by large floods. This cobble zone has very little value for the reestablishment of riparian tree species unless the gradual deposition of sediments takes place on this area as a result of large flood events. The left bank is extensively eroded by the floods, and the only vegetation remaining are terrestrial species found on the distant riparian terrace.

  Due to the extent of disturbance on the left hand bank, only the right hand bank and its riparian vegetation will be used to determine the required flows from a vegetation perspective. Here the presence of the large terrace and vegetation on and below this will be used extensively. The extensive impact of grazing on the site does complicate the matter due to the consistent removal of juvenile species. This aspect will need to be addressed during the workshop.

- **SITE 3a - Bushmens River - Weenen Nature Reserve**

This site displayed the best riparian and marginal zones. This is particularly true for the left hand bank where less sign of previous flooding and associated scouring was evident. It also appeared that the river banks were relatively stable. It is expected that this site will respond well to recommended flows once these have been established. The protection of the site from heavy grazing by cattle due to its inclusion in the Weenen Nature Reserve will be a valuable. The lateral flow of water into the riparian banks and the clear vegetation zonation will serve as useful features with which to work from a vegetation perspective.

- **SITE 3b - Bushmens River - Darkest Africa**

A new site was selected due to the extensive changes which had occurred due to the floods of the previous wet season. The right bank of this site was most indicative. with a clearly demarcated hydromorphic riparian zone requiring frequent inundation during summer. In addition to extensive flood damage, this site was severely disturbed by removal of the riparian zone by the owner. It was therefore necessary to find an additional site slightly higher upstream. This site, however, displays very little riparian vegetation and is possibly more useful for the other components of the study. A reasonably good marginal vegetation cover is present which could be used for the determination of the lower flows and smaller elevated events only.

The riparian zone on both banks are covered entirely by rocks and boulders boulders which prevents the establishment of trees. A very narrow and dry riparian zone is present above the flood line on both banks where terrestrial vegetation dominates.

- **SITE 5 - Tugela Ferry (Thukela River)**

The flood line at this site is clearly evident. Below this, the vegetation on both sides of the river is restricted to *Sesbania punicea* and *Acacia* seedlings on sandy, partially grasses terraces. These emerging species are browsed extensively by goats The riparian vegetation above the flood line on the right bank is essentially comprised of relatively dry species such as *Dombeya sp.*, *Phyllanthus reticulatus* (potato bush), *Ehretia rigida* and *Maytenus senegalensis.* It will be necessary to cater for this vegetation when considering annual floods and freshes to ensure that the bank is adequately recharged during summer.

Riparian vegetation is absent within the riparian zone on the left bank due to an extensive area covered by rocks and large cobbles.

10. Thukela IFR Refinement Study Approach

THUKELA IFR REFINEMENT STUDY APPROACH

MD LOUW
DECEMBER 1996

During the 1995 workshop, eight IFR sites were addressed by two groups over a period of five days. The present refinement will address four IFR sites over a period of two and a three quarter days. This implies that to give the same amount of detailed attention will need some adjustment of the previous approach. The following stepwise procedure is recommended:

1. A site visit to all the sites except for IFR 5 which was visited during the previous workshop. During the site visit, all necessary information regarding the IFR sites (except for Hydrology) will be given at the site. This will replace the usual five minute presentations given during the workshop. On site investigations of possible low flows and high flows will also be investigated. A flow measurement, water level survey and photo-point monitoring will be undertaken to supply an additional hydraulic calibration point.
2. A hydrological presentation will be given.
3. Based on the new categorisation method (see chapter 3) an overall present category for the river and a future desired state category for the river will be determined.
4. Based on the site visit and available information, a confidence level will be coupled to each IFR site to determine which sites the specialists have the most confidence in to determine an accurate IFR.
5. Based on the above results, one of the Bushmens site will be selected to undertake a detail IFR.
6. This information will then be used to, by means of applying a hydrological factor, check the adequacy of the results at the other Bushmens site.
7. The detail IFR will then be determined for the Thukela IFR site 2.
8. By the same means as for point 6 above, this results will then be used to check results at IFR 5.
9. An overall confidence in the results will then be coupled by each specialist to each IFR site.
10. By means of the Bulk Water Estimate method, IFRs at points lower downstream in the system will then be determined. This will check any possible problems that could exist in the rest of the system.

The workshop will be followed by an additional step where hydrological modelling linked to real climate will be undertaken to determine the exact time series (i.e. maintenance flows, drought flows and the link periods). These results will then be utilised for the dam modelling to see whether the IFRs can be supplied and, if not, what can be supplied and the implications of these scenarios.

THUKELA REFINEMENT IFR STUDIES
(SOUTHERN TRIBUTARIES)

Report on a Workshop
held at the
Owl and Elephant Guest House, Weenen,
21 - 24 January 1997

FINAL REPORT
August 1997

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CONTRIBUTORS TO THE THUKELA INSTREAM FLOW REQUIREMENTS REFINEMENT STUDY (SOUTHERN TRIBUTARIES)

Contributors	Activity
IFR Study	
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Prof. JH O'Keeffe (IWR, RU)	Group facilitator
Pre-Workshop activities	
Mr A Birkhead (CWE)	Hydraulics, site selection, photo-point monitoring
Mr M Coke (Natal Parks Board)	Fish, site selection
Prof. D Hughes & Dr V Smakthin (IWR, RU)	Hydrology
Mr N Kemper (Ninham Shand)	Habitat integrity, riparian vegetation, site selection
Ms MD Louw (DWAF)	Site selection, photo-point monitoring, programme, IFR site selection paper
Mr D Nyschens (DWAF)	Cross-sectional surveys, photo-point monitoring
Prof K Rowntree (RU)	Fluvial geomorphology, site selection, photo-point monitoring
Workshop	
Mr A Birkhead (CWE)	Hydraulics
Dr M Chutter (Afridev)	Aquatic invertebrates, water quality
Mr M Coke (Natal Parks Board)	Fish
Mr J Cooke (Consultburo)	Engineering background & project leader
Mr E Dollar (RU)	Fluvial geomorphology
Prof. D Hughes (IWR, RU)	Hydrology
Mr N Kemper (Ninham Shand)	Riparian vegetation
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EXECUTIVE SUMMARY

Introduction

Determination of an Instream Flow Requirement (IFR) for a river affected by a proposed water development is part of the Integrated Environmental Management (IEM) process. It is necessary to estimate the IFR in order to assess the quantity of water which can be made available for future use on a sustainable basis. The study reported on here is a refinement of the original 1995 IFR workshop to determine the IFR for the Thukela River downstream of the confluence of the Little Thukela and Thukela Rivers to a point downstream of the confluence with the Buffalo River. The Refinement study focuses on the Upper Jana and Mielietuin Dams.

Four sites were selected (2 each on the Thukela and Bushmans Rivers) for the IFR Refinement Study. Based on site visits and information supplied by specialists (**APPENDIX 1**), the Future Desired States (FDS) of the rivers were defined as follows:

THUKELA RIVER:

- **To determine a flow regime which will promote/facilitate**
  - **the natural ecological state ***
  - **aesthetic quality (wild and scenic character of the Thukela River)**
  - **conservation of the natural heritage including species biodiversity and landscapes.**

  **** at least maintain as is - no further degradation***.

- **To maintain a perennial flow.**

- **To determine a flow regime that will promote the sustainability of the riverine resources for those depending on the presence of a healthy riverine ecosystem.**

BUSHMANS RIVER:

- **To recommend flows that will maintain the scenic character of parts of this river.**

- **To recommend flows that will address the possibility of poor water quality.**

- **To recommend flows that will maintain the possible high habitat integrity in parts of river and maintain or improve the possible lower habitat integrity in the other parts of the river.**

The instream flow requirements for the 4 selected sites were estimated and expressed as low and high flows for maintenance and drought purposes. The results of these estimates are given in Table 1.

TABLE 1: FLOW ESTIMATES FOR MAINTENANCE AND DROUGHT FLOWS AT EACH OF THE IFR SITES (Flow in $m^3.s^{-1}$)

SITE	RIVER			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
3A	BUSHMANS	M	LOW	1	1.8	2.2	2.5	3	2.5	2	1.5	1	0.7	0.7	0.7
			FLOOD	5	12	20,10	30,10	60,10	20,10	10					
		D	LOW	0.5	0.8	1	1.2	1.3	1.2	0.9	0.7	0.5	0.4	0.4	0.4
			FLOOD		5	8	8	12	8						
3B	BUSHMANS	M	LOW	1.1	2	2.5	2.7	3.3	2.8	2.2	1.6	1.1	0.77	0.77	0.77
			FLOOD	5.5	13.3	11,22.2	11,33.3	11,67	11,22.2	11.1					
		D	LOW												
			FLOOD												
2	THUKELA	M	LOW	3	5	7	8	9	8	7	5	3.5	2.5	2	2
			FLOOD	13	20	30,60	30,70	200,50	50,30	30					
		D	LOW	1.3	2	3	3.5	4	3.5	3	2	1.5	1	1	1
			FLOOD		20	30	30	100	30	30					
5	THUKELA	M	LOW	4.3	7.7	10.7	12.8	15.3	13	10.2	7.3	5	3.6	3.1	3
			FLOOD	15	20	30,70	30,80	60,200	30,60	30					
		D	LOW	1.9	3.1	4.6	5.6	6.4	5.6	4.4	2.8	2	1.4	1.4	1.4
			FLOOD		20	30	30	100	30	30					

M = MAINTENANCE FLOWS; D = DROUGHT FLOWS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

The relevance and importance of instream flow assessments is discussed in the IFR 1995 report (DWAF, 1997). In this report, an instream flow assessment is defined as **"the identification of those fundamental components of the flow regime of a riverine ecosystem considered essential for ensuring perpetuation of its features"**. These fundamental components are used to determine the Instream Flow Requirement (IFR) for a river.

Determination of an IFR for a river affected by a proposed water development project is one of the specialist studies that forms part of the Integrated Environmental Management (IEM) process undertaken for the proposed water resource development. It is necessary to estimate the IFR of river ecological systems and human communities in order to assess the quantity of water which can be made available for future use on a sustainable basis, *i.e.* related to the management objectives of the river.

The study reported on here is a refinement of the original 1995 IFR workshop to determine the IFR for the Thukela River downstream of the confluence of the Little Thukela and Thukela Rivers to a point downstream of the confluence with the Buffalo River. The Refinement study focuses on the Upper Jana (middle Thukela River) and Mielietuin (Bushmans River) Dams.

The reasons for undertaking the Refinement study are:

- No detailed motivations were given for the flow requirements for the site downstream of the upper Jana Dam as the site was deemed inadequate as well as poor hydraulic information and a scaling factor was used to calculate the flows.
- Motivations for the recommended flows were not documented by specialists, as is now standard practice, and were hidden in reports and assumptions were made regarding the motivations.
- Depths or inundation levels for each of the recommended flows were not recorded.
- All the hydraulics used for the depths and water level conversions to flows were inaccurate.
- Cross-sections were of insufficient detail.

1.2 REFINEMENT STUDY

Requirements from the Thukela 1995 IFR workshop (including the Northern and Southern tributaries) for the Feasibility phase of the study were specified as follows (see also **Introduction & Background**, by MD Louw, **APPENDIX 1**):

- Cross-sectional surveys for all the sites need to be re-surveyed;
- Hydraulic calculations for all the sites need to be repeated and calibrated with observed data;
- Additional IFR sites in the tributaries need to be investigated if any of the proposed options in the tributaries are investigated during the feasibility phase;

- All normal IFR investigations for any new IFR sites need to be undertaken;
- IFR site 2 needs to be in a more representative site in the gorge;
- The results of the IFR need to be modelled to determine how they can be supplied by the proposed developments;
- A monitoring protocol needs to be determined for the Design, Construction and Operation phases.

IFR actions taken during the Refinement study were (see also **Introduction & Background**, by MD Louw, **APPENDIX 1**):

To date:
- Reselection of sites on the Thukela and Bushmans River;
- Selection of new sites on the Bushmans River;
- Cross-sectional surveys of the above sites at the required standard;
- Hydraulic calculations with at least 4 calibration points;
- Riparian vegetation and fluvial geomorphological investigations for the new sites
- Photo-point monitoring of all the sites at known flows;
- Hydrological analysis of the previous data for the new sites as well as check on the adequacy of the data;
- Modelling of the IFR results with the IFR release model (Hughes) to determine the transition between maintenance and drought flows;

Actions still required during the Feasibility phase of this study:
- Yield analysis modelling of the above results to determine different scenarios of possible supply of the IFR;
- Determination of an acceptable scenario from the environmental viewpoint and the implications of any other scenarios;
- The determination of a monitoring protocol.

The above actions are shown in **FIGURE 1**, which depicts the IFR actions which should take place during the feasibility phase.

Workshop participants were provided with a **Starter Document** (**APPENDIX 1**) which contained papers with additional information on the following topics, prior to the workshop:

- Introduction and Background - M. D. Louw
- IFR 95 Results - M. D. Louw
- Future Desired State: Thukela and Bushmans Rivers - M. D. Louw
- Thukela IFR Refinement Study: A summary of the process followed for IFR Site Selection - M. D. Louw and N. P. Kemper
- Thukela River IFR Revision - Hydrology - D. A. Hughes and V. Smakhtin
- Thukela and Bushmans Rivers Water Resource Development Feasibility Study Instream Flow Requirement Hydraulics - A. L. Birkhead
- Geomorphology - K. Rowntree
- Riparian Vegetation Requirements - Thukela River - N. P. Kemper
- Thukela IFR Refinement Study Approach - M. D. Louw

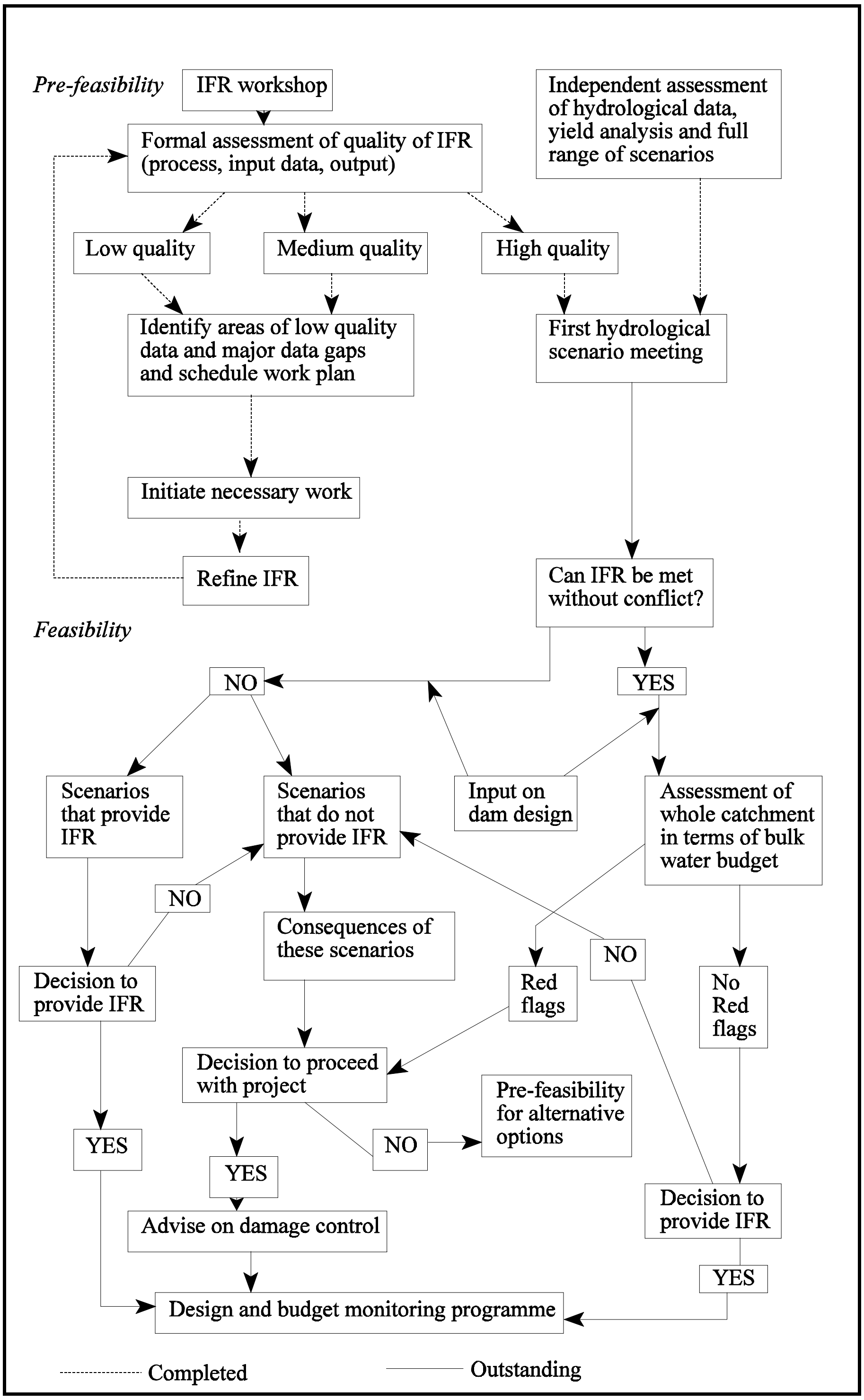

FIGURE 1: SUGGESTED FLOW PATH FOR BBM-RELATED ACTIVITIES DURING DWAFs FEASIBILITY PHASE

2. IFR SITES

2.1 SELECTION OF IFR SITES

The IFR sites are a "snapshot" of the river: the river is a dynamic system, with extremes from high to low; *e.g.* the gorge (more resilient) and alluvial areas (more sensitive). The process of identifying and selecting IFR sites is outlined in **Thukela IFR Refinement Study: A Summary of the Process followed for IFR Site Selection**, by Louw and Kemper (**APPENDIX 1**). IFR site selection is guided by a number of considerations such as:

- The locality of gauging weirs with good quality hydrological data
- The locality of the proposed developments
- The locality and characteristics of tributaries
- The habitat integrity/conservation status of the different river reaches
- The reaches where social communities depend on a healthy river ecosystem
- The suitability of the sites for follow-up monitoring
- The habitat diversity for aquatic organisms, marginal and riparian vegetation
- The suitability of the sites for accurate hydraulic modelling throughout the range of flow, especially low flows
- Accessibility of the sites
- An area that could be critical for ecosystem functioning. This is often a riffle which will stop flowing during periods of low or no flow. Cessation of flow constitutes a break in the functioning of the river. Those biota dependent on this habitat and/or continuity of flow will be adversely affected. Pools are not considered as critical since they are still able to function as an ecosystem or at least maintain life during periods of no flow.
- The locality of geomorphological reaches and representative reaches withing these.

2.2 ADEQUACY OF SITES FOR IFR DETERMINATION

The following process was used in the Refinement workshop:

1. A site visit to three of the four selected sites (since IFR 5 was visited during the previous workshop) was accompanied by information dissemination of information available for the sites.
2. A presentation on the hydrology of the system (D. Hughes).
3. An overall current state and a Future Desired State for the sites and the rivers was determined.
4. A confidence level, based on the available information, was attached to each site to determine which sites the specialists had most confidence in to determine accurate IFRs.
5. One of the Bushmans River sites was selected for a detailed IFR.
6. A hydrological factor was applied to the IFR for this site to obtain an IFR for the other site. The adequacy of the derived IFR was checked.
7. A detailed IFR for Thukela IFR site 2 was determined.
8. Applying a hydrological factor, the IFR for IFR site 5 was derived and the results checked.
9. Specialists attached an overall confidence in the IFR results.

10. By means of the Bulk Water Estimate method, IFRs at points lower downstream in the system will be determined. This will check any possible problems that could exist in the remainder of the river.
11. Hydrological modelling linked to real climatic data, to determine the hydrological flow time series. These results can be utilised for the dam modelling to determine whether the IFRs can be supplied and, if not, what can be supplied and the implications of these scenarios.

Some sites lend themselves better to IFR determination, but these sites only become apparent during the pre-workshop studies and surveys. Due to time constraints, the best sites are therefore used for detailed IFR. IFRs will then be extrapolated to the other IFR sites, converted to hydraulic parameters for those sites and checked for adequacy.

The process was to identify the study area and selecting stretches of the rivers in which IFR sites should be situated. Reaches relevant for the 1995 study were identified. Of these sites, 4 sites were selected for the 1997 Refinement Study, two each on both the Thukela and Bushmans Rivers (**FIGURE 2**). These were:

2.2.1 Thukela River

IFR 2: 28E44.585 S 30E08.369E
This was moved upstream from the 1995 IFR site to the gorge section of the river channel to ensure that the site was geomorphologically representative of the river. The site consisted of a pool/rapid-riffle/pool section, with slack water areas and marginal vegetation.

IFR 5: 28E45.350S 30E32.867E
This site was selected instead of IFR sites 6 and 8 because it was more readily accessible and it was possible to undertake flow measurements at this site for hydraulic calibration.

2.2.2 Bushmans River

Based on the 1995 IFR workshop, it was decided that an additional site on this major tributary of the Thukela be included for the 1997 workshop.

IFR 3A: 28E53.395S 30E1.031E
A boulder/cobble plane bed area near the border of the Weenen Nature Reserve, which is less disturbed than the surrounding irrigation areas, was selected for geomorphological and fish reasons.

IFR 3B: 28E48.01 30E10.681
The previously selected IFR site had been extensively damaged and altered by flood and the land owner. A site upstream in the gorge was selected on the basis of a bedrock rapid with upstream and downstream pools; there was marginal vegetation but riparian vegetation was limited.

IFR sites 2, 3A and 3B were visited by the participants. IFR site 5 was visited during the previous workshop and not visited again due to time constraints. The site visits allowed participants to obtain a general impression of the conditions in the rivers (Thukela and Bushmans Rivers) and to identify important characteristics of the rivers at the selected IFR sites. Brief descriptions by experts of available information were given (more detailed information was in the **Starter Document**, **APPENDIX 1**).

2.3 SITE EVALUATION

TABLE 1 gives an indication of how good the available data was considered by the specialists and therefore how adequate the sites are for the IFR process.

Based on **TABLE 1**, it was decided to use IFR sites 2 and 3A since the best information is available for these two sites. Therefore, IFR site 2 was selected, but judged against IFR site 5, and IFR site 3A was selected and judged against IFR site 3B.

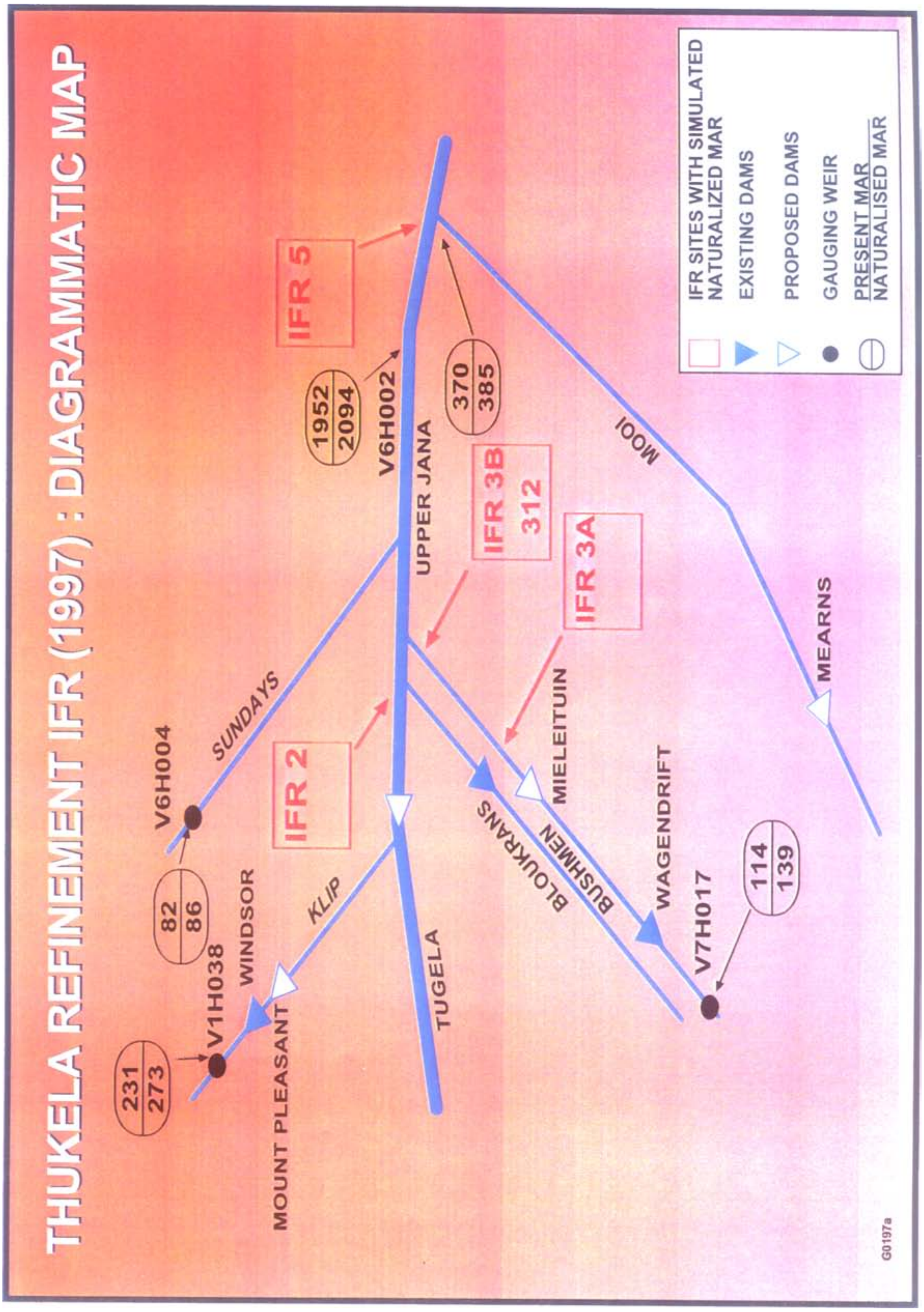

FIGURE 2: DIAGRAMMATIC MAP SHOWING RELATIVE POSITIONS OF SITES FOR THE 1997 REFINEMENT STUDY

TABLE 1: INSTREAM FLOW REQUIREMENT SITE EVALUATION TABLE

IFR SITES		RIVER	IFR COMPONENT									
			HYDRAULICS	HYDROLOGY		FISH	RIPARIAN VEGETATION	FLUVIAL GEOMORPHOLOGY	AQUATIC INVERTEBRATES	WATER QUALITY	FLOW PHOTO
				NATURAL	PRESENT DAY						
2	**low**	THUKELA	**M-H**	**H**	**M-L**	**H**	**L**	**M**	**M**	**L**	**H**
	high	THUKELA	**M-H**	**M**	**M**	**M**	**L-M**	**M-H**	**M**	**L**	
5	**low**	THUKELA	**M-H**	**M**	**M-L**	**H**	**L**		**M**	**L**	**M**
	high	THUKELA	**M**	**M**	**M-L**	**M**	**L**	**M**	**M**	**L**	
3 a	**low**	BUSHMANS	**M**	**H**	**M-L**	**H**	**M**		**M**	**L**	**H**
	high	BUSHMANS	**M**	**M**	**M**	**H**	**M-H**	**M-H**	**M**	**L**	
3 b	**low**	BUSHMANS	**L-M**	**H**	**M-L**	**H**	**L**		**M**	**L**	**M-H**
	high	BUSHMANS	**M**	**M**	**M**	**M**	**L-M**	**L**	**M**	**L**	

N = none; L = low; L-M = low-medium; M = medium; M-H = medium-high; H=high

3. FUTURE DESIRED STATE

A set procedure for establishing the Future Desired State of a river has not yet been determined, but is based on the "Abstract from Water Environment Objectives: A First Contribution by Kleynhans for the Water Law Review" (**APPENDIX 1**). The procedure used is listed:

1. Specialists must assign the river to a category (described in the above document) to describe the PRESENT class, from their specialist point of view. A motivation should accompany the decision on the present class.

2. A **realistic FUTURE DESIRED STATE** (FDS) category must then be assigned to the same river using the classes described in the document above. The river importance must be considered as motivation for the FDS. The FDS must also be motivated for.

3. If possible, an overall current category for the river is then determined, as well as a realistic FDS. The Future Desired State for the river is agreed upon by all the specialists.

In order to determine a Future Desired State for a water resource which will protect the resource for ecological functioning and integrity, the Resource Base and Resource Base Reserve of the river need to be identified. The water resource is classified on the basis of its ecological integrity status, importance of the water resource, sustainability of the resource and the desired state of the resource and this is used to set receiving water environment objectives.

These principles are used to determine the overall objective for the Thukela and Bushmans Rivers and the future desired states for these rivers based on their objectives. The IFR is then based on the FDS and the objective for the river.

During the 1995 IFR workshop, an objective for the instream flow requirements for the Thukela River was stated as follows (DWAF, 1997):

- **To determine a flow regime which will promote/facilitate**
  - **the natural ecological state ***
  - **aesthetic quality (wild and scenic character of the Thukela River)**
  - **conservation of the natural heritage including species biodiversity and landscapes.**

  **** at least maintain as is - no further degradation*.**

- **To maintain a perennial flow.**

- **To determine a flow regime that will promote the sustainability of the riverine resources for those depending on the presence of a healthy riverine ecosystem.**

During the Refinement study, the objective of the future desired state (as it is now known) was re-evaluated. Even though no set procedure exists to determine the future desired state a more formal and quantifiable process was used. The 1995 IFR was then revisited and modified so that there would be an **improvement** in the natural ecological state, rather than only a maintenance of the current situation.

The specific objectives for the Bushmans River were established during the 1995 IFR and confirmed during the 1997 Refinement IFR:

- **To recommend flows that will maintain the scenic character of parts of this river.**

- **To recommend flows that will address the possibility of poor water quality.**

- **To recommend flows that will maintain the possible high habitat integrity in parts of river and maintain or improve the possible lower habitat integrity in the other parts of the river.**

TABLE 2 shows the Future Desired States for the Thukela and Bushmans Rivers, and this is followed by motivations for these FDSs. Some of the components (*e.g.* riparian vegetation and aquatic invertebrates) as well as the overall river category (**TABLE 2**) show a range of conditions for both the present state and future desired state. This is because the components could not easily be categorised into one of the allotted states and showed a range of conditions.

TABLE 2: THE PRESENT AND FUTURE DESIRED STATE OF THE BUSHMANS AND THUKELA RIVERS

IFR COMPONENT	BUSHMANS										THUKELA									
	PRESENT STATE						FUTURE STATE				PRESENT STATE						FUTURE STATE			
	A	B	C	D	E	F	A	B	C	D	A	B	C	D	E	F	A	B	C	D
FISH			U					U				U						U		
RIPARIAN VEGETATION		U	U					U	U					U	U				U	
AQUATIC INVERTEBRATES			U	U					U			U	U	U	U			U		
FLUVIAL GEOMORPHOLOGY G		U						U				U						U		
A			U						U				U						U	
WATER QUALITY			U					U					U					U		
AESTHETIC, ECOTOURISM & NOSS BIODIVERSITY		U						U					U					U		
HABITAT INTEGRITY			U					U					U					U		
RIVER			U*					U	U			U	U	U	U			U	U	

***: The present state of the river is at the upper end of the C scale, almost a B.**
Where more than one block has been indicated for either Present or Future state, a range of conditions operates.
G = gorge section of the river, which is not as likely to change as the alluvial section of the river;
A = alluvial section of the river.

3.1 THUKELA RIVER (IFR sites 2 & 5)

3.1.1 Aquatic Invertebrates

Present Category: **E**:

As a result of the land-use impacts, over-exploitation of the riparian zone, and water quality deterioration (Ladysmith), the reaches are considered to be seriously modified.

Future Desired State: **B**

Motivation: There are no known instream biota of special conservation concern restricted to the reaches for which IFRs are to be determined. A moderately high allocation of flow will allow recovery of the ecosystem, provided that steps are taken to manage water quality, to manage the catchment to reduce erosion and to properly protect the riparian zone and river banks. Re-establishment of the fringing vegetation would make this FDS achievable.

3.1.2 Fish

Present Category: **B**

Future Desired State: **B**

Motivation: A decline in water quality or in habitat availability, especially the riffle habitats, must be avoided.

3.1.3 Geomorphology

Present Category: The gorge sections are graded **B** and the lower gradient (alluvial) sections are graded **C**.

Future Desired State: Gorge - **B**; alluvial section - **C**

Motivation: The gorge has high geomorphological resilience and the high diversity of habitat should be maintained. The alluvial sections have been subjected to increased siltation and large scale rehabilitation is unlikely to be feasible as a result of high population densities in the catchment. The present diversity of habitats should be maintained by preventing excessive siltation and channel narrowing.

3.1.4 Riparian Vegetation

Present Category: **D - E**

Due to the impact of floods and grazing pressure as well as the associated removal or destruction of the riparian zone, the sites are considered to be largely to seriously modified.

Future Desired State: **C**

Motivation: The riparian zone has a variety of structural and ecological functions which are important for the stability and integrity of the river. The Future Desired State is therefore one which has a more intact riparian zone which can achieve the structural and ecological functions which are currently in a state of disrepair.

The objective for the FDS for the Thukela River is to manage the river for the present macro channel (large river). The **motivation** for doing this is that the uniqueness of the river is due to its size; intermediate floods construct the channel and subsequently the flow regime should be managed for this. The resilience of the river may be lost during floods if the river is maintained in the micro channel. Furthermore, improvement of biodiversity is possible if the macro channel is maintained; if the micro channel is maintained, the morphology of the channel may change dramatically during a flood event and leave a large river with reduced habitat availability.

3.2 BUSHMANS RIVER (IFR sites 3A and 3B)

3.2.1 Aquatic Invertebrates

Present Category: **C - D**

From the water resource point of view, the river is considered to be moderately modified, as the river is used to provide water to the irrigation areas. However, as a result of a deterioration in water quality, a large change of natural habitat, biota and basic ecosystem function has occurred.

Future Desired State: **C**

Motivation: Water quality should improve with nutrient concentrations decreasing as a result of the dam; furthermore, the dam will also retain sediment. It is recommended that a multi-level draw-off point be built into the dam, so that water quality can be further regulated and improved.

3.2.2 Fish

Present Category: **C**

Future Desired State: **B**

Motivation: Damming should permit an improvement in the trophic level of water quality. Fish populations should therefore improve.

3.2.3 Geomorphology

Present Category: The gorge sections are graded **B** and the lower gradient (alluvial) sections are graded **C**.

Future Desired State: Gorge - **B;** alluvial section - **C**

Motivation: The gorge has high geomorphological resilience and the high diversity of habitat should be maintained. The alluvial sections have been subjected to increased siltation and large scale rehabilitation is unlikely to be feasible as a result of high population densities in the catchment. The present diversity of habitats should be maintained by preventing excessive siltation and channel narrowing.

3.2.4 Riparian Vegetation

Present Category: **B - C**

The current state is considered to be largely natural with few modifications to moderately modified.

Future Desired State: **B**

Motivation: The riparian zone has a variety of structural and ecological functions which are important for the stability and integrity of the river. The Future Desired State is therefore one which has a more intact riparian zone which can achieve the structural and ecological functions which are currently in a state of disrepair.

3.3 OVERALL FUTURE DESIRED STATE FOR THE BUSHMANS AND THUKELA RIVERS

There exists a range of future desired states down the length of the rivers and this is reflected in the range of categories selected for the overall river FDS (**TABLE 2**). Some areas will be susceptible to morphological changes as a result of changes in flow regime, *e.g.* alluvial areas, while other areas will be less prone to changes due to their inherent stability, *e.g.* gorge areas.

Therefore, a category **B** would be the FDS for the average river and **C** would be the FDS for the particularly susceptible, as well as alluvial, areas.

4. INSTREAM FLOW REQUIREMENTS

Habitat integrity is a composite of individual components, of which flow regime is only one component. However, this workshop addresses only the flow regime, and how this component can be used to obtain the Future Desired State, and does not address other issues relevant in the catchment. For example, the riparian vegetation is impacted by people and animals, and leads to reduced bank stability, and the normal functioning of the riparian vegetation and habitats are impaired. The riparian vegetation needs regeneration by alteration of some of the components that affect it (*e.g.* goats), and not only flow regime. Therefore, various components need to be altered to successfully improve habitat integrity. In other words, there are constraints, such as human and other natural constraints, as to what can be achieved in order to reach the Future Desired State. However, a small change in flow may lead to a large improvement in one of the components, such as the invertebrates, while an improvement in the riparian vegetation may be achieved by altering the flow regime, which can lead to further improvements in the invertebrates.

4.1 DEFINITIONS

The definitions of Maintenance, Drought and Capping flows used were the same as those for the Sabie-Sand IFR (DWAF, 1996, p. 38).

4.1.1 Maintenance Flow

Maintenance flows should provide for the full suite of ecological and geomorphological processes and biological activities. It represents the series of **lowest** flows that should occur in the river during normal years. Below the maintenance IFR, the river would start to experience stress.

- It is the flow regime that should occur most of the time.
- It usually can be exceeded by natural flows that are higher than the IFR.
- It should facilitate the achievement and maintenance of the FDS.
- It should only be reduced to drought flows when in a natural drought situation.

Maintenance flows should not be adhered to rigidly year after year. Variability **upwards** (*i.e.* at higher flows than recommended) in wet years is vital. Usually such extra high flows are catered for naturally within the system by incremental inflows in the wet season (tributaries, dam spill, *etc.*), and may not need to be budgeted for. However, caution should be exercised in that the natural upwards adjustments in flows may get increasingly less over time.

4.1.2 Drought Flow

Drought flows should allow the continuing existence of species, but do not usually cater for recruitment. In terms of recruitment, most species will experience increased stress while some are advantaged. Drought flows are necessary for maintaining ecosystem diversity and resilience. Importantly, natural droughts are more extreme than dry years. In very disturbed systems, flows may be required under certain drought conditions, even if they are not occurring naturally. The drought IFR is considered insufficient to maintain the river in the FDS if it is supplied to the river outside of true drought conditions. It should not be used by planners for hydrological yield analysis of planned schemes.

Drought flows should occur:
- Rarely
- For short periods of time (possibly < 1 year)
- Coupled to a natural drought.

4.1.3 Capping Flow

These flows are a necessary part of the recommended IFR where future base-flows are likely to exceed natural base-flows on a continual basis, *e.g.* irrigation releases. They generally represent discharges that should not be exceeded during the dry season, when continuous high flow releases from a proposed dam are likely to exceed the natural base-flow of the river for an extended period of time and without natural variability in flow. Capping flows are routinely addressed for the maintenance IFR, but are generally not assessed for the drought IFR.

4.2 RECOMMENDATIONS AND MOTIVATIONS

4.2.1 IFR FOR SITE 3A

4.2.1.1 Objective

It was decided to select a site in Weenen Nature Reserve, near the border of the Reserve, due to the extensive irrigation areas further downstream. Diverse habitat at IFR Site 3A was provided by a riffle area, a secondary channel, good marginal vegetation and clear terraces.

The objective for Site 3A is to recommend flows that will:

- improve the habitat integrity, biodiversity and aesthetic value of the river by improving the riparian vegetation, aquatic invertebrates and water quality;
- maintain the fish populations and diversity and the geomorphological conditions in the

gorge and alluvial sections.

The flow of the Bushmans River is flashy, rather than steady, due to the shape of its catchment and the nature of the rainfall. Although the secondary channel at Site 3A was not formed recently, it may have formed during a major flood event and is therefore a temporary feature. It was therefore decided to maintain the main channel, rather than both, as this would determine the base-flow. The main channel is the better habitat, with greater diversity of habitats. There are boulders present in the main channel which can provide shelter and therefore the secondary channel is not necessarily needed. The water level in the main channel is 35cm higher than in the secondary channel.

4.2.1.2 Months Selected

The months selected as important months, for ecological and hydrological, reasons were:
February: the wettest month;
September: the driest month;
November: intermediate month.
Detailed motivated IFR flows were determined for these months and the flows were extrapolated to the remainder of the months.

The environmental factors considered for the selection of the months were components such as fish, aquatic invertebrates, habitat integrity, riparian vegetation and social issues. February and September are considered the harshest months, based on these environmental considerations: in September there are drought conditions and, in February, the water and air temperatures are high.

TABLE 3 shows the recommended Instream Flow Requirements for IFR site 3A.

4.2.1.3 Maintenance Flows

4.2.1.3.1 Low Flows

September: $0.7m^3.s^{-1}$

This flow provides sufficient current for patches of fast current, channel depth and width to support a satisfactory biodiversity and population sizes of invertebrates. At this flow rate, the reeds and grasses will still have water around the roots.

Why not lower?

Less flow would mean a loss of depth and current speed which is unacceptable for invertebrates. This flow rate was considered the best estimate: a flow of $0.5m^3.s^{-1}$ is close to the natural runoff, but this was considered too low and therefore the slightly higher flow was recommended.

February: $3m^3.s^{-1}$

The overriding component for this flow recommendation is the fish component. At this flow, the main channel is completely filled and although the water in the secondary channel is not flowing it can be flushed by spates. This recommended flow provides adequate depth for juvenile fish as well as for adult eels amongst the rocks. The adult fish will mostly be found in the pools. The reeds will also be inundated by water. There is no motivation to increase the flow above $3m^3.s^{-1}$.

November: $1.8m^3.s^{-1}$

Motivation for this flow rate was provided by riparian vegetation. At this flow, the water will reach into the marginal zone and encourage the recovery and growth of the marginal vegetation after the winter period. Increased photoperiod and temperatures will encourage rapid growth of marginal vegetation if sufficient water is available in the marginal vegetation zone. This flow will also stimulate fish to migrate and initiate breeding.

Why not lower?

A lower flow would lead to a restricted marginal zone which would provide inadequate cover for fish using this area for refuge when the water levels increase in December.

Remainder of the months:

The flows were extrapolated for the remaining months from the natural hydrograph.

4.2.1.3.2 Flood Flows

November: $12m^3.s^{-1}$

A flood of this magnitude, following a natural hydrograph and of 3 - 4 days duration, will reach into the base of the wet riparian zone and is important for the riparian vegetation. This flood will allow for recharge of the riparian zone after the winter period. Water will encourage the growth of vegetation in response to the increasing photoperiod and temperature and reduce the stress levels in the vegetation. This flow will flood the secondary channel, which provides sheltering habitat for fish when the flood recedes. The flood will also provide early summer spawning migration stimulus for scaly and catfish. A single flood event in November is not unusual.

Why not lower?

Recharge of the riparian zone is likely to begin from $9m^3.s^{-1}$ but a more general and uniform recharge is more likely to occur at higher flow levels. Lower flood levels will not achieve adequate recharge of the riparian zone as the recharge will be too localised.

October: $5m^3.s^{-1}$

This flow is recommended for water quality requirements and will flush the river over the 2 days of flood. The depth provided by this flow is also adequate for the fish and riparian vegetation components.

December: 10 & $20m^3.s^{-1}$
January: 10 & $30m^3.s^{-1}$
February: 10 & $60m^3.s^{-1}$
March: 10 & $20m^3.s^{-1}$

Multiple floods in this period will maintain some of the natural variability in the flow regime, which provides habitat diversity and allows frequent flows in the secondary channel and flushes out sediments.

The period December - March requires a major flood for geomorphological reasons, as a sediment transport function. A large event in February of $60m^3.s^{-1}$ will provide the desired scouring effect.

The riparian vegetation motivation is for a flood of $80m^3.s^{-1}$. A large flood should occur on average once a year as this extends the water into the wet riparian zone. This will result in the deposition of sediments and nutrients in this zone and encourage the germination of the seedbank and the associated extension and recovery of this zone. A significantly smaller flood would not deposit sediment in this area and may result in a restricted wet riparian zone and discontinuous fringe vegetation. However, when considering the natural hydrograph, a flood of this size appears to be ambitious. Therefore, a flood size of $60m^3.s^{-1}$ is recommended.

A flood of $60m^3.s^{-1}$, which approximates to bankfull, should occur once in the wet season (December - March). This represents the channel forming flood, which is necessary for sediment transport and clearing encroaching vegetation. Furthermore, this flood event is also necessary for preventing channel aggradation in the lower gradient reaches downstream of the gorge (up to the second gorge) as there are high sediment inputs from the southern tributaries.

Smaller floods of 10 - $30m^3.s^{-1}$ are effective for transport of finer sediment and removing silt and fine sand from between cobbles. Floods should not be smaller because good depth is required to initiate sediment transport on the protected channel bed. Lower flood levels will be insufficient to reach in-channel bench and lateral bars. The smaller floods, of $10m^3.s^{-1}$, will allow flushing flows in the secondary channel while the higher flows will reach into the riparian vegetation.

Why not lower?

Smaller floods are not recommended since loss of flow variability is already considerable at these recommendations.

4.2.1.4 Drought Flows

4.2.1.4.1 Low Flows

September: $0.4m^3.s^{-1}$

The recommended flow is the minimum lowest flow level as determined by water quality, invertebrates and fish requirements. The riffle area is limited but probably still sufficient to maintain small populations of fish and invertebrates. This flow will still provide some channel width and therefore habitat for the fish: adult fish will hide in pools and juvenile fish will be in the riffle area.

Why not lower?

Lower flow would result in great reduction in current width and speed which is unacceptable to fish populations. The same flow level was extrapolated to July and August.

February: $1.3m^3.s^{-1}$

The recommended flow is based on the need to wet the flattish area to the left of the deepest channel. The shallows created in this way will provide habitat for invertebrates, amphibian larvae and juvenile fish. The main channel is almost completely filled at this level and the minimum of habitat (0.5m deep) is still available for adult scaly and catfish, and there is adequate habitat for juveniles.

October: $0.5m^3.s^{-1}$
November: $0.8m^3.s^{-1}$

The flows recommended for these months are extrapolated rather then motivated as water quality needs to be considered: runoff contributions from agricultural areas include high nutrient levels as a result of increased return flow from increased irrigation due to rising temperatures. The flow of $0.8m^3.s^{-1}$ fills the base of the channel, although it does not cover the flat areas on the left bank, and provides depth and velocity for fish movement. Return flows from the downstream irrigated areas are likely to be nutrient-rich and could lead to algal blooms in the river: river bed flushing and removal of algal mats may take place at the recommended flow.

Remainder of the months:

The flows were extrapolated for the remaining months from the natural hydrograph.

4.2.1.4.2 Flood Flows

November: $5m^3.s^{-1}$

The fish and riparian vegetation components provide the motivation for the recommended flood level. At this level, the water enters and flows through the secondary channel. A flood of this size will flush out the accumulated algae and initiate fish migrations and early spawning. The water will inundate the marginal vegetation in the secondary channel and encourage its growth and extension on the right hand bank of the secondary channel.

Why not lower?

A smaller flood would not flow in the secondary channel (water starts flowing in this channel at $4.5m^3.s^{-1}$) and therefore the width of the marginal zone would be restricted.

December: $8m^3.s^{-1}$
January: $8m^3.s^{-1}$
February: $12m^3.s^{-1}$
March: $8m^3.s^{-1}$

Single and smaller flood events are recommended for this period. A flood of $20m^3.s^{-1}$ would inundate the marginal as well as riparian zone, although, based on the hydrological data, this flood is too high. A flood of $12m^3.s^{-1}$ is the minimum that will flood the marginal vegetation, but not the riparian zone, which needs it. Floods of $8m^3.s^{-1}$ will provide depth, even in the secondary channel, improve water quality and provide cues for spawning; below this level, there is no flow in the secondary channel which is an important nursery area for fish. There are no geomorphological motivations for flood sizes ranging from 8 - $12m^3.s^{-1}$.

4.2.1.5 Requirements for Capping Flows

Ecological Principle

Constant base-flows throughout the year will reduce habitat diversity through time and remove low-flow stresses from the system. This is likely to encourage the abundance of a few species at the expense of others (*e.g. Simulium chutteri* in the Vaal, Orange and Great Fish Rivers; carp in the Vaal River). There is uncertainty as to what the effects in the Thukela River would be.

There exists a capping flow of $1m^3.s^{-1}$ in the first 5km below the dam, which is then abstracted into the irrigation channel. This does not present a problem under the recommended flow regime. But the capping flow should not exceed $2m^3.s^{-1}$ in winter and should also not be a constant flow of $2m^3.s^{-1}$.

Recommendation

If future demands should increase the level of the capping flow, then the following reservation is put in: if there should be a constant flow of $2m^3.s^{-1}$ in winter, then the summer flows must be increased to maintain variability between seasonal flows.

TABLE 3: INSTREAM FLOW REQUIREMENTS FOR SITE 3A (BUSHMANS RIVER)

IFR BUILDING BLOCKS			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP			
CAPPING															VOL	MAR	MED
IFR for MAINTENANCE	LOW FLOW	flow	1	1.8	2.2	2.5	3	2.5	2.0	1.5	1.0	0.7	0.7	0.7		%	%
		depth	0.46	0.55	0.58	0.61	0.64	0.61	0.57	0.52	0.46	0.41	0.41	0.41	51.2	16.4	
		fdc%	97	95	92	90	96	98	99	87	82	91	99	87			
	FLOODS														29.1	9.3	
	1. Magnitude[a]		5	12	20, 10	30, 10	60, 10	20, 10	10								
	2. Depth		0.75	0.99	1.18, 0.93	1.36, 0.93	1.78, 0.93	1.18, 0.93	0.93								
	3. Duration		2	3	3, 3	3, 4	5, 3	3, 3	3						80.3	25.7	
	4. Return period		1	1	1, 1	1, 1	1, 1	1, 1	1								
	5. fdc %		38	34	12, 42	15, 46	6, 62	28, 60	31								
IFR for DROUGHT[b]	LOW FLOW	flow	0.5	0.8	1	1.2	1.3	1.2	0.9	0.7	0.5	0.4	0.4	0.4			
		depth	0.37	0.43	0.46	0.48	0.5	0.48	0.44	0.41	0.37	0.34	0.34	0.34	29.1	9.3	
		fdc%	100	100	100	100	100	100	100	100	100	100	100	100			
	FLOODS																
	1. Magnitude[a]			5	8	8	12	8							4.7	1.5	
	2. Depth			0.75	0.87	0.87	0.99	0.87									
	3. Duration			2	3	3	3	3							33.8	10.8	
	4. Return period			1	1	1	1	1									
	5. fdc %			69	58	60	58	75									

[a]. Magnitude refers to the flow at the flood peak.
fdc%: flow duration curve percentage;

[b]. NOT to be used in design calculations or without prior consultation with a river ecologist.
Discharges in m^3s^{-1}, flood duration expression in days, volumes in million m^3, depths in m.

4.2.2 MATCHING IFR SITE 3A WITH IFR SITE 3B

IFR Site 3B consisted of a bedrock rapid with upstream and downstream pools. Marginal vegetation was present but riparian vegetation was limited due to the recent floods and the steep sloping rocky river banks.

A Mean Annual Runoff (MAR) scaling factor of 0.9 (based on actual gauging weir data) was used to obtain flow recommendations for IFR site 3B from the values recommended for IFR site 3A. The proposed IFR Site 3B maintenance flows are shown in **TABLE 4**.

Hydraulically, the flow changes under low and high flow conditions are logical. Under low flows, there in an increase in width and depth from IFR site 3A to IFR site 3B, but under high flows there is a decrease in width and depth from IFR site 3A to IFR site 3B. Under high flows the channel becomes narrower and shallower. The velocity at IFR site 3B is consistently higher.

The flows at IFR site 3B, under low flow conditions, are considered acceptable and it was not considered necessary to revisit the low flows.

The overriding component for IFR site 3B is the fish component; the riparian vegetation is not likely to be affected. IFR sites 3A and 3B are very similar and problems are not expected at the recommended flow regime. More habitat, for fish, is provided at IFR site 3B than IFR site 3A and it was felt that if the fish component were satisfied, then it was not necessary to reconsider the flows.

TABLE 4: PROPOSED MAINTENANCE FLOWS FOR IFR SITE 3B FROM RECOMMENDED MAINTENANCE FLOWS FOR IFR SITE 3A

MONTH		HYD FAC	IFR3A		IFR3B		
			FLOW	parameter	FLOW	parameter	
						rapid	veg
OCT	low	0.9	1	d 0.46 w 18.9 v 0.16	1.1	d 0.54 w 23 v 0.18	0.83 16.3
	high		5	d 0.75 w 46.8 v 0.28	5.5	d 0.73 w 35.6 v 0.46	1.1 24.2
NOV	low		1.8	d 0.55 w 37 v 0.2	2	d 0.61 w 28.5 v 0.25	0.91 18.5
	high		12	d 0.99 w 52 v 0.41	13.3	d 0.9 w 44.4 v 0.71	1.35 30.6
DEC	low		2.2	d 0.58 w 39 v 0.21	2.5	d 0.63 w 30.6 v 0.29	0.95 19.5
	high		10 / 20	d 0.93/1.18 w 51/54 v 0.37	11 / 22.2	d 0.85/1.04 w 42/48.2 v 0.66/0.87	1.29/1.56 28.9/35.1
JAN	low		2.5	d 0.61 w 40	2.7	d 0.64 w 31	0.96 19.9
	high		10 / 30	d 0.93/1.36 w 51/56	11 / 33.3	d 0.85/1.2 w 42/50.6	1.29/1.77 28.9/41.2
FEB	low		3	d 0.64 w 42	3.3	d 0.66 w 33.5	0.99 21.2
	high		10 / 60	d 0.93/1.78 w 51/60	11 / 67	d 0.85/1.56 w 42/56.6	1.29/2.24 28.9/51.5
MAR	low		2.5	d 0.61 w 40	2.8	d 0.64 w 32.7	0.97 20.1
	high		10 / 20	d 0.93/1.18 w 51/54	11 / 22.2	d 0.85/1.2 w 42/50.6	1.29/1.77 28.9/41.2
APR	low		2	d 0.57 w 38	2.2	d 0.62 w 29.4	0.93 18.8
	high		10	d 0.93 w 51	11.1	d 0.85 w 42	1.29 28.9
MAY	low		1.5	d 0.52 w 34	1.6	d 0.59 w 27.1	0.88 17.6
JUN	low		1	d 0.46 w 18.9	1.1	d 0.54 w 23	0.83 16.3
JUL	low		0.7	d 0.41 w 25	0.77	d 0.48 w 20.3	0.72 14.5
AUG	low		0.7	d 0.41 w 25	0.77	d 0.48 w 20.3	0.72 14.5
SEP	low		0.7	d 0.41 w 25	0.77	d 0.48 w 20.3	0.72 14.5

where:
HYD FAC = MAR hydrological scaling factor;
low = maintenance flow ($m^3.s^{-1}$);
high = maintenance flood flow ($m^3.s^{-1}$);
d = average channel depth (m);
w = average channel width (m);
v = flow velocity ($m.s^{-1}$);
parameter rapid = the gorge cross-section at IFR site 3B (hydraulic cross-section 3B.1);
parameter veg = downstream of the gorge cross-section at IFR site 3B (hydraulic cross-section 3B.3).

4.2.3 IFR FOR SITE 2 (THUKELA RIVER)

4.2.3.1 Objective

IFR Site 2 consists of a pool/rapid-riffle/pool section, with some slack water areas and marginal vegetation. Riparian vegetation was disturbed due to floods and grazing. This site met the requirements specified by the fish and geomorphology specialists.

The objective for Site 2 is to recommend flows that will:

- improve the habitat integrity, biodiversity and aesthetic value of the river by improving the riparian vegetation, aquatic invertebrates and water quality;
- maintain the fish populations and diversity and the geomorphological conditions in the gorge and alluvial sections.

An important consideration for IFR site 2 is the maintenance of the macro channel. The presence of the secondary channel provides additional habitat, such as marginal vegetation.

4.2.3.2 Months Selected

The months selected as important months, for ecological and hydrological, reasons were:
February: the wettest month;
September: the driest month;
May and October/November: intermediate months.
Detailed motivated IFR flows were determined for these months and the flows were extrapolated to the remainder of the months.

The environmental factors considered for the selection of the months were components such as fish, aquatic invertebrates, habitat integrity, riparian vegetation and social issues. February and September are considered the harshest months, based on the environmental considerations: in September there are drought conditions and, in February, the water and air temperatures are high.

4.2.3.3 Maintenance Flows

TABLE 5 shows the recommended Instream Flow Requirements for IFR site 2.

4.2.3.3.1 Low Flows

September: $2m^3.s^{-1}$

This channel width will reach into the established clumps of grass/sedges which are found between the rocks and in the secondary channel. This flow will ensure sufficient flow velocity for the rheophilic insects and fish, even in the backwaters. This flow that provides adequate habitats for *Amphilius* (a riffle-dependent species) in the centre of the river bed where flow velocity is adequate for this species. The established clumps of marginal vegetation appear, from the extent of their root masses, to have existed for many years and are important refuge and feeding areas for fish: quiet backwaters provide sufficient shelter for juvenile minnows. It is therefore necessary to maintain a flow of water between these rocks to keep these clumps of grass alive. This flow provides stones-in-current, stones-out-of-current and pools with some fringing vegetation: the maintenance of this range of habitats is necessary for invertebrates. Adult fish will be restricted to remnant pools. The water quality will not be impaired at this low flow and there are no social impacts at this low flow.

Why not lower?

Maintenance of this condition was observed to occur at $2.2m^3.s^{-1}$ and below $2m^3.s^{-1}$ it is likely that this will no longer occur. Fish and aquatic invertebrates are the overriding components in September and a lower flow will not be tolerated because the *Amphilius* population may decline if the habitat becomes limited, which will happen if the flow is reduced to less than $2m^3.s^{-1}$. Similarly, a lower flow will result in a loss of invertebrate habitat and may also result in undesirable increases in water temperature. Lower flows will probably result in the elimination of important feeding and refuge areas.

Since the FDS for this site is category B, it is important to maintain a more conservative (higher) flow: insufficient information is available to adequately explain the consequences of reducing the flow below $2m^3.s^{-1}$.

February: $9m^3.s^{-1}$

Although February is considered to be an ecologically active (growth and reproduction) time for fish and riparian vegetation, the recommended flow is based on a hydrological motivation as the minimum flow ever experienced in February was $10m^3.s^{-1}$. However, further motivation for this flow rate is that a moderate flow and depth is achieved in the secondary channel, with wetting of the marginal vegetation. The flow achieved in the secondary channel will also result in sediment movement in this channel. This is considered important since the secondary channel is a habitat and refuge for fish fry and needs to flow strongly enough to provide this habitat and avoid build up of sediments which will encourage the encroachment of marginal vegetation and the subsequent loss of this channel. The channel is lined with marginal vegetation which requires water flowing through the channel. From a geomorphological aspect, the secondary channel should be maintained as base-flow channel rather than an event driven channel with some scour of fine sediments occurring continuously and minimising vegetation encroachment. This flow rate will provide good shelter for juvenile catfish and minnows after spawning in the flooded marginal vegetation in the secondary channel (the flood events are important for spawning, but flood events occur over and above the flow requirement).

Why not lower?

The flows cannot be lower than this, because flow would cease in the secondary channel, and siltation following flood events would favour vegetation encroachment. The secondary channel provides additional habitat and water only starts flowing at a rate higher than $7.4m^3.s^{-1}$; flowing water and not stagnant water is required in the secondary channel.

May: $5m^3.s^{-1}$

There are no strong overriding factors for May as this is considered an intermediate month. A natural hydrograph is recommended with receding base-flows and the flow is extrapolated from February and September. At this flow, sufficient shelter will be maintained for juvenile fish and therefore marginal vegetation is needed. However, fast flowing water is not required, not even in the secondary channel: fast flow is not crucial for fish.

November: $5m^3.s^{-1}$

This is the start of an ecologically important season and the quantity of available habitat is an issue: small fish require refuges in marginal vegetation while invertebrates require a range of habitats. A flow of $5m^3.s^{-1}$ allows some water into the secondary channel and the marginal habitats. This will increase the habitat diversity, prevent high water temperatures and increase the abundance of habitat for the early summer increase in activity. Less than $5m^3.s^{-1}$ does not provide sufficient marginal habitat. The marginal cobble beds will become partially inundated creating extensive quiet backwaters and margin, which provide adequate shelter for early-spawned juvenile fish. The motivation for the instream flow requirement for November has been extrapolated from the ecological requirements for previous months.

October: $3m^3.s^{-1}$

This flow is recommended because of an increase in ambient temperature and subsequent potential increase in water temperature, although typically the October base-flow is not increased on the September base-flow.

Remainder of the months:

Base-flows were extrapolated, from the months for which base-flows were estimated, to the remainder of the months, following a natural hydrograph,

4.2.3.3.2 Flood Flows

October: $13m^3.s^{-1}$

Since fish are the overriding component for the flood recommendation in October, a flood with sufficient depth to initiate fish spawning is recommended. This can be achieved with a flood of $13m^3.s^{-1}$. The 30cm rise in water level acts as a small spate to initiate fish spawning as well as some sediment activity. This initiates the first dispersal-migrations of adult fish to find spawning habitats. It will also flush out some of the accumulated fines, and flush out backwaters and pools, which will improve water quality. Lower flows would not activate adult fish, nor provide sufficient velocity to move sediments. A flood of this size is a wake-up flush rather than a large flood.

November: $20m^3.s^{-1}$

There is no motivation for more than 1 flood of this magnitude in this month although the flood duration is 4 days. The riparian vegetation is the overriding component for this flood and a flood of this level will allow the water to inundate the middle-to-high levels of the marginal vegetation zone. This will expand the distribution of this zone in the early part of the growth season and create conditions suitable for flowering and habitat creation for other organisms. A flood of smaller magnitude will not encourage the expansion of this zone and would therefore restrict the creation of suitable marginal habitat early in the summer season. Further motivation for this medium-sized flood is provided for fish requirements: rising water temperatures over the previous month or two will have resulted in maturation of fish gonads. This flood will stimulate major spawning migrations by scaly and mudfish. It will further result in inundation of large areas of cobble and boulder beds amongst which scaly and mudfish spawn.

February: $200m^3.s^{-1}$

The overriding components for a flood of this magnitude are geomorphological and riparian vegetation requirements. The duration of the flood should be 6 days: 2 days up and 4 days down. This flood is a channel forming discharge and a major sediment transport event necessary for scouring of pools and lateral channels. Accretion of lateral bars will take place during flood recession. This is a flow level sufficient to approach bankfull levels in the main channel. Furthermore, a flood this size will reach well into the wet riparian zone and encourage removal of debris, deposition of seeds, sediments and nutrients in this zone. It will encourage germination of the seedbank. These processes are responsible for spreading and perpetuating riparian species in the riparian zone. Deposition on the receding limb on the left hand bank will encourage the creation of substrate for colonization and stabilization of this area and extension of the riparian zone. Additional motivation is provided by fish requirements, in that all flood flows experienced during mid-summer will result in adult fish spawning.

Why not lower?

Although these levels are not exact, a smaller flood would lead to a restriction of the riparian zone and subsequent colonization by terrestrial species. A smaller flood will also provide insufficient sediment transport.

December: 30 & $60m^3.s^{-1}$
January: 30 & $70m^3.s^{-1}$
February: $50m^3.s^{-1}$ (in addition to the $200m^3.s^{-1}$ flood)
March: 50 & $30m^3.s^{-1}$
April: $30m^3.s^{-1}$

The duration of the floods is 4 days, with 1 day up and 3 days down, *i.e.* a natural hydrograph, to give in-channel freshes. According to available information, this river system is governed by variability, and therefore a variable flood flow regime is required. However, only 2 floods per month are recommended although a range of flood sizes is recommended to maintain some variability in the flow regime for a variety of ecological purposes. The flood variability will serve to maintain some of the natural habitat variability, which is essential to prevent dominance by individual species, and also to provide changing habitats over time to maintain biodiversity. Floods of this magnitude will result in inundation of lateral bars and will allow scouring of the lateral channels and pools and accretion of the lateral bars; *i.e.* floods of this magnitude allow for channel construction processes. The floods should have a slow receding limb to encourage deposition of sediments for the maintenance and creation of marginal habitat for establishment of marginal and riparian vegetation. These floods will allow water to inundate the wet riparian zone (right-hand bank) and the potential wet riparian zone (left-hand bank): this will bring about a recharge of these zones by providing water for growth, transpiration and flowering of the riparian vegetation. All floods experienced

during mid-summer will cause adult fish to spawn.
The flow of $30m^3.s^{-1}$ recommended for April is not considered a large flood, but merely an elevated base-flow.
Why not lower?
Insufficient depth will be provided to reach the lateral bars. Smaller floods will not achieve the same effect as there will be insufficient inundation into the wet riparian zone and absence of recharge in the riparian zone will lead to stress and death of wet riparian species and encourage invasion by dry terrestrial species such as *Acacia* species. Furthermore, the recommended flood regime still only provides approximately 20% of the natural flood variability in the system.

4.2.3.4 Drought Flows

4.2.3.4.1 Low Flows

September: $1m^3.s^{-1}$

Aquatic invertebrates are the overriding component since they are affected by low flows. The recommended flow is the perceived required minimum depth, current speed and channel width or perimeter for aquatic invertebrates as well as fish. At this flow, there will be some water in the backwater channel although it will be stagnant, and there will be some flow in remnant riffles. This is the minimum acceptable flow for survival of *Amphilius,* which is a riffle-dependent species. Other fish species will survive in pools. The recommended flow ensures that water will keep flowing down the river, although trickling between stones in some sections. Water quality will become a problem when the first rains come down and wash deposits off the land. Human health issues, which are associated with a deteriorating water quality, become a problem. Poor water quality can lead to algae growing on rocks.
Why not lower?
Water quality concerns make flows of $<1m^3.s^{-1}$ unacceptable in all low flow months, for ecological and human health considerations. Furthermore, a lower flow means that the riffle habitat becomes too restricted as there is an exponential loss of channel width and depth. **The low flow of $1m^3.s^{-1}$ should be seen as the absolute worst condition and should not become a norm.** These motivations and low flows also apply for July and August.

February: $4m^3.s^{-1}$

Fish are the overriding component and important issues to consider are depth of water, water temperature and riffle requirements. This flow provides the minimum acceptable riffle area for *Amphilius* and reasonable pool areas for all other fish species. At this flow, water is available to the persistent clumps of grasses which are located between the rocks in the area between the backwater and main channels, for growth and temperature control for maintenance of these grasses.
Why not lower?
Lower flows are not recommended because no water flow between the rocks would lead to the grass clumps drying out and dying. This is an important habitat during normal years and therefore these should be maintained as best as possible. Furthermore, water

quality may also become an issue, during the hot months.

October: $1.3m^3.s^{-1}$

The recommended flow will provide some flow in the main channel. This is a slight increase from the September flow, because water and ambient temperatures are increasing with subsequent water quality and associated human health problems. If the level were to drop below this level, water quality problems would become critical. Increased algal growth could also become a significant problem. However, water quality is the main issue, mainly because of the associated increase in water temperature. Water quality problems should not be solved using dilution, but should be controlled at the source, although this is difficult as the pollution is diffuse. Although fish are not significant components for the recommended flow, temperature increases activate their gonads and they will also be affected by water quality and temperature.

November: $2m^3.s^{-1}$

This is the beginning of the growth season, responding to increasing temperatures and photoperiod, and the riparian vegetation is the overriding component. At this flow, water is available to areas of the marginal vegetation at the start of the season and will activate growth and encourage extension of this important habitat.

Why not lower?

A lower flow will lead to a depauperate marginal vegetation zone and subsequent shortage of refuge habitat for fish and amphibians when the larger summer flows occur in December and January. Water quality is still an important issue, and hence a lower flow cannot be recommended.

Remainder of the months:

The flows are extrapolated to the remainder of the months following a natural hydrograph. Lower flows are recommended for July, August and September, so that extra water will be available in October and November, to deal with the water quality issues.

4.2.3.4.2 Flood Flows

November: $20m^3.s^{-1}$
December: $30m^3.s^{-1}$
January: $30m^3.s^{-1}$
February: $100m^3.s^{-1}$
March: $30m^3.s^{-1}$
April: $30m^3.s^{-1}$

Freshers are important in drought years, to flush out water quality problems, remove algal mats, scour out channels, extend the marginal vegetation as well as maintain it. The ecosystem should be considered as a whole rather than considering the individual components, and as a result, the floods during drought years need to be larger than $30m^3.s^{-1}$. Although the floods are smaller and less frequent (but of the same duration) than during maintenance years, the same motivations as for maintenance floods apply: an increase in flow variability is required. Floods during drought years serve the same purpose as those during the maintenance years except the frequency is reduced and the floods start later in the season.

Floods of $30m^3.s^{-1}$ will inundate the marginal vegetation while the flood of $100m^3.s^{-1}$ will allow good inundation of the lateral cobble bars. The smaller floods will scour the fines from the lateral channels and a flood of $100m^3.s^{-1}$ will allow significant sediment transport, and some scour of pools is possible. However, the effect of the flows (*i.e.* scour versus deposition) will depend on the sediment load of the incoming water and therefore on its source.

The range and sequence of spates will permit fairly normal spawning migrations and breeding success by scaly mudfish, catfish and minnow species during drought years. The timing and extent of water-level fluctuation are more significant than flow level attained. A flood of $100m^3.s^{-1}$ covers the marginal vegetation and inundates the base of the wet riparian zone. Although this does not wet and encourage germination of the seedbank and remove debris as with maintenance years, it will provide adequate water for recharge of this zone and facilitate relief of water stress and allow growth of riparian vegetation.

The river is unique in that it appears to be well-buffered against droughts, but this may be due to its size. Even during worst droughts on record, there are numerous high flow events indicating that the Thukela is a large river, well-buffered against droughts and with less variation between wet and dry years than small rivers. Lower flows would not be as large as normal base-flows in the natural river.

4.2.3.5 Requirements for Capping Flows

It is important to consider flow variability when considering capping flows.

The predicted irrigation requirements at IFR site 2 are for constant flows of 8 - 12 $m^3.s^{-1}$ down to Middeldrift.

There are two concerns surrounding the capping flows and these are both social and ecological. The first is that of the levels of requirements for the capping flows. Elevated flows may mean that crossing the river becomes a year long problem and not only for brief periods during floods. The second concern is the ecological response to a constant base-flow when the flow variability is removed and some species become dominant species as a result of this. This can be seen at IFR site 1, which is a different channel shape but has had a constant base-flow and it is obvious from the nature of the riparian vegetation that this has happened. There also exists the possibility that a new habitat may arise, such as *Potamogeton*, which may increase biodiversity, but is not desirable.

To maintain the same base-flow in all seasons is ecologically detrimental. Therefore, in order to maintain seasonality, the minimum summer requirement should be double the winter requirement. The predicted flow requirements at IFR site 2 is $10m^3.s^{-1}$ to supply downstream users: but this winter requirement is high and will have serious ecological consequences. It will prejudice species that do well under low flows and encourage other species, particularly pest species because conditions become optimum for them and they out compete other species. The river is resilient, because of the shape of the channel, and the habitat diversity may be pushed further out due to widening of the channel. This may, or may not, circumvent the problem.

If this minimum elevated level of $10m^3.s^{-1}$ is maintained, the ecological requirement is that the flow be reduced to zero for a month in winter, but this may not be feasible because of the abstraction requirements.

Recommendation

Therefore, it is recommended that if the winter base-flow is increased and maintained for extended periods, that the summer baseflow, as a rule, should be double. The consequences of an elevated less variable flow will change the nature of the river which may have severe consequences for the ecology of the river.

Base-flows in summer months should peak to at least double base-flows in winter (*e.g.* if base-flows in June-September are maintained at $10m^3.s^{-1}$, then base-flows in February should be $20m^3.s^{-1}$. If possible, some periods of lower flows (down to $2m^3.s^{-1}$) should be maintained in winter, to aid the stress effects of low flows.

Furthermore, if the capping flows are introduced, the floods will need to be adjusted upwards.

TABLE 5: INSTREAM FLOW REQUIREMENTS FOR SITE 2 (THUKELA RIVER)

IFR BUILDING BLOCKS			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP			
CAPPING															VOL	MAR	MED
IFR for MAINTENANCE	LOW FLOW	flow	3	5	7	8	9	8	7	5	3.5	2.5	2	2		%	%
		depth	0.80	0.91	0.98	1.01	1.04	1.01	0.98	0.91	0.84	0.76	0.71	0.71	162	11	
		fdc%	72	95	98	99	100	100	100	97	93	94	87	89			
	FLOODS																
	1. Magnitude[a]		13	20	30, 60	30, 70	200, 50	50, 30	30						149	10	
	2. Depth		1.14	1.28	1.44, 1.79	1.44, 1.89	2.72, 1.69	1.69, 1.44	1.44								
	3. Duration		4	4	4, 5	4, 5	10, 5	5, 4	4								
	4. Return period		1	1	1	1	1	1	1						311	21	
	5. fdc %		29	60	66, 35	79, 44	20, 75	60, 78	65								
IFR for DROUGHT[b]	LOW FLOW	flow	1.3	2	3	3.5	4	3.5	3	2.0	1.5	1	1	1			
		depth	0.62	0.71	0.80	0.84	0.87	0.84	0.80	0.71	0.65	0.57	0.57	0.57	70	4.6	
		fdc%	99	99	99	100	100	100	100	100	100	100	100	100			
	FLOODS																
	1. Magnitude[a]			20	30	30	100	30	30								
	2. Depth			1.28	1.44	1.44	2.13	1.44	1.44								
	3. Duration			4	4	4	7	4	4								
	4. Return period			1	1	1	1	1	1								
	5. fdc %			60	66	79	47	78	65								

[a]. Magnitude refers to the flow at the flood peak. **[b]. NOT to be used in design calculations or without prior consultation with a river ecologist.**
fdc%: flow duration curve percentage; Discharges in m^3s^{-1}; flood duration expression in days; volumes in million m^3; depths in m.

4.2.4 MATCHING IFR SITE 5

The purpose of matching the flows at IFR site 5 was to check the flows that would be achieved at IFR site 5 because the hydraulics for a previous IFR workshop (1995) were faulty (DWAF, 1997). As a result, the recommendations and motivations for IFR site 5 needed to be revisited. In the 1995 workshop, the flow was motivated on the basis of depth, following requirements for fish. Factors which also need to be considered at this site are water quality and social factors.

The objective for IFR site 5 is to recommend flows that will:

- maintain the potential for the riparian habitat integrity and to improve the instream habitat integrity;
- ensure the sustainability of a healthy riverine ecosystem to produce resources for local users;
- improve water quality.

The flow regime at IFR Site 5 was obtained by adding the recommended IFR flows from IFR Site 2, IFR Site 3B (which is extrapolated from IFR site 3A) and runoff from the Sundays River (which is the MAR at the gauging weir and the MAR at the confluence factored by a scaling factor of 2.5: the maintenance low flows were calculated using the 75 percentile values and the drought low flows were calculated using the 90 percentile values). The flood flows were extrapolated from IFR Site 2.

TABLE 6 shows the recommended IFR flows obtained from the above calculations for IFR Site 5.

TABLE 7 shows the comparison between the values obtained in the 1995 workshop with those obtained in this workshop.

4.2.4.1 Maintenance Flows

4.2.4.1.1 Low Flows

The channel depth obtained in the refined IFR are the same as was recommended and motivated for in the 1995 IFR workshop. The instream flow requirement for IFR site 5 cannot be decreased as the IFR for Site 2 is more sensitive than IFR Site 5; the flow at IFR site 5 is dependant on the flow from both IFR Sites 2 and 3A. The recommended flows are lower than the natural flow, with the percentage occurrence (fdc%) ranging from 82 - 99%. The IFR flow that was obtained for IFR Site 5 was deemed suitable by the specialists and further refinement or motivations were not necessary.

4.2.4.1.2 Flood Flows

The motivations for the maintenance flood levels at this site are largely the same as those for IFR2.

February: $200m^3.s^{-1}$

A flood of this size with a duration of 15 days, and a sharp increase and a long tailing off period, will extend approximately half way up the cobble slope will give a resultant channel width of 95m. Although there is low confidence in the level, since there are no clear breaks (in the channel) indicating bankfull, this will be a channel forming flood and there will be sediment transport. A lower flood level will have insufficient sediment transport and would encourage channel encroachment and a resultant change in channel morphology.

December: 30 & $70m^3.s^{-1}$
January: 30 & $80m^3.s^{-1}$
February: $60m^3.s^{-1}$
March: 30 & $60m^3.s^{-1}$

The larger floods will extend over the lower cobble zone. The hydrograph shape is a rapid rise with a long tailing-off period. Floods of this size aid the build up of deposition and aid in building up of the channel: re-working of sediment over the cobble zone and maintenance of the bed of the active channel will take place. It is expected that there will also be local scour and deposition at floods of this magnitude. Floods of lower magnitude would not achieve sufficient depths and velocities over the cobble zone. The range of flood sizes results in variability, which is necessary for ecological purposes.
The smaller flood will inundate the riparian vegetation.

November: $20m^3.s^{-1}$

A flood this size acts as a wake-up call for riparian vegetation.

October: $15m^3.s^{-1}$

A flood this size acts as a wake-up call for fish.

4.2.4.2 Drought Flows

These levels are the same as those recommended for IFR site 2, and are motivated for by the same reasoning. Of particular importance is the promotion of variability in the system.

4.2.4.3 Requirements for Capping Flows

The same ecological reasoning for the capping flows as for IFR site 2.

TABLE 6: INSTREAM FLOW REQUIREMENTS FOR SITE 5 (THUKELA RIVER)

IFR BUILDING BLOCKS			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP			
CAPPING															VOL	MAR	MED
IFR for MAINTENANCE	LOW FLOW	flow	4.3	7.7	10.7	12.8	15.3	13.0	10.2	7.3	5.0	3.6	3.1	3.0		%	%
		depth	0.77	1	1.01	1.06	1.11	1.06	1.0	0.93	0.81	0.72	0.68	0.68	250.9	11.9	
		fdc%	84	93	99	98	99	99	95	92	90	82	89	93			
	FLOODS																
	1. Magnitude[a]		15	20	30, 70	30, 80	60, 200	30, 60	30								
	2. Depth		1.1	1.2	1.3, 1.72	1.3, 1.8	1.64, 2,48	1.3, 1.64	1.3								
	3. Duration		4	4	4, 6	4, 7	6, 15	4, 6	4								
	4. Return period		1	1	1	1	1	1	1								
	5. fdc %		54	87	92, 59	92, 60	84, 26	72	72								
IFR for DROUGHT[b]	LOW FLOW	flow	1.9	3.1	4.6	5.6	6.4	5.6	4.4	2.8	2.0	1.4	1.4	1.4			
		depth	0.57	0.68	0.79	0.85	0.89	0.85	0.78	0.66	0.58	0.51	0.51	0.51	106.1	5.0	
		fdc%	92	95	100	99	100	100	99	98	99	99	98	97			
	FLOODS																
	1. Magnitude[a]			20	30	30	100	30	30								
	2. Depth			1.2	1.3	1.3	1.94	1.3	1.3								
	3. Duration			4	4	4	7	4	4								
	4. Return period			1	1	1	1	1	1								
	5. fdc %			87	92	92	56	96	72								

[a]. Magnitude refers to the flow at the flood peak. **[b]. NOT to be used in design calculations or without prior consultation with a river ecologist.**

fdc%: flow duration curve percentage; Discharges in m^3s^{-1}; flood duration expression in days; volumes in million m^3; depths in m.

TABLE 7: COMPARISONS OF 95 IFR AND REFINED IFR: IFR Site 5 (THUKELA FERRY)

IFR BUILDING BLOCKS				OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	%
IFR for MAINTENANCE	LOW FLOW	95 IFR	f (d)	12 (0.7)	15 (0.75)	18 (0.8)	20 (0.83)	20 (0.83)	18 (0.8)	15 (0.75)	10 (0.68)	8 (0.64)	6 (0.6)	8 (0.64)	10 (0.68)	420	20
		REF IFR	f (d)	4.3 (0.77)	7.7 (1)	10.7 (1.01)	12.8 (1.06)	15.3 (1.11)	13.0 (1.06)	10.2 (1.0)	7.3 (0.93)	5.0 (0.81)	3.6 (0.72)	3.1 (0.68)	3.0 (0.68)	250.9	11.9
	FLOOD	95 IFR	f (d)	30 (0.9) 3	50 (1.3) 3	100 (1.8) 7	100 (1.8) 7	300 (2.4) 7	100 (1.8) 7	50 (1.3) 5							
		REF IFR	f (d)	15 (1.1)	20 (1.2)	30, 70 (1.3, 1.72)	30, 80 (1.3, 1.8)	60, 200 (1.64, 2.48)	30, 60 (1.3, 1.64)	30 (1.3)							
IFR for DROUGHT	LOW FLOW	95 IR	f (d)	6 (0.6)	10 (0.68)	10 (0.68)	13 (0.71)	13 (0.71)	10 (0.68)	6 (0.6)	4 (0.5)	3 (0.4)	2 (0.3)	3 (0.4)	4 (0.5)		
		REF IFR	f (d)	1.9 (0.57)	3.1 (0.68)	4.6 (0.79)	5.6 (0.85)	6.4 (0.89)	5.6 (0.85)	4.4 (0.78)	2.8 (0.66)	2.0 (0.58)	1.4 (0.51)	1.4 (0.51)	1.4 (0.51)	106.1	5.0
	FLOOD	95 IFR	f (d)	20 (0.8)	20 (0.8)	20 (0.8)	20 (0.8)	50 (1.3)	20 (0.8)								
		REF IFR	f (d)		20 (1.2)	30 (1.3)	30 (1.3)	100 (1.94)	30 (1.3)	30 (1.3)							

f: recommended flow velocity ($m^3.s^{-1}$)
(d): average depth across channel (m)

5. CONFIDENCE IN THE RESULTS OBTAINED

The confidence in the results is determined to indicate whether any further work must be undertaken prior to using the IFR results for the next phases and for the determination of available yield of the proposed schemes. The method used was that each specialist compiled a descriptive value of their confidence in both supplying the IFR as well as the motivations used for the low and high flows.

5.1 COMMENTS FROM THE ECOLOGISTS

Confidence in the results obtained, from each of the specialists, is indicated in **TABLE 8**.

It was felt that there was low confidence in the IFR Site 3B maintenance low flow for riparian vegetation, because there is no vegetation at this site to indicate whether the flow is suitable. Low to medium confidence was expressed for the results for the flood flow for IFR Site 5, because there are no clear morphological breaks, and the channel may be a modified channel and not in equilibrium. The medium confidence expressed for the aquatic invertebrates was on account of Simuliidae. The low to medium confidence in the flows for water quality were on account of the lack of nutrient availability and oxygen demand.

Participants of the workshop were confident in the results generated, particularly because the hydraulic data were good. Hydraulics are the key link between ecology and geomorphology and the consequences of not doing the hydraulic analysis thoroughly are expensive. The hydraulic data takes a lot of time to prepare but is important because it affects the confidence in the results achievable. There is an indispensable minimum requirement for the hydraulic analysis and that which was done here was the absolute minimum. The hydraulic surveys are essential to get the work done properly: in this case, there were 4 visits. However, more data is required to improve confidence in the data, by obtaining more points, especially for the low flow. The hydraulic information and calibration reflects the calibrations and observations in the field. If during the limited site visits (due to time and cost constraints) a range of high flows are not encountered, the confidence will be influenced.

More background information on floods is required for future IFR studies, as the current flood hydrology data is insufficient. This will significantly improve confidence in the information available. An example is a flood frequency curve, showing the frequency of events rather than the % excedence value. It may also be better to represent this data seasonally, rather than on a monthly basis.

5.2 COMMENTS FROM THE ENGINEERS

The overall confidence in the process and results obtained was expressed as medium to high, particularly since the process was more refined than previous IFR assessments. The specialist knowledge of the sites and flow depths required was good, and resulted in a discussion and check-and-balance approach, although it was felt that the process was subjective. This may be improved by introducing a process of peer review and more experience being gained by workshop participants.

The hydraulic variability at IFR site 2 was reasonably well understood and this led to medium confidence in the low flow results. However, it was felt that the hydraulics of the secondary channel, which had a significant influence on the IFR, were unconvincing. There was less confidence in the high flow regime, because the flood regime was not sufficiently documented to support the geomorphological motivations. The results of IFR site 2 were extrapolated to IFR site 5, and as a result, there was also medium confidence in the results obtained for IFR site 5. Confidence in the low flow results obtained for IFR site 3A are medium to high, because the hydraulics and habitat distribution were well understood. However, it was felt that the results obtained for the higher flows were not well substantiated particularly when the upstream reach was considered. The confidence in the results obtained for IFR site 3B are low-medium, since these were extrapolated from IFR site 3A. The mechanics of the river at IFR site 3B are better understood than at IFR site 3A and therefore it was preferable to have used IFR site 3B.

In general, for each of the sites, the higher flows are critically important and it was felt that these were given very little attention to improve understanding.

TABLE 8: CONFIDENCE IN THE INSTREAM FLOW REQUIREMENTS

IFR SITES		IFR COMPONENT				
		FISH	RIPARIAN VEGETATION	FLUVIAL GEOMORPHOLOGY	AQUATIC INVERTEBRATES	WATER QUALITY
2	LOW	M-H	M		M-H	L-M
	HIGH	H	M-H	M-H	M-H	L-M
3A	LOW	H	M-H		M-H	L-M
	HIGH	H	H	M-H	M-H	L-M
3B	LOW	H	L		M-H	L-M
	HIGH	H	L-M	M	M-H	L-M
5	LOW	M	M-H		M-H	L-M
	HIGH	M-H	M-H	L-M	M-H	L-M

LOW: maintenance low flows;
HIGH: maintenance flood flows;
CONFIDENCE LEVEL:

N = none;
L = low;
L-M = low-medium;
M = medium;
M-H = medium-high;
H = high.

6. FURTHER WORK AND STATEMENTS

1. The next step is the IFR modelling (initiated at the workshop; see section entitled **Hydrological modelling**) followed by evaluation of the model and the flow regime generated. After this, the process is dependent on the engineering evaluation: an assessment of the capacity of the dams to meet the IFR requirements.

2. The monitoring protocol needs to be determined, before the white paper is produced (2 - 2.5 years). The monitoring process needs to be started within the next 6 months: the baseline studies should start when the project is approved, and further monitoring should take place when the project starts.

3. The IFR is based on the Future Desired State of the river as determined by the IFR specialists which includes a social scientist representing the requirements of affected persons dependent on a healthy river ecosystem. The process of presenting the IFR results with implications of providing and not providing the IFR to the public to determine a final accepted state for the river is not well established. However, this will have to be done and as a starting point, the process used for the Berg River IFR can be used as a basis.

4. The report should be sent to an independent reviewer, such as Brian Allanson, Rob Hart, Arthur Harrison, Chris Appleton *etc.* for independent review. However, the Terms of Reference letters need to be written carefully, such that the reviewers judge the process and the motivations rather than the actual numbers.

7. HYDROLOGICAL MODELLING

7.1 BACKGROUND TO THE MODEL

It is important to recognise that the model described and used is still under development.

Instream Flow Requirements should reflect natural flows and these natural flows are triggered by natural rainfall events. Therefore, a time series data set of climatic triggers is needed, such as those provided by gauging weirs. However, there are many sites selected for IFRs where daily flow measurements are not present. Therefore flows at a gauged reference site, which reflects the natural flow at the IFR site, or simulated flows are used: the reference site flows should be unaffected by abstractions and should be stationary or made stationary. The reference flow data are used to produce flow duration curves which are used by the model in association with operating rules to define the release triggers.

Inverse percentage points on the flow duration curves are smoothed with a moving average function (the length of this moving average can vary according to user requirements) to give a low flow status of the river. The moving average is a mean through the minimum flow values, and separates out the base-flows. The length of the running mean should be part of the operating rule (specifically for the Thukela, as it smooths the erratic nature of the Thukela; it may be necessary to have different lengths of moving average depending on whether the system is going into or coming out of a drought, *i.e.* have a longer moving average to prevent the system from going in to drought maintenance and a shorter moving average when the system is coming out of a drought so that normal IFR flows can be substituted for the drought IFR as soon as possible).

This low flow status curve is used to compare with the operating rules of the system and is used to trigger flow events, *i.e.* it will determine whether the river should be operated under maintenance or drought flow.

The **Operating Flow Rules** (low flows/base-flows) are the % points on the flow duration curve at which the operating rules change, *i.e.* the % at which either the Drought, Maintenance or Capping flows are introduced. These flow rules are determined at an IFR workshop in an interactive process (see section "CALIBRATION OF THE MODEL"), on a river-by-river basis. The principle of the model is that if the low flow status drops below the maintenance low flow level (determined at the IFR workshop), then the drought operating rules (low flow levels) are introduced and *vice versa*. The operating (flow) rules determine the fluctuations between the flow levels and are the levels between the drought and maintenance low flows.

Instream Flow Requirements are set as a result of the changed hydrograph from the natural flow due to upstream dams and abstractions. The recommended flow regime is set at IFR workshops and operating rules are required to manage the rivers at this recommended flow regime. These operating rules determine the frequency with which releases for either maintenance or drought flows are required.

The difference between the drought and maintenance operating rules determines how frequently the flow will be allowed to drop into drought flow. If there is a large difference, it will happen often, but if there is a small difference, drought flows will occur less frequently. Seldom will the operating rule for drought be maintained for the whole year although this depends on whether the river has extended dry periods (although this is not necessarily the case for the Thukela, because it appears to recover from droughts rapidly).

The **Flood Operating Rules** are more complex than the maintenance flow requirements and need further refinement for the model. Simple guiding rules are recommended.

It is important to be able to recognise that natural flood events are happening (or are about to happen; this is so that these flood flows can be topped up in order to achieve the recommended IFR flood sizes). Therefore it is important to set criteria (flood operating rules) so that events can be recognized, in other words, at what point is a flow considered a flood event. If the criteria are set too low, small events can become major events which may lead to false triggers (this is especially disastrous for ecological requirements, *e.g.* fish spawning events). Criteria defining events can be governed by *e.g.* flood duration, rate of rise and peak flow.

7.2 CALIBRATION OF THE MODEL

The purpose of calibration session at the workshop was to set simple operating rules for the

Thukela River (at the selected IFR sites) which can then be used by the engineers to model the flow requirement and set sizes of dams so that the recommended IFR flow regime can be achieved. The final operating rules and volumes are to be submitted to Bob Pullen, for engineering considerations.

7.2.1 Operating Flow Rules

Drought flows were used to calibrate the model (*i.e.* these flows were used to check the operating rules set for the model): drought flows are the worst conditions in any month, but should not be allowed to persist for a year. The capping flow percentage was set at a constant 2% above the maintenance flow, although this can be changed and should also be considered in the operating rules.

Various operating rules lead to changes in the flow variability: some of the variability includes occasional months where the system operates at drought levels, although this is not considered ecologically disastrous, provided that this does not happen in the same month every year. Furthermore, dropping the levels to drought operating levels too frequently is considered ecologically undesirable, since the maintenance levels selected are considered the absolute minimum that the system can operate at without considering that it is operating at drought levels.

7.2.2 Flood Operating Rules

The model is not yet able to cope with 2 floods in a month. Therefore, in those months where 2 floods were recommended, the flood volumes were added and 2 x the base-flows subtracted to obtain the final flood requirements. The operating rules for flood requirements can change on a monthly basis. The calibration only recognizes the maintenance flood events *i.e.* if there is no event, there will not be an artificial flood event. The large flood was moved to anywhere between December and February. The % point controls whether it is a drought or normal flood release. (if the rate of rise criteria is too low, a flood event may be triggered by too small an event).

7.3 IFR2

Gauging weir V1H001 (at Colenso) data was used as the reference weir for IFR2: the “Patching” model was applied to generate a time series for the period 1951-1971 (Spioenkop Dam was completed in 1971), which was then used to generate the operating rules for IFR2. The operating rules for Maintenance, Drought, Capping and Flood flows and the rate of rise criteria are listed in **TABLE 9**.

7.4 IFR3

Data from gauging weir V7H072 was used as reference data: the “Patching” model was applied to generate a time series for the period 1964-1994, which was then used to generate the operating rules for IFR3. The operating rules for Maintenance, Drought, Capping and Flood flows and the rate of rise criteria are listed in **TABLE 10**.

Since the data that was used to derive the operating rules for IFR3 were from a period which was drier (1964-1994) than the data for IFR2 and IFR5 (1951-1971), the operating rules for IFR3 are very different from IFR sites 2 and 5. In future models, the data period used should be consistent, and similar operating rules for different IFR sites may well emerge.

7.5 IFR5

Gauging weir V6H002 data was used as the reference weir for IFR5: the "Patching" model was applied to generate a time series for the period 1951-1971, which was then used to generate the operating rules for IFR5. The operating rules for Maintenance, Drought, Capping and Flood flows and the rate of rise criteria are listed in **TABLE 11**.

TABLE 9: SUMMARISED MONTHLY MODELLED FLOWS FOR IFR2

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Total Release Volume		8.5	13.2	19.4	23.4	24.4	23.3	18.3	14.0	9.9	7.1	5.6	5.5	172.6
Maintenance Release	Vol	7.4	12.0	18.7	23.0	23.4	22.3	17.1	13.4	9.7	6.72	5.28	5.16	165.9
	fdc%	80	83	92	96	93	92	88	93	94	92	89	90	
Drought Release	Vol	0.2	0.44	0.33	0.19	0.0	0.16	0.21	0.1	0.15	0.03	0.15	0.05	1.9
	fdc%	5	8	4	1	0	1	2	1	3	1	5	0	
Releases between maintenance and drought	Vol	0.84	0.88	0.44	0.21	1.04	0.83	1.0	0.43	0.07	0.32	0.17	0.35	6.56
	fdc%	14	8	3	1	6	5	9	4	1	6	4	8	
Flood Release	Vol	1.12	2.75	13.2	15.0	55.8	12.5	4.4	0.0	0.0	0.0	0.0	0.0	104.7
	days	7	12	14	15	31	14	13	0	0	0	0	0	
Operating Rules (%)	Maintenance	86	86	85	85	85	85	85	85	85	85	85	85	
	Drought	92	92	90	89	89	89	89	89	89	89	89	90	
	Capping	84	84	83	83	83	83	83	83	83	83	83	83	
	Flood	20	20	20	20	20	20	20	20	20	20	20	20	
	Flow	10	10	10	15	25	15	10	-	-	-	-	-	

Vol = volume ($10^6 m^3$)
fdc% = flow duration curve percentage
Flow = rate of rise criteria ($m^3.s^{-1}.day^{-1}$)

TABLE 10: SUMMARISED MONTHLY MODELLED FLOWS FOR IFR3

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Total Release Volume		2.68	5.01	6.85	7.03	7.66	7.16	5.25	4.13	2.57	1.88	1.82	1.79	53.8
Maintenance Release	Vol	2.41	4.78	6.47	6.36	7.33	6.53	4.8	3.61	2.26	1.67	1.61	1.6	49.4
	fdc%	84	90	90	84	90	84	84	80	81	83	83	85	
Drought Release	Vol	0.1	0.15	0.12	0.2	0.31	0.29	0.25	0.17	0.14	0.1	0.08	0.06	2.0
	fdc%	6	7	4	6	9	8	10	8	10	9	7	5	
Releases between maintenance and drought	Vol	0.18	0.08	0.26	0.47	0.02	0.34	0.2	0.35	0.18	0.1	0.12	0.13	2.42
	fdc%	8	2	5	9	0	6	5	11	8	6	8	9	
Flood Release	Vol	0.31	1.48	2.75	5.22	8.65	2.76	0.24	0.0	0.0	0.0	0.0	0.0	21.4
	days	2	8	6	10	12	6	1	0	0	0	0	0	
Operating Rules (%)	Maintenance	90	90	90	90	90	90	90	90	90	90	90	90	
	Drought	95	95	95	95	95	95	95	95	95	95	95	95	
	Capping	88	88	88	88	88	88	88	88	88	88	88	88	
	Flood	20	20	20	20	20	20	20	20	20	20	20	20	
	Flow	5	5	5	5	5	5	5	5	5	5	5	5	

Vol = volume ($10^6 m^3$)
fdc% = flow duration curve percentage
Flow = rate of rise criteria ($m^3.s^{-1}.day^{-1}$)

TABLE 11: SUMMARISED MONTHLY MODELLED FLOWS FOR IFR5

		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT
Total Release Volume		12.0	21.8	30.3	36.5	38.4	36.5	27.8	20.6	13.6	9.86	8.39	8.13	264
Maintenance Release	Vol	11.2	20.3	28.5	35.0	36.5	34.7	26.0	18.8	12.7	8.95	7.59	7.7	248
	fdc%	87	86	91	93	90	92	89	86	87	80	83	92	
Drought Release	Vol	0.48	0.54	0.3	0.31	1.11	0.34	0.38	0.38	0.27	0.46	0.31	0.04	5.01
	fdc%	8	6	2	1	6	2	3	4	4	11	8	1	
Releases between maintenance and drought	Vol	0.29	1.0	1.49	1.23	0.85	1.46	1.49	1.41	0.6	0.45	0.48	0.39	11.1
	fdc%	3	7	5	4	2	5	7	9	7	7	8	6	
Flood Release	Vol	0.99	2.21	17.2	16.3	82.8	15.8	3.32	0.33	0.13	0.0	0.0	0.0	139
	days	5	13	15	15	40	17	10	1	0	0	0	0	
Operating Rules (%)	Maintenance	89	87	87	87	87	87	87	87	87	87	87	89	
	Drought	93	93	93	93	93	93	93	93	93	93	93	93	
	Capping	87	85	85	85	85	85	85	85	85	85	85	87	
	Flood	20	20	20	20	20	20	20	20	20	20	20	20	
	Flow	15	15	15	20	30	20	15						

Vol = volume ($10^6 m^3$)
fdc% = flow duration curve percentage
Flow = rate of rise criteria ($m^3.s^{-1}.day^{-1}$)

8. CONCLUSIONS - RECOMMENDATIONS

The final modelling will establish whether water is available for the IFR for the Thukela River and a range of scenarios and implications will be prepared. The instream flow requirement and the various scenarios then needs to be explained to the social consultants, in relation to the category of the river, explaining the ecology, building of the dams and the costs involved. This needs careful consideration with both ecologists and social consultants, so that the implications, costs etc. of the various scenarios can be explained to the communities. The consultation with the community representatives was felt best left to this stage since they were unlikely to be able to either contribute nor extract anything from attending the actual IFR workshop.

9. REFERENCES

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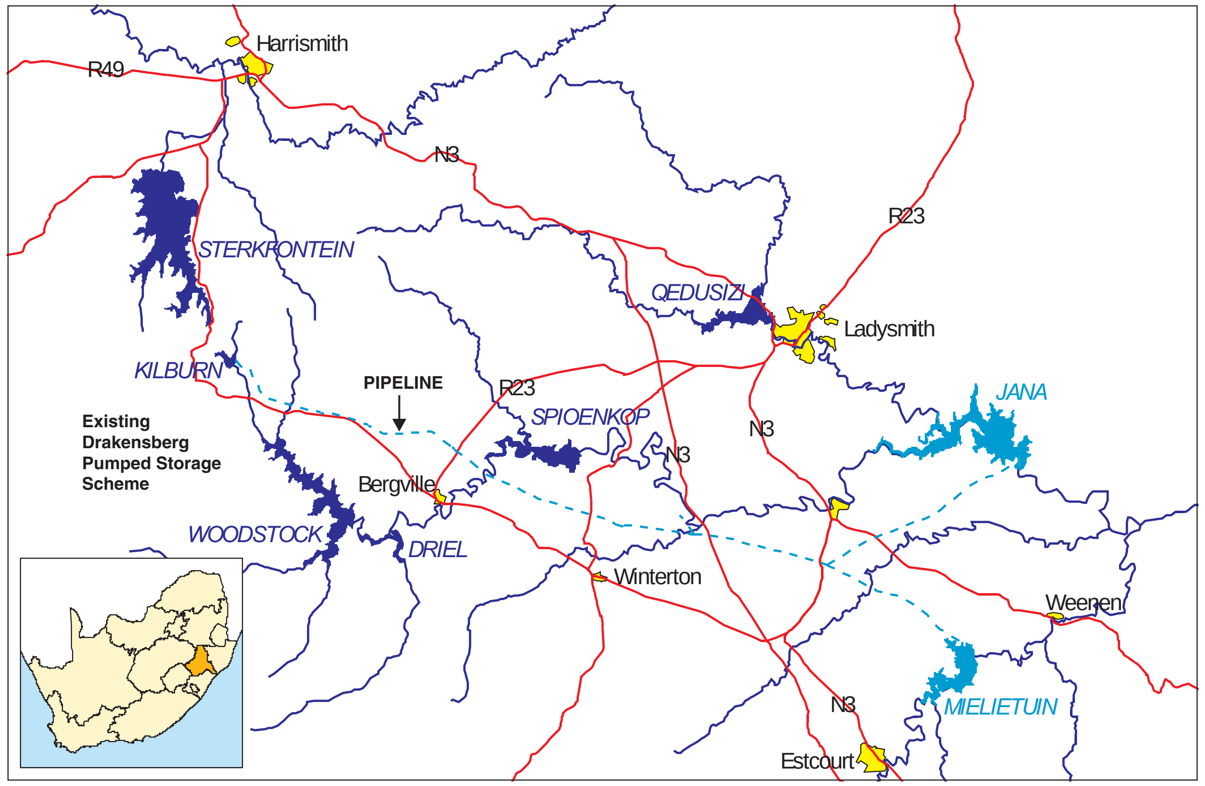
TWP

An Overview of the Thukela Water Project Feasibility Study

MAY 2001

THE THUKELA WATER PROJECT



This overview was prepared by the Thukela Water Project Feasibility Study Project Management Team on behalf of the Directorate Water Resource Planning of the South African Department of Water Affairs and Forestry.

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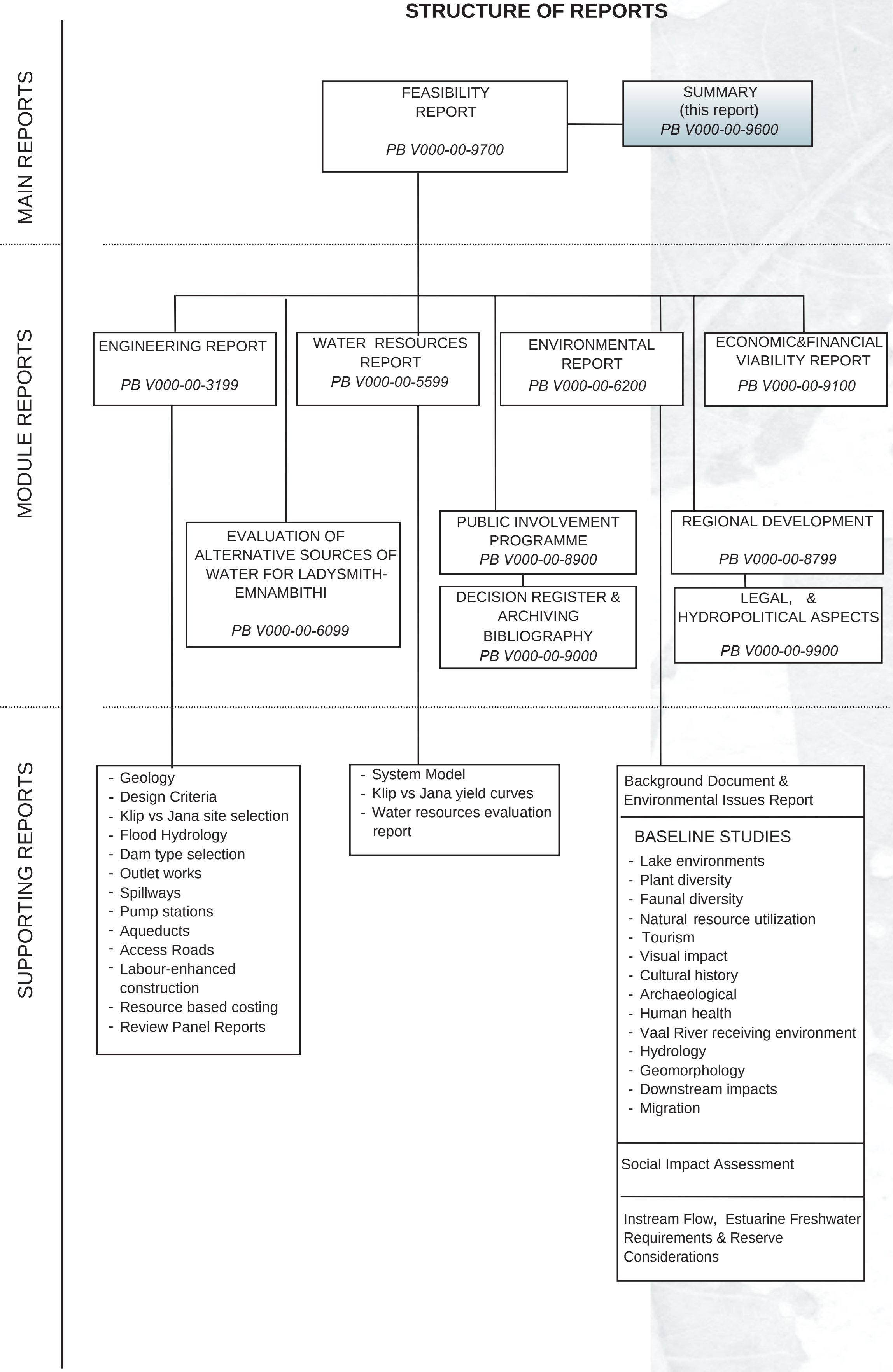
THUKELA WATER PROJECT FEASIBILITY STUDY

STRUCTURE OF REPORTS

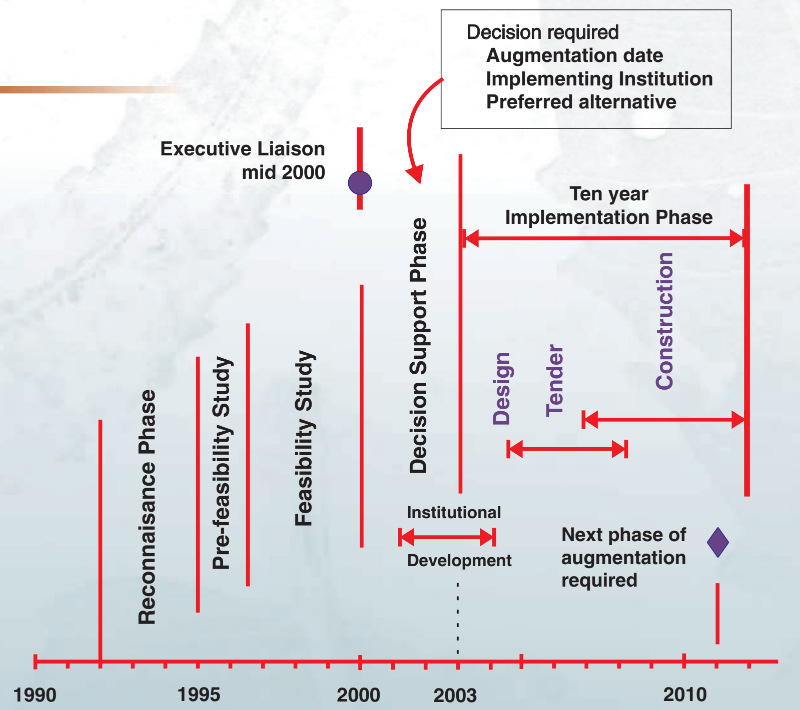


- Finalisation of project details is dependent on determination of the Reserve for the Thukela River, the outcome of a comprehensive Environmental Impact Assessment and associated Environmental Management Plan.
- Progress to a design and implementation phase of the project, if selected as the next stage of augmentation of water supplies to the VRS, will be dependent on environmental authorisation of the project in terms of the Environment Conservation Act.
- In order to meet the selected target date for delivery of additional supplies into the VRS, it will be necessary to confirm the selection of the TWP from among the alternative strategic options not later than ten year before this augmentation date.
- Implementation of the TWP at a (1998) capital cost of R5 billion could probably be beyond the means of the SA Government's expenditure budget and it will be necessary to set up an appropriate implementing agent, probably in some form of partnership with the private sector, to raise the necessary funding, design and construct the project and operate the system for a period of time. This institutional development would be the critical path to successful implementation to meet the desired target delivery date.

In summary, the Feasibility Study has identified and classified all aspects and issues associated with the future construction of the project in sufficient detail to enable decision-makers to compare the Thukela Water Project with other strategic augmentation alternatives.

Implementation Time Line

The implementation time line indicated alongside has been used during the Feasibility Study as being the soonest that VRS water augmentation would be required.



Project time line from Reconnaisance to Implementation

SYNOPSIS

Aerial view of Thukela River Mouth

The Thukela Water Project (TWP) is a proposed major, five billion Rand (1998 prices), water resource development project that will be situated in KwaZulu-Natal, South Africa. Its strategic intent is to augment water supplies to the industrial heartland of the country, otherwise known as the Vaal River System (VRS).

The Thukela Water Project, situated in the uThukela Region of KwaZulu-Natal, has the potential to stimulate local and regional economic growth, and can contribute significantly to the South African Government's policy objectives, viz: security of water supply to the VRS; economic empowerment of previously disenfranchised people; poverty alleviation and job creation.

In assessing the viability of the Thukela Water Project, the Department of Water Affairs and Forestry (DWAF) has fully embraced the principles of Integrated Environmental Management (IEM). This has been underpinned by thorough and comprehensive public involvement in support of incremental decision-making.

Feasibility Study findings indicate that the Thukela Water Project is technically feasible, and environmentally and economically viable. As such, the Thukela Water Project stands as an attractive alternative to augment the water resources in the Vaal River System following Phase 1B of the Lesotho Highlands Water Project.

Should a decision be made to continue with the Thukela Water Project, it will be necessary to refine the technical configuration of the scheme in line with findings of a Thukela River Reserve Determination and an Environmental Impact Assessment which will also provide the basis for Environmental Management Plans for the design, construction and operational phases.

THUKELA

Introduction

Water is one of the most fundamental and indispensable natural resources. It is essential for life, the environment, health, food production, industry and power generation. In South Africa, water is a limited resource, the scarcity of which is exacerbated by uneven distribution, both geographically within the country and seasonally. Due to this variability there is an ever-present risk of water shortages and restrictions, with consequent limitations to social development and economic growth.

The DWAF is entrusted with the responsibility to protect, use, develop, conserve, manage and control the water resources of South Africa. Consistent with good governance and sound water resource management and planning, the DWAF is committed to the development of national strategies and policies that are aimed at conserving and developing South Africa's water resources in an integrated, rational, equitable and sustainable manner.

The provision of adequate supplies of water in the VRS has enjoyed a high priority within the DWAF for many decades. The VRS supplies water to six provinces, viz. Gauteng, Free State, Mpumalanga, North West, Northern Cape and Northern Province. Collectively, these areas support a major proportion of the country's population, produce more than 50 % of South Africa's economic wealth, and yield 85 % of South Africa's electricity supply.

Current estimates of the water resources, versus demand in the VRS, show that the risk of shortages becomes greater than that which is deemed reasonable to ensure economic security somewhere during the second decade of this century.

Augmentation of the VRS water resources, therefore, becomes crucial. However, it is believed, the need for augmentation can be delayed by implementing water demand management and water conservation measures to curb the excess use of water in the VRS.

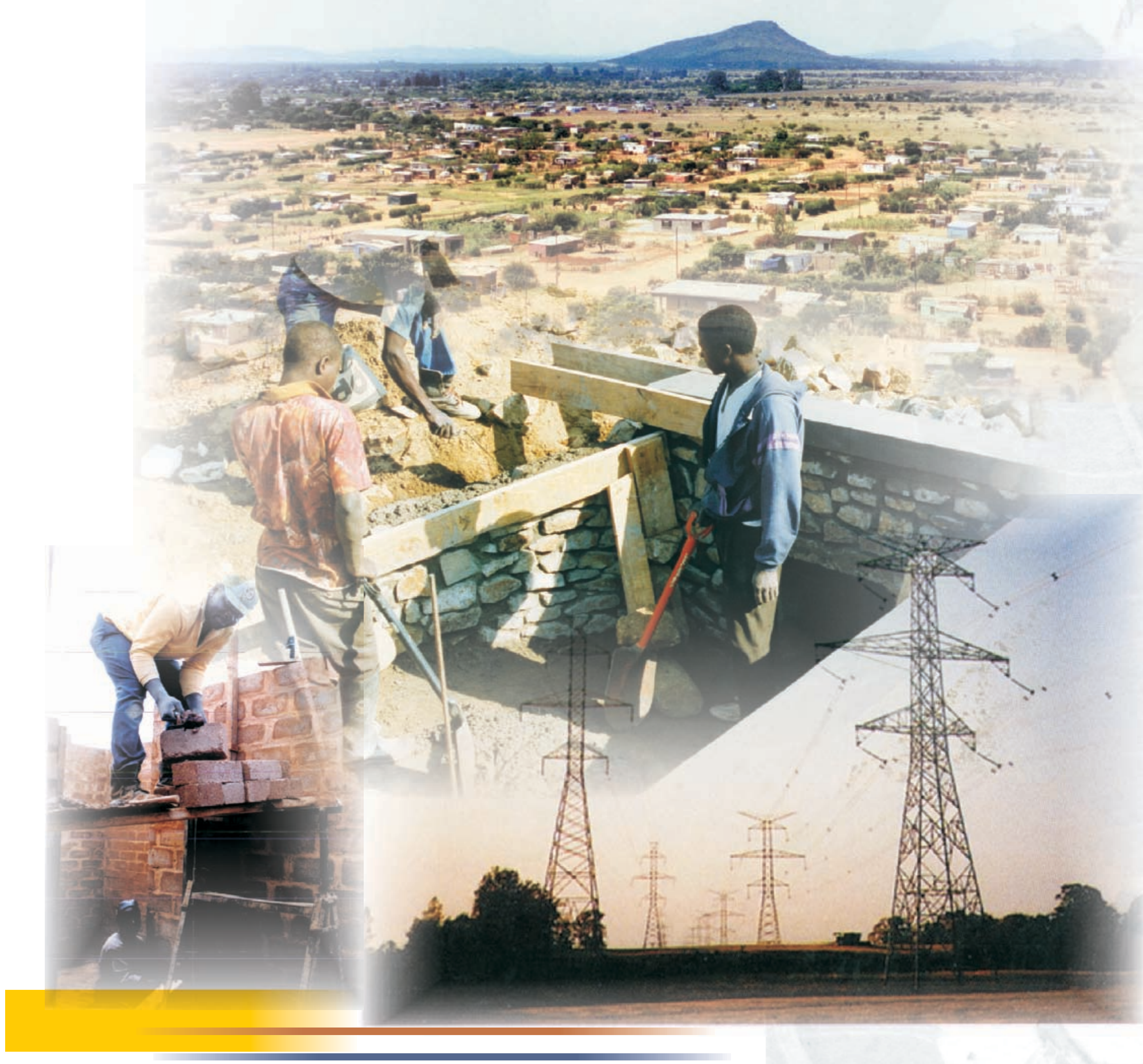
In 1994, the DWAF initiated the Vaal Augmentation Planning Study (VAPS) to provide a comprehensive and sound basis for decision-making by National Government concerning the best means of managing and providing water supplies to the VRS. As part of ongoing water resource development and management at national level, the VAPS considered such aspects as non-augmentation, demand management, the desalination of sea water, the importation of water from sources outside South Africa, and inter-basin transfers within South Africa. One of the latter options was the regulation of surplus water in the Thukela River Basin and the transfer of approximately 15 m^3/s via the existing Drakensberg Pumped Storage Scheme to the VRS.

The TWP was investigated at Reconnaissance and Pre-Feasibility levels so as to inform decision-making by National Government. At Pre-Feasibility level of study, the TWP showed sufficient merit for the DWAF to commission a comprehensive Feasibility Study in 1996. The primary aim of the TWP Feasibility Study was to investigate all factors that might affect the viability of the development proposal. To this end, the TWP Feasibility Study was designed to provide the DWAF with information and data necessary to compare further phases of the Lesotho Highland Water Project with the Thukela Water Project as possible options to augment the water resources of the VRS.

Study Approach

The TWP Feasibility Study commenced in late 1996 and took three years to complete. The study comprised 16 modules and culminated in a Main Feasibility Report supported by approximately 60 module reports, summaries and other documents. The structure of reports for the TWP Feasibility Study is described on the inside back cover of this Overview Report.

- The project will cause permanent negative local impacts as inundation of the dam basins, particularly the dam at Jana, destroys highly valued valley bushveld ecosystems, some people will have to be relocated to make way for the dams and aqueduct, commercial farmers and tourism operators will have to sell their properties, the sense of place wilderness-like areas would be destroyed and the sediment regime and river morphology downstream of the main dams could be disturbed if adequate mitigatory measures are not implemented.
- Negative consequences of the TWP can be mitigated and managed in an affordable and sustainable manner to avoid, minimise, and in some cases only compensate for damage done. Similar affordable impact management strategies can be employed to significantly expand and add value to the many positive opportunities which will be derived from development of the project.



Findings and Conclusions

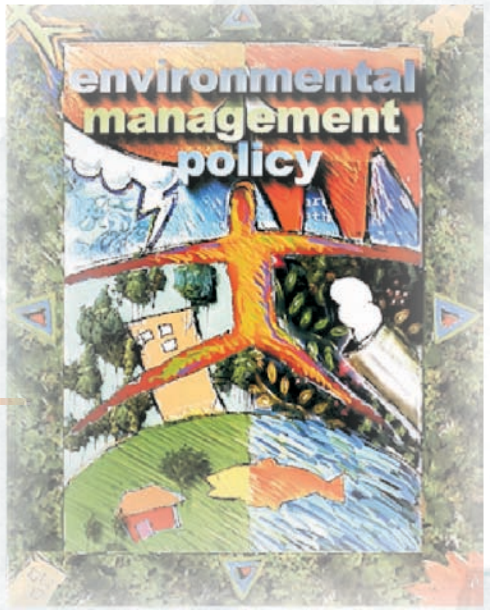
Arising from the Feasibility Study, it can be concluded that the Thukela Water Project:

- Is technically, environmentally (natural and social) and economically feasible.
- Up to 15 m³/s (about 450 million m³/a) can be transferred out of the Thukela River catchment, in addition to the existing transfer to the VRS via the Thukela Vaal Project at the Drakensberg Pumped Storage Scheme, without negatively affecting existing and projected long-term water use in the Thukela River Catchment, while also maintaining the sustainability of riverine ecosystems.
- The most attractive means of transferring water from the Thukela River to the VRS is to develop the proposed TWP comprising major dams at Jana in the Thukela River and at Groot Mielietuin in the Bushmans River, a pipeline from the two dams to the existing Kilburn Dam at the Drakensberg Scheme, pumping stations and associated infrastructure.
- The proposed project is a cost-effective means of augmenting water supply to the VRS, benefiting from the capacity of the existing Drakensberg Scheme to lift the additional water required over the Drakensberg mountains to the VRS.
- The project can be implemented in time to provide additional water transfers by 2011, the earliest date by which it is expected that augmentation will be necessary.
- The development proposals are situated in the relatively poor uThukela Region of KwaZulu-Natal; the local and regional economy can enjoy potentially large benefits from investment of the capital amounts and the creation of temporary and permanent employment opportunities.
- Development and operation of the project can be managed in a way which can make a major contribution to achieving Government objectives such as poverty alleviation, employment creation, equitable access to resources, integrated rural development and co-operative governance.
- The TWP is a strategic development option which will have consequences, both negative and positive, in the source basin, in the VRS and throughout the national economy.
- The two major dams comprising the development proposals are significant in size and technically complex by world standards, and will be subject to local, regional and global scrutiny for compliance with current best practice worldwide and for irresutable evidence that they represent the best available response to the growing water demand in the VRS.
- Conceptualisation, planning, design, evaluation, implementation and operation of the TWP will be the focus of ongoing interest and scrutiny from all quarters and the relevant information must be made readily accessible to facilitate evaluation.
- At a regional level, the development proposals will have major temporary impacts during the construction phase as people move into the region with negative social consequences. Training and skills development for local job seekers should increase dramatically. Business and commercial opportunities in the region are expected to expand. Infrastructure, such as roads and electricity supply, will be developed and environmental disturbances such as noise, dust and loss of sense of place will occur.
- Permanent consequences of the project at a regional level will be some increase in employment opportunities, expanded road and other infrastructure, expanded opportunities for tourism business and commerce, and a significant change in the flow regime of the Thukela River.
- At a local level, construction of the project will have severe negative consequences for a limited number of people directly affected by the works, negative impacts on the environment as work areas are disturbed and destroyed, an invasion of the privacy and lifestyle of some people close to the work areas, and positive consequences for those who are employed on the works (perhaps for the first time in some recently established land reform settlements).

Principles of Integrated Environmental Management

Integrated Environmental Management (IEM) is a philosophy which prescribes a code of practice for ensuring that environmental considerations are fully integrated into all stages of the development process in order to achieve a balance between conservation and development. The DWAF has adhered to the basic principles of IEM which include:

- Informed decision-making.
- The adoption of an holistic understanding of the term environment that includes physical, biological, social, economic, cultural, historical and political components.
- Thorough consideration of alternatives.
- Democratic regard for individual rights and obligations.
- Opportunity for public and specialist input into the decision-making process.



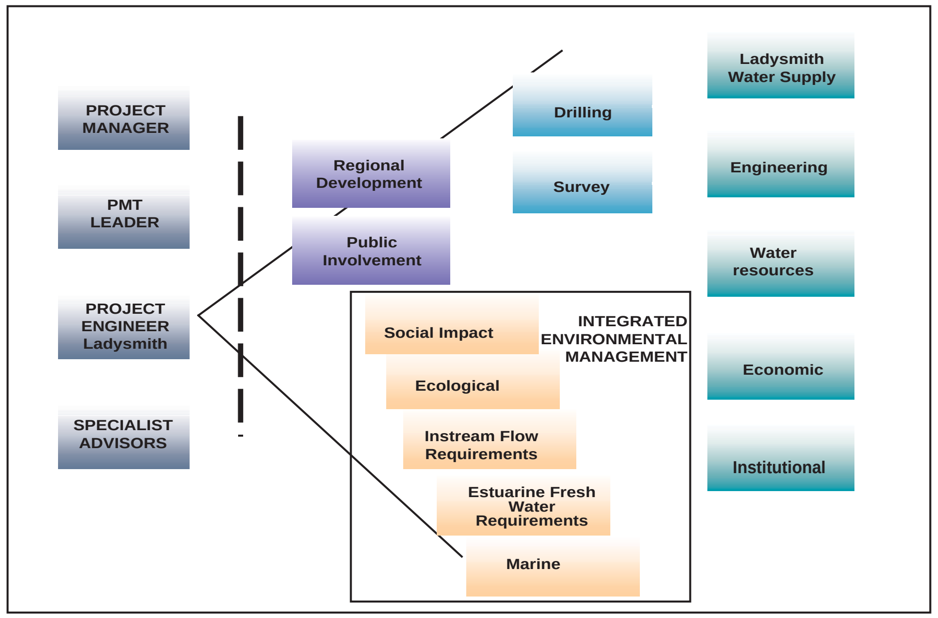
Public Involvement

Public involvement formed a cornerstone of all previous phases as well as the TWP Feasibility Study.

The principles for public participation recommended by the Department of Environmental Affairs and Tourism were adopted for the purposes of the TWP Feasibility Study. These are:

- The meaningful and timeous participation of Interested & Affected Parties.
- A focus on important (key) issues.
- The consideration of alternatives.
- Accountability for information used for decision-making.
- Inclusivity.
- Encouragement of co-regulation, shared responsibility and a sense of ownership.
- Dispute resolution.

Within the above principles, public involvement included a number of activities. Apart from introductions to stakeholders and assistance to study team members during field work, Interested & Affected Parties were identified and their involvement in the Feasibility Study was facilitated. To facilitate participation, inform-



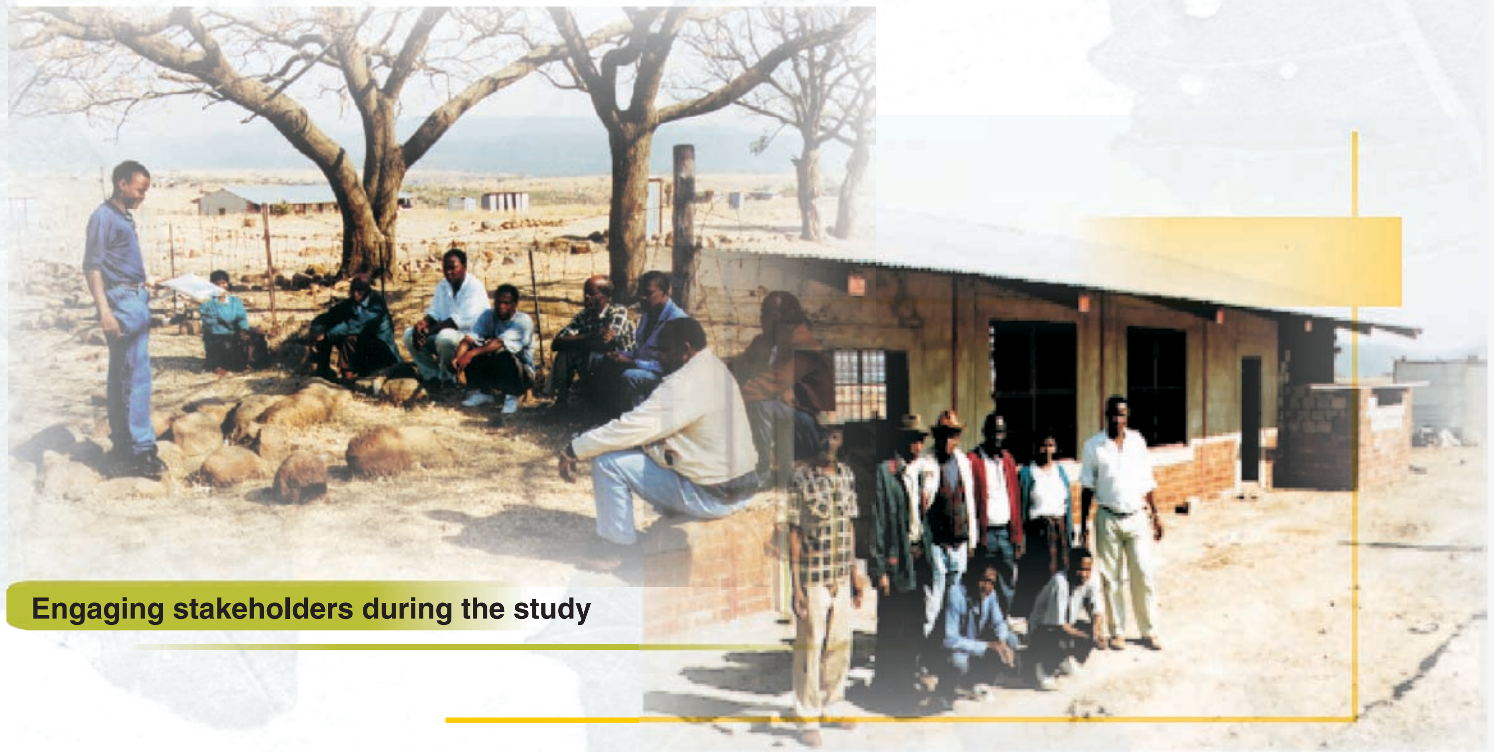
Components of the Study

-ation was disseminated to stakeholders by a number of methods, including pamphlets, newsletters and an Internet Web Site. Where there were capacity constraints to involvement, training needs were identified and training was provided.

The programme of public involvement comprised meetings, services, products and general liaison activities. It is widely acknowledged that the public involvement programme for the TWP Feasibility Study has achieved its aims and objectives, and, importantly, has successfully applied the recommended principles of public participation. This is evidenced by key aspects such as:

- A continuation of public involvement from the Reconnaissance and Pre-feasibility Studies, to the Feasibility Study, with an ever increasing number of stakeholders participating as development proposals were formulated and elucidated. A database of over 1000 people and organisations has been maintained during the course of the study.
- The provision of sufficient project information in an easily understandable manner to enable the participation of stakeholders in the formulation of project alternatives.
- A clear and unambiguous focus on matters that were important at any time during the study, for example, the pipeline versus canal aqueduct alignments and regional development.
- The allocation and utilisation of significant resources to consider alternatives, particularly aqueduct types and alignments.
- Particular attention to detailed information used in decision-making by the production of Technical Bulletins.
- Technical and other assistance was given to stakeholders in the preparation of statements on their perspectives, for example, a perspective paper on the concept of a Thukela River Park.
- As and when disputes and conflicts arose, these were dealt with as part of the public involvement programme.

After a lengthy and inclusive public involvement programme, the DWAF believes that stakeholders in the Thukela River Catchment have been afforded opportunity to participate meaningfully during the TWP Feasibility Study. In addition, stakeholders from further afield have also participated, but to a lesser degree. Various positive and negative issues and recommendations have been raised by stakeholders. These are not statements of fact but, rather, opinions and perspectives. Importantly, they have been accommodated within the Feasibility Study where applicable, appropriate and possible.



Engaging stakeholders during the study

required for the construction of the TWP. By inference, if appropriate training is not provided for the local economically active workers, then the advantages of the proposed scheme could be somewhat negated.

Commodities

The demand for various commodities, for example, construction materials, and intermediate and consumer goods, is anticipated to be high creating opportunities for the manufacturing, commercial and service sectors. However, it is believed that the entrepreneurial sector in the uThukela Region and KwaZulu-Natal will require assistance to capture this demand to ensure that the source catchment optimises benefits arising from the TWP.

Enterprises (capital)

As can be expected, almost two thirds of the enterprises employed during the construction of the TWP will fall into the civil engineering sector. It is estimated that 10 % of the total benefits accruing to enterprises will go to emerging contractors. This is considered reasonable given the type of construction activity to be undertaken. However, the social accounting matrix indicates that by using traditional implementation methodology, only a small percentage of the various benefits will accrue to local community-based businesses. This is considered unacceptable and, therefore, proactive intervention will be required to achieve Government objectives.

Households (income)

It has been noted that, during the construction phase, the distribution of income between rural and urban households, will be urban orientated. This phenomenon requires investigation and, if necessary, counter measures will need to be formulated in support of predominantly rural communities in the uThukela Region. With regard to the distribution of income groups, equity was found in the projections for the construction phase. Importantly, however, income distribution during the operational phase tends towards the lower income groups.

Financing Arrangements

At this stage in the project cycle, only a superficial analysis of possible institutional and funding options has been undertaken, mainly to gain a perspective on how various models will impact on the timing of the TWP.

Various models, ranging from Government as the sole implementing agent, through a public private sector initiative to a mainly private sector, undertaking, have been considered. However, more detailed analysis will be required with the involvment of the Public Private Sector Partnership Task Team of the Department of Finance.

PPP

Financial and Economic Viability

Financial and economic cost benefit and sensitivity analyses have been undertaken as part of the TWP Feasibility Study. Variables considered were the following: the affect of using different discount rates, the affect of different values of water for estimating the benefit of the water transferred, the affect of increasing the capital cost of the TWP, and the minimum water transfer rate necessary to ensure break-even between costs and benefits.

Results show that the benefit cost ratios are all significantly greater than one over the full range of sensitivity tests. This is considered favourable and from a financial and economic cost benefit perspective, the Thukela Water Project is viable, yielding acceptable rates of returns.

Macro Economic Impact Analysis

A social accounting matrix has been developed to estimate the macro economic impact of the TWP. Importantly, it has been assumed that the benefits or forward linkages arising from the supply of water to the VRS would be the same, irrespective of the source of water. This analysis was, therefore, focussed on the macro economic impact that the TWP would have on the uThukela Region and the Province of KwaZulu-Natal.

A summary of the major impacts is as follows:

Gross Geographic Product

Economic activity measured in terms of Gross Geographic Product should increase by at least 10 % in the uThukela Region and 0.5 % in KwaZulu-Natal. However, if a special effort is made to comply with Government objectives to stimulate the local economy through pro-active intervention, then these anticipated impacts could increase significantly.

Employment

Assuming traditional construction methods are employed, i.e. machine intensive, it is estimated that more than 4 000 construction jobs will be created in the uThukela Region and an additional 2 000 jobs in KwaZulu-Natal. However, if a diligent effort is made to enhance the labour content of construction practices, then the number of job opportunities created could be significantly greater.

Factor payments (labour)

Skilled and semi-skilled labour constitutes a high percentage of the direct and indirect workforce

Study Area

Spioenkop Dam

The TWP bisects the uThukela Region of KwaZulu-Natal, an area of approximately 11 000 km^2 located in the north-western part of the province, between the port of Durban and Gauteng, part of the industrial heartland of the country. The Drakensberg mountain range and neighbouring Lesotho form the western boundary, the Free State, the northern boundary, and the Mzinyathi and iNdlovu Regions of KwaZulu-Natal the eastern and southern boundaries, respectively.

The uThukela District Municipality, with various Local Municipalities and Traditional Authorities, provides the institutional backbone of the region. The uThukela Region has a Gross Geographic Product of approximately R 2.1 billion which represents 2 % of the economy of KwaZulu-Natal. The population of the uThukela Region is estimated to be 650 000 people (1998), which equates to approximately 7 % of the population of KwaZulu-Natal. It follows that the per capita contribution to economic activity is well below the provincial average. This low level of economic activity has resulted in a small regional tax base as illustrated by the regional fiscal deficit of R 292 million in 1998.

Economic activity in the region is primarily focussed on manufacturing. The agricultural sector is mainly based on beef and game farming in the eastern and central sub-regions.

Dryland agriculture and irrigation farming occur in the upper, or western, sub-region.

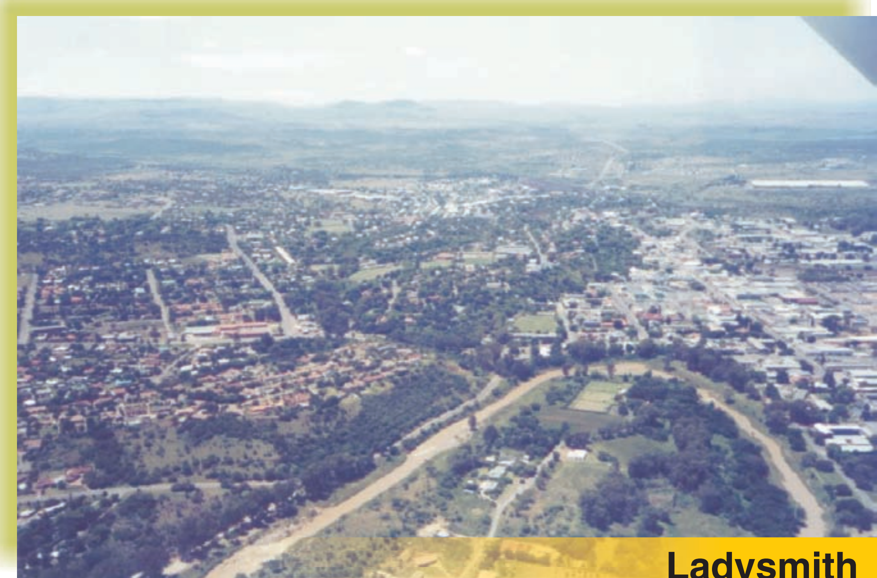
Tourism and ecotourism appear to be growing economic sectors, primarily focussed on the natural beauty and splendour of the Drakensberg Mountains, game farming enterprises and white water adventure activities.

Three major dams have been constructed in the Upper Thukela Catchment, viz. Wagendrift Dam for water supply to Estcourt and Weenen, Spioenkop Dam for water supply to Ladysmith and regulating the Thukela River downstream, and Woodstock Dam for storage of water to feed into the existing transfer to the Vaal River System via the Tugela Vaal Transfer Scheme (i.e. via the Drakensberg Pumped Storage Scheme).

Ladysmith is the largest town and serves as the main administrative and economic centre.

The towns of Estcourt, Weenen, Colenso, Winterton and Bergville will also be affected by one or more of the components of the TWP.

An estimated 74 % of the population of the uThukela Region is rural and relatively poor. By optimising the design and configuration of the TWP it will be possible to align and place infrastructure, such as roads, electricity transmission lines, telecommunication lines and buildings, in a manner that benefits these rural communities into the longer-term.



Ladysmith

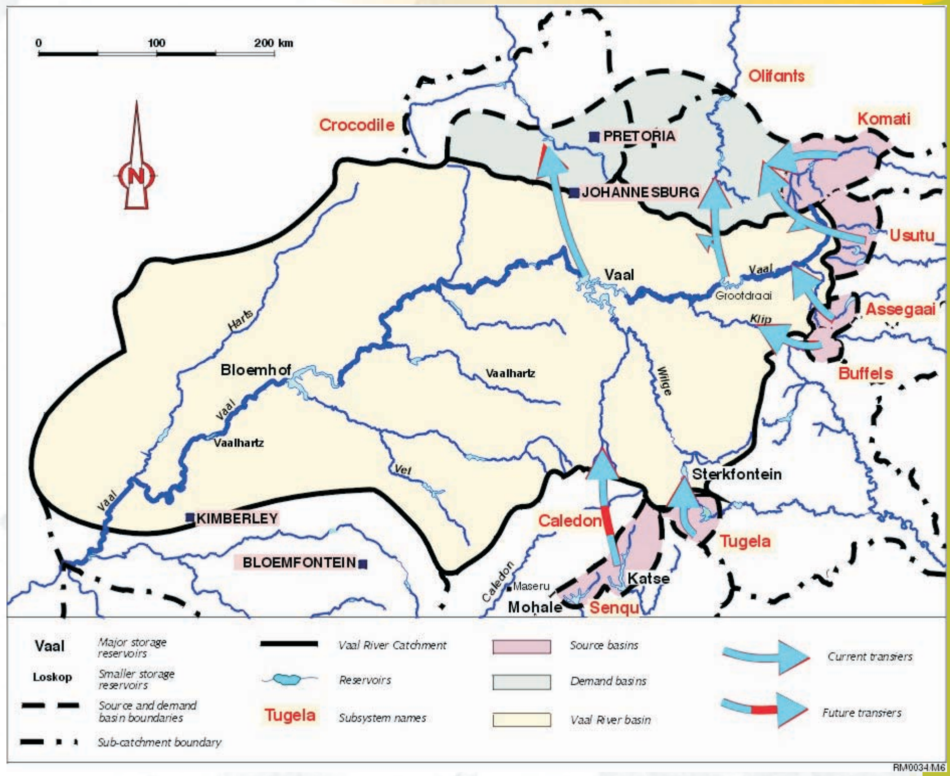
In-basin Water Requirements and Resource Availability

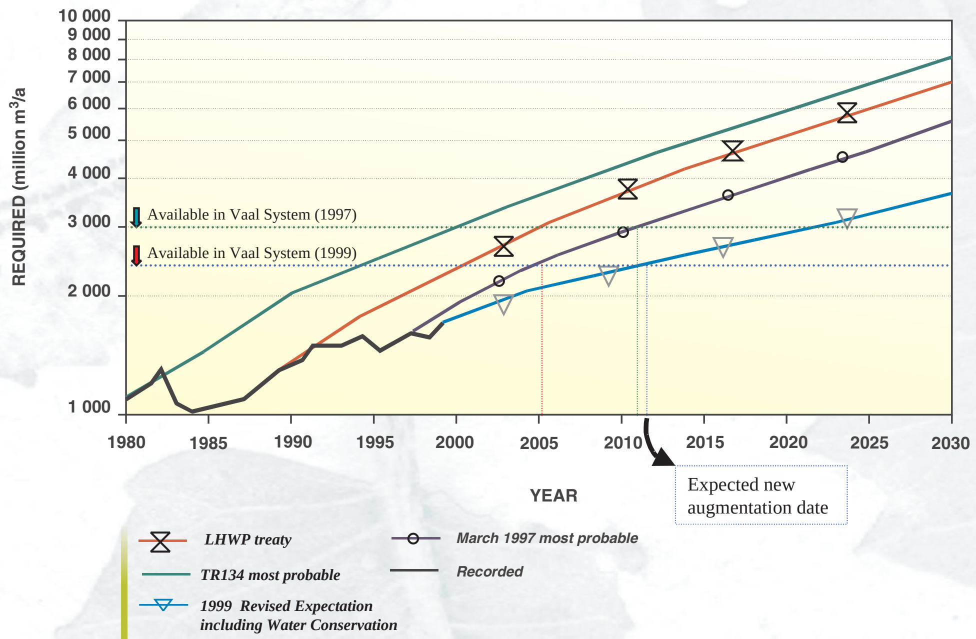
The National Water Act (Act 36 of 1998) requires the DWAF to implement a national water resource management strategy that will provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole, and also on a regional or catchment level.

Included in this strategy is the provision of the Environmental Reserve, the amount of water that is required to meet social and ecological needs. Sophisticated water resource system analysis modelling techniques are used to determine the instream flow requirements that are necessary to maintain the Reserve. In terms of the Thukela River Catchment, the Reserve must be met prior to making decisions on major water use, such as considering interbasin transfers.

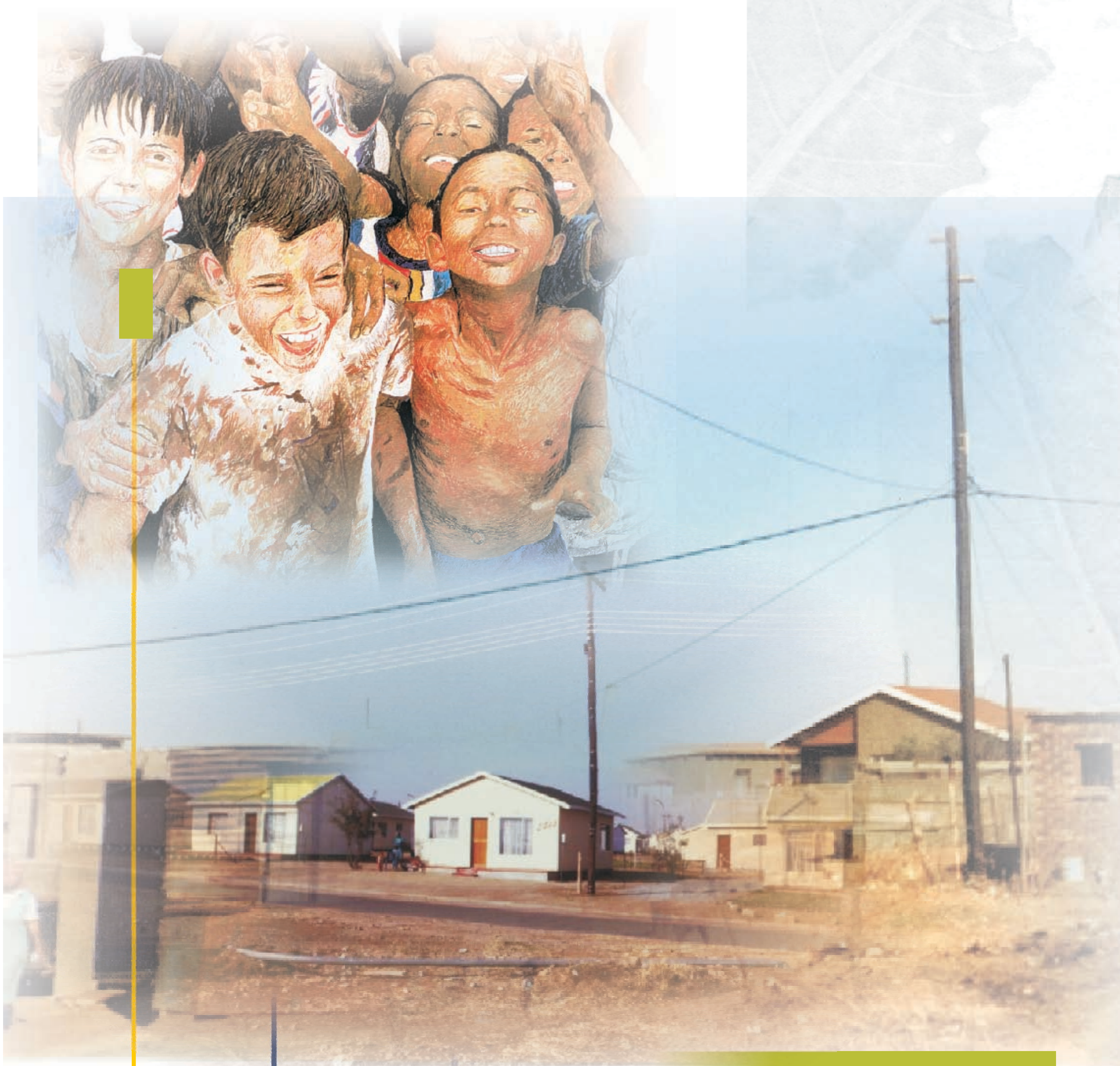
Using instream flow estimates and 2030 in-basin projections, it was determined that the TWP could supply the required additional draft of 450 million m³ per annum at an assurance of between 95 and 98 %. Considering that in-basin requirements have been estimated conservatively, and, with storage created by two dams proposed as part of the TWP, a surplus of water may exist between the time that the proposed dams are constructed and 2030.

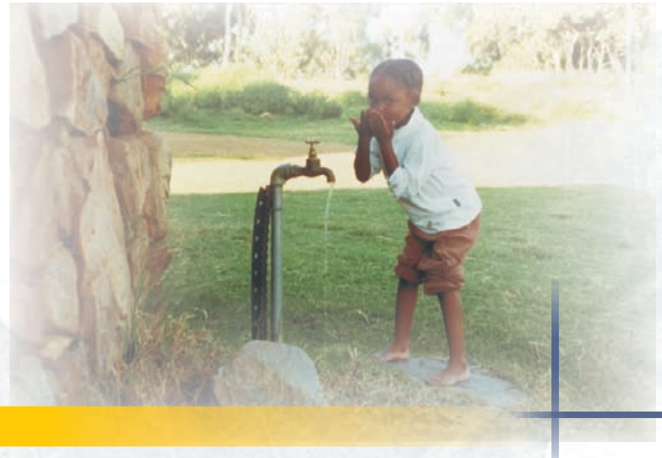
Vaal River Supply Area





Vaal River Water Demand Projections





- Issues around the effects of AIDS are not yet fully understood.

Regional level

- A comprehensive understanding of the sediment movement processes in the Thukela River, their cause and effect, is essential and of fundamental importance to a full understanding of the feasibility of the TWP. In the Feasibility Study, work on the subject was started but much still remains to be done.
- The TWP presents a unique opportunity to stimulate and kick start considerable development and economic empowerment in the Thukela Region. However, this is unlikely to occur if comprehensive regional development plans and spatial planning for regional and local government structures are not implemented. To do this effectively will require proactive participation of all institutions to accept joint responsibility in social upliftment programmes. There is a significant opportunity for effective liaison, communication and joint action by National, Provincial and Local Government Departments.
- Unacceptable levels of crime and security may occur as a result of poverty, AIDS-orphans, migration and easier access throughout the region, related to the implementation of the TWP and the investment in infrastructure and other services. To combat this will need policing, combined with integrated regional development planning and implementation. There will also have to be effective communication, liaison and joint action by National, Provincial and Local Government Departments.

- **Site specific level**

- Initial investigations have revealed that the construction of a dam at Jana and flooding of the basin will bring about the loss of a large contiguous area of Northern Valley Bushveld, which is endemic and a threatened veld type in KwaZulu-Natal.

  The loss of this habitat and potentially of certain fauna makes this issue important, specifically because of legal principles in NEMA, and international agreements on biodiversity, of which South Africa is a signatory.

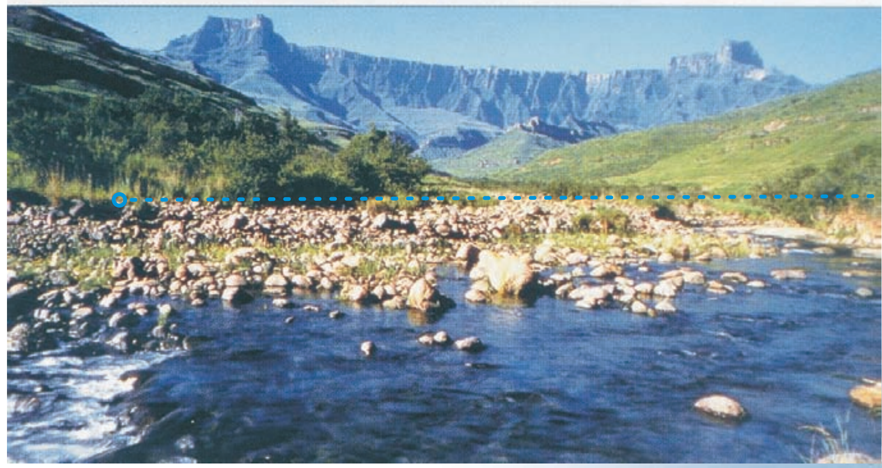
- Flooding of the impoundment will cause economic, physical and cultural disruption to landowners, farm labourers and communities currently resident in the potential dam basins.

  Approximately 74 private land-owners, 40 labourer families, 2 tenant families and up to 450 households along the aqueduct route and, to a lesser extent, in the in the dam basins could be affected either economically or physically. Both communal subsistence agriculture and commercial farming enterprises will be affected. This includes arable and grazing land.

- Resettlement is a highly emotive and sensitive issue. The process will have to be planned carefully, transparently and inclusively. If not handled properly, it has the potential to substantially disrupt the implementation of the TWP.

All of the negative impacts can be investigated and managed satisfactorily. So too can positive impacts be enhanced by special intervention.

Although a significant amount of environmental baseline assessment has been conducted during the Feasibility Study, it is intended that a comprehensive Reserve Determination and full Environmental Impact Assessment will be conducted on the proposed project during the next phase of investigation (i.e. the Decision Support Phase).



The Thukela Water Project

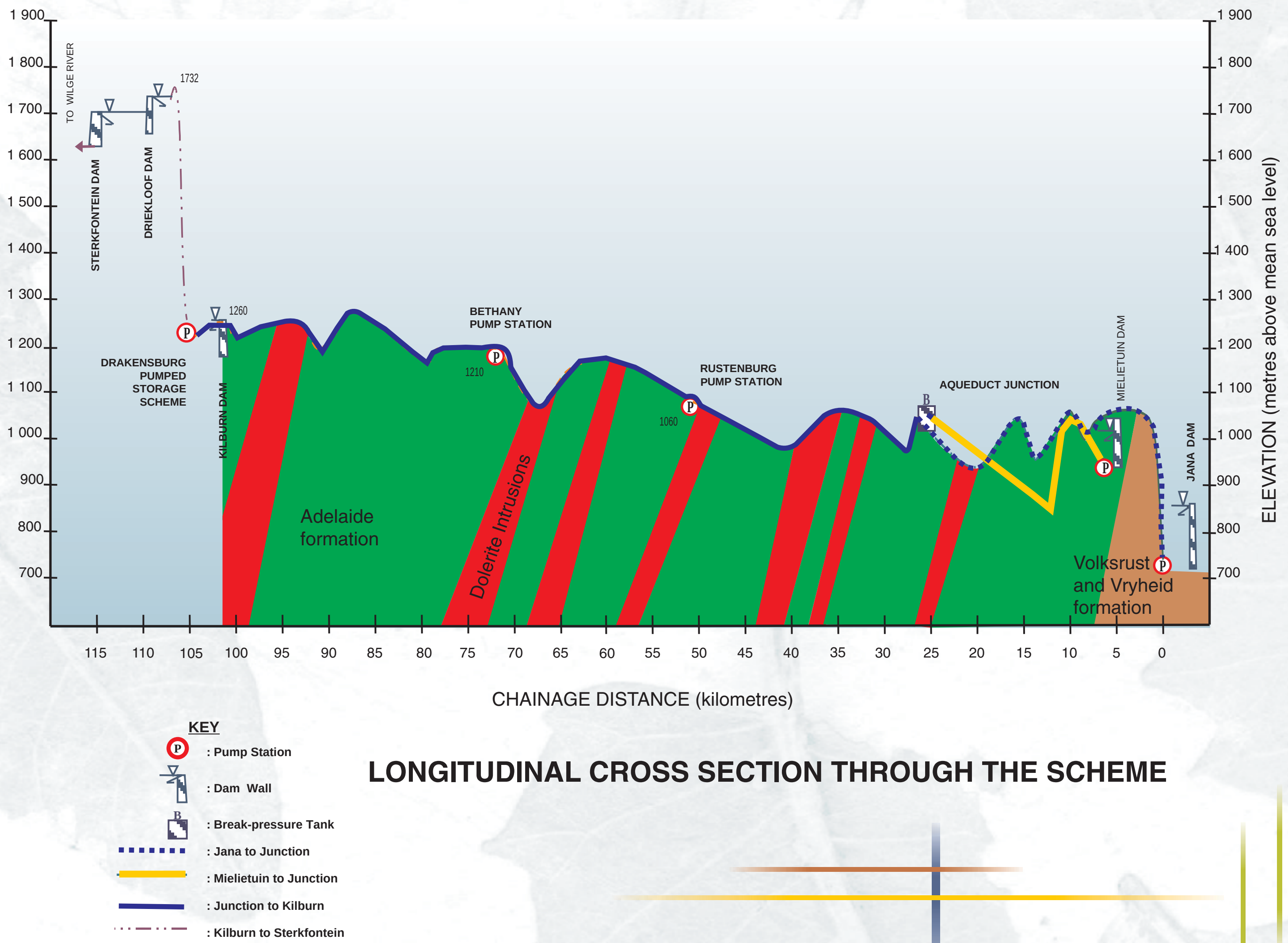
It is envisaged that all components of the TWP will be constructed over a period of about 8 to 10 years. The aim of the TWP is to increase the delivery rate of raw water to the VRS, via the Drakensberg Pumped Storage Scheme, by 15 (m^3/s). Depending on operating regimes, this could add up to more than 450 million m^3 of additional water being transferred per annum.

The estimated capital and compensation costs (excluding financing and operating costs) for the TWP amount to just less than R5 000 million in March 1998 terms.

The following main elements of infrastructure will be required in the scheme (see diagram on page 8):

- Jana Dam in the Thukela River situated approximately 30 km south-west of Ladysmith and 15 km downstream of the confluence of the Thukela and Klip Rivers.
- Mielietuin Dam in the Bushmans River, situated between Weenen and Estcourt, and immediately upstream of the western boundary of the Weenen Nature Reserve.
- 120 km of pipeline aqueduct linking the proposed dams to the existing Kilburn Dam at the foot of the Drakensberg Pumped Storage Scheme.

Due to future uncertainties (e.g. the determination of the Reserve) information has been made available to decision-makers within a range of project component sizes from which to eventually select an optimum scheme. A reference scheme size has been suggested at feasibility level.



LONGITUDINAL CROSS SECTION THROUGH THE SCHEME

Environmental Aspects

During feasibility level environmental investigations, nothing was found to indicate that the TWP should immediately be abandoned or that there was high risk in proceeding to the next phase of investigation which will include an Environmental Impact Assessment and Reserve Determination.

The TWP is a large and complex development intervention originating from policy level decisions within National Government. These policies relate not only to strategic water supply. Other policies such as poverty alleviation, job creation, land reform, economic empowerment of previously disadvantaged people, and the establishment of equity in resource access have also been considered.

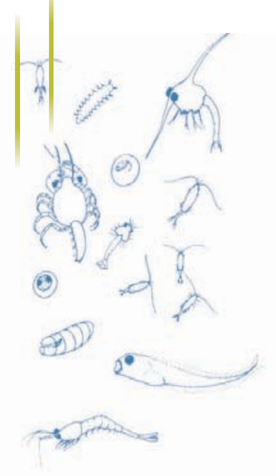
It is a project that will have profound effects at various levels and in many different ways over a long period of time, and will directly affect the quality of life of large numbers of people. There is, therefore, a specific onus on the DWAF to ensure that environmental considerations are accorded appropriate recognition and respect in the administrative processes and planning activities which they undertake.

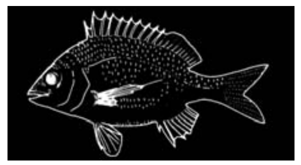
The environmental feasibility of the TWP has, therefore, been assessed at three levels:

- National strategic policy level
- Regional level
- Site specific level

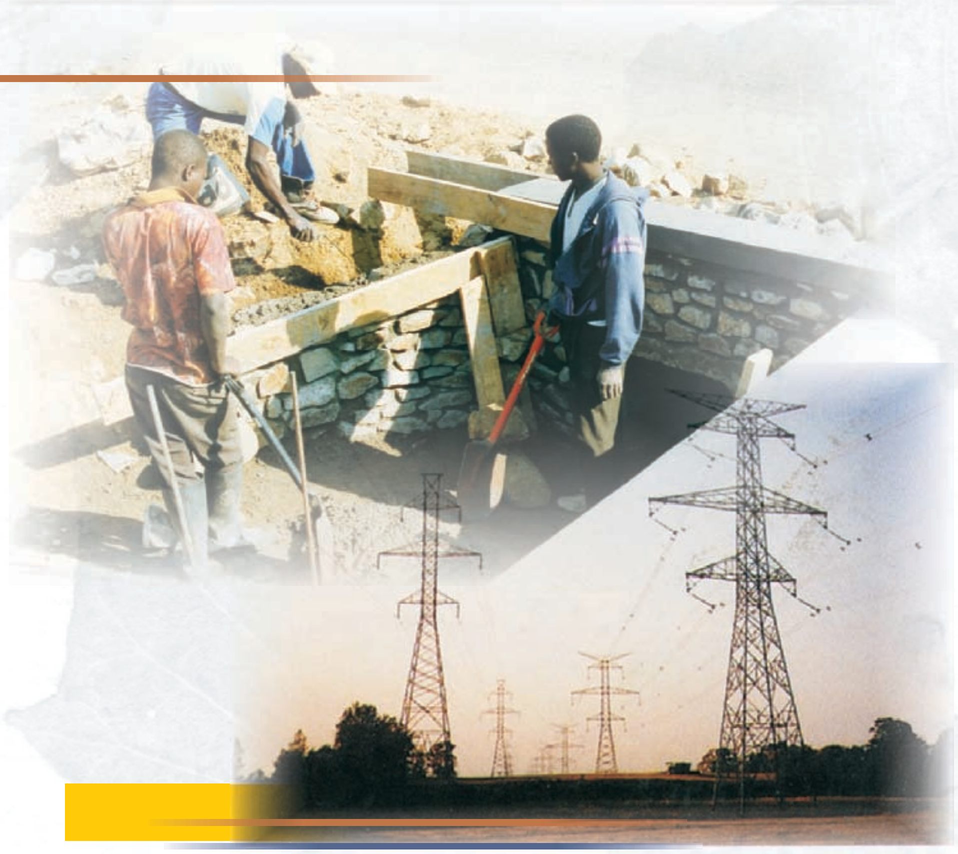
The environmental investigations showed the following to be of particular importance:

- **National strategic policy level.**
  - The Reserve (basic social and natural river water requirements for the Thukela River and its tributaries) has not yet been determined.
  - A formal strategy is currently being developed for the management of the water resources of the Thukela River as part of a national water resource management strategy.
  - A decision not to augment the water resources of the VRS would potentially simulate trends synonymous with a slump in the national economy. There would be job losses and increasing levels of unemployment, a reduction in disposable incomes, and a shortage of funds (through taxes) for national development initiatives.
  - Implementation of the TWP would require political support at National, Provincial and Local Government levels.
  - The ramifications of negative international and domestic sentiment regarding big dams should be considered in the decision-making process.





Regional Development



By deciding to base the TWP Feasibility Study Office in Ladysmith, the DWAF has gained the benefit of understanding the institutional and social dynamics that drive the uThukela Region.

The TWP Project Management Team has played an important role in establishing various regional development and economic forums within the uThukela District Municipality. These forums and other business and labour organisations have been empowered with the necessary knowledge to be in a position to capitalise on and optimise spin-offs that could accrue to the uThukela Region as a consequence of the TWP.

Numerous benefits have been identified by a dedicated KwaZulu-Natal based team during the course of the feasibility investigations. These opportunities can be grouped as follows:

- Community development and social welfare
- Tourism
- Commercial and industrial
- Agriculture
- Skills training and capacity building
- Labour enhanced construction
- Materials procurement
- Logistics and communications
- Electrification
- Roads and transport

It is considered highly probable that the National Government can realise many of its policy objectives such as poverty alleviation, local economic development, job creation and empowerment through regional development opportunities arising from the TWP.

Another important component of facilitating regional development was to gain a thorough understanding of bulk water supply for domestic and industrial use in the greater Ladysmith/Emnambithi area. This investigation was necessary in order to take full cognisance of future water requirements of this area, the main in-basin water user. The product of this investigation, funded by the DWAF, was a comprehensive assessment of the bulk water supply options for the area.

However, it is evident that a special effort will be required to ensure that the benefits arising from the TWP are optimised for the people of the uThukela Region and KwaZulu-Natal. This can be achieved by close co-operation between the DWAF, the uThukela District Municipality, the Provincial Office of the Department of Land Affairs, the KwaZulu-Natal Department of Traditional Affairs and Local Government, the KwaZulu-Natal Department of Agriculture and Environmental Affairs, the Implementing Agent, and local business and labour organisations. This is necessary in order to align with existing development plans and even to formulate specific TWP spin-off strategies, for example, procurement policies, SMME policies and incentive schemes.

COMPONENT MAIN RESERVOIRS	Jana Dam	Mielietuin Dam
Cumulative catchment area (km²)	6 600	1 350
Cumulative mean annual runoff (million m³)	1 446	288
Storage in catchment upstream (million m³)	863	60
Total storage in dam reservoir (million m³)	1 500	350
Full supply level (masl) (note a)	RL 860	RL 1025
Type of dam (note b)	RCCG	RCCTH
Height of dam (m) (Planning definition) (Note c)	160	87
Spillway length (m) and type (note d)	165 FOCS	69 FOCS
Spillway flood peak discharges (m³/s) (Attenuated)		
1:200	4 400	825
Regional Maximum Flood	6 900	1 700
Peak Maximum Flood	12 800	4 200
Total freeboard (m)	11	9
Construction volumes in wall and tailpond dam		
Excavation (all materials incl rock) (million m³)	3.08	0.34
Drilling & grouting (m)	50 550	24 300
Concrete (million m³)		
Roller compacted	2.96	0.47
Mass (20 MPa)	0.61	0.01
Structural (25 MPa)	0.14	0.02
Reinforcing (metric tons)	12 000	1 920
Dam wall construction period (years)	5	3

PUMPING STATIONS AT DAMS	Jana to Colenso Junction	Mielietuin to Colenso Junction
Design discharge (m³/s)	10	5
Dam wall level - minimum (masl) (note a)	RL 737	RL 957
Terminal elevation (masl) (note e)	RL 1088	RL 1088
Number of main pumps (VSD) (note f)	5	3
Number of HL booster pumps (FS) (note f)	5	-
Number of LL booster pumps (FS) (note f)	5	3

AQUEDUCT PUMPING STATIONS	Rustenburg PS to Bethany	Bethany PS to Kilburn Dam
Forebay water level - minimum (masl) (note a)	RL 1061	RL 1211
Main pumps elevation (masl)	RL 1050	RL 1200
Terminal elevation (masl) (note e)	RL 1217	RL 1260
Number of main pumps (FS) (note f)	7	6
Number of booster pumps (FS)	7	-

AQUEDUCT (PIPELINES)	Jana to Colenso Junction	Mielietuin to Colenso Junction	Junction to Rustenburg PS	Rustenburg PS to Bethany	Bethany PS to Kilburn Dam
Design discharge (m³/s)	10+	5-	15	15	15
Pipeline nominal diameter (m)	2.4	1.8	3.0	3.0	3.0
Length of pipeline (km)	25.6	19.6	24.6	22.4	29.4

Note:

a masl = metres above mean sea level
RL = Reduced level
b RCCG = Roller Compacted Concrete Gravity Section
RCCTH = Roller Compacted Concrete Thick Arch Section
c Planning definition : height of Full Supply Level above river bed level
d FOCS = Free Overflow Central Spillway
e Terminal elevation : at the next forebay/pumpstation
VSD = Variable speed drive motor
FS = Fixed speed drive motor
HL = High level (eg Jana pump elevation RL900)
LL - Low level (eg Jana pump elevation RL780)

Jana Dam

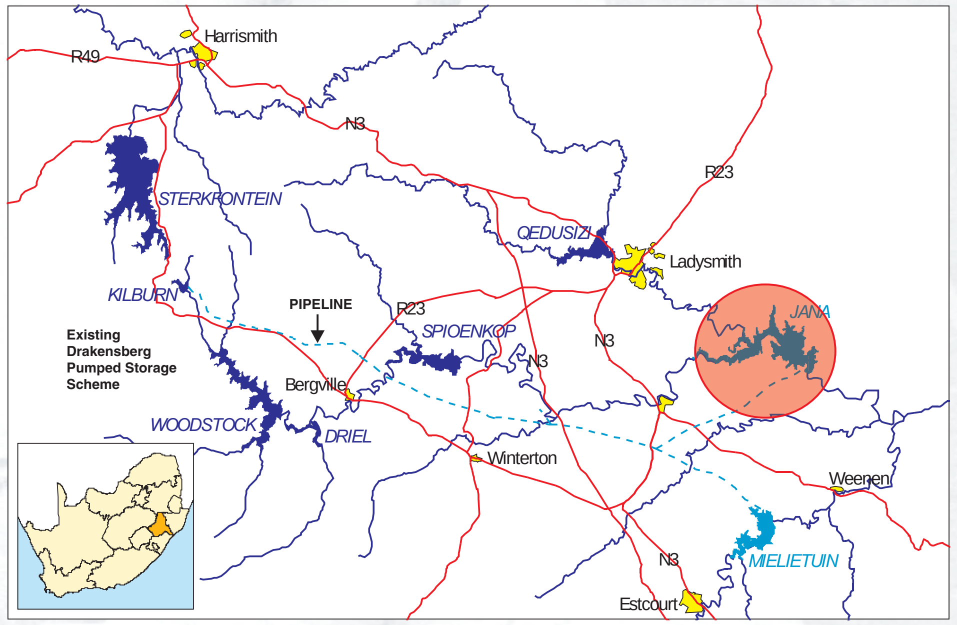
The Jana Dam site is situated in the Thukela River approximately 30 km south-east of Ladysmith and 15 km downstream of the confluence of the Thukela and Klip Rivers. The site is remote and the terrain rugged with steep valley sides.

The Roller Compacted Concrete Gravity structure will be founded on competent sandstone/ dolomite formations. Adequate sources of aggregate are located immediately upstream of the wall and well below the full supply level of the reservoir.

A central stepped ogee spillway with the possibility of a gated side channel spillway down the left abutment has been proposed. A model study of the spillway will need to be undertaken during the Design Phase in order to refine the design details by evaluating the hydraulic performance of the spillway and the competence of the downstream river bed and banks during major flood events. An option seriously considered during the Feasibility Study is the creation of a plunge pool behind a 40 m high tail pond dam.

The capital cost, i.e. excluding design, supervision, compensation and environmental costs, of Jana Dam has been estimated to be between R1.2 and R2 billion, depending on the final size and type of dam to be constructed.

Aerial view of dam site at Jana



Jana Dam Locality Map

first water must flow from the Thukela River to the VRS during the year 2011. This is the best available estimate of timing at the time of writing and any change may materially affect the programming of further work.

Labour enhanced construction

Aqueducts

View of open canal

An open canal was originally proposed to convey water from the storage dams to Kilburn Dam. However, affected parties in the Thukela River Catchment voiced their concerns, primarily environmental, over this method of conveying water. A steel pipeline was investigated as an alternative during the Feasibility Study.

The open canal would have a length of 183 km with three booster pumping stations en route. In contrast, the route of the steel pipeline would be more direct (121 km) and only two booster pumping stations would be required. Although the less expensive steel pipeline is presently the recommended alternative, the open canal remains an option.

Aqueducts link the proposed dams and the existing Kilburn Dam from which water will be transferred to the VRS via the existing Drakensberg Pumped Storage Scheme. Three aqueduct options were investigated, viz:

- A single pipeline ranging from 1.6 to 3.4 m in diameter or double pipeline along the same route.
- Open canals (with limited lengths of tunnel, pipeline and inverted siphons).
- A combination of open canals and pipelines.

The overall length of the pipeline option from Jana and Mielietuin to Kilburn Dam would be 121km. This includes a tunnel (approximately 1 km long and 20 m deep) about 12 km east-south-east of Kilburn Dam.

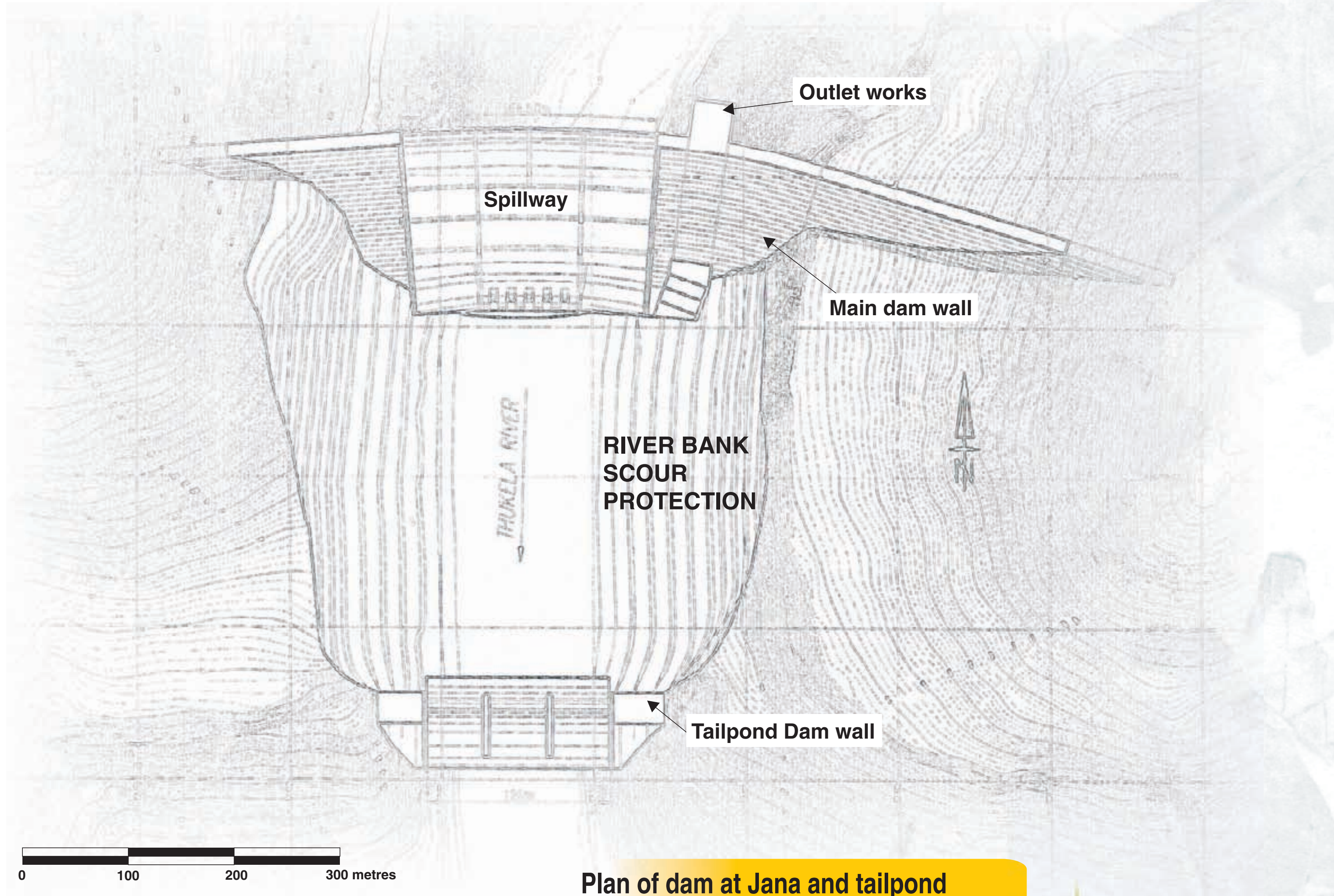
A 30 m fenced construction servitude is envisaged. A permanent unfenced servitude of approximately 20 m would be required after construction, without a permanent service road. The pipeline will be covered by approximately 1.8 m of soil. Large on-site construction housing camps are not envisaged. Accommodation for the work force should be situated in existing towns wherever possible.

The construction time associated with a pipeline aqueduct is likely to be about three years. The aqueduct can be sub-divided into a number of contracts, probably five. Pipe laying would proceed at a rate of about three weeks per kilometre. The construction of the pipeline aqueduct would also include the construction of valve chambers, crossings under roads and railways, scour outlets and river crossings, water hammer protection devices, flow metering equipment and inspection access facilities. There would be a pump station at each dam plus two intermediate pumping stations along the route of the pipeline.

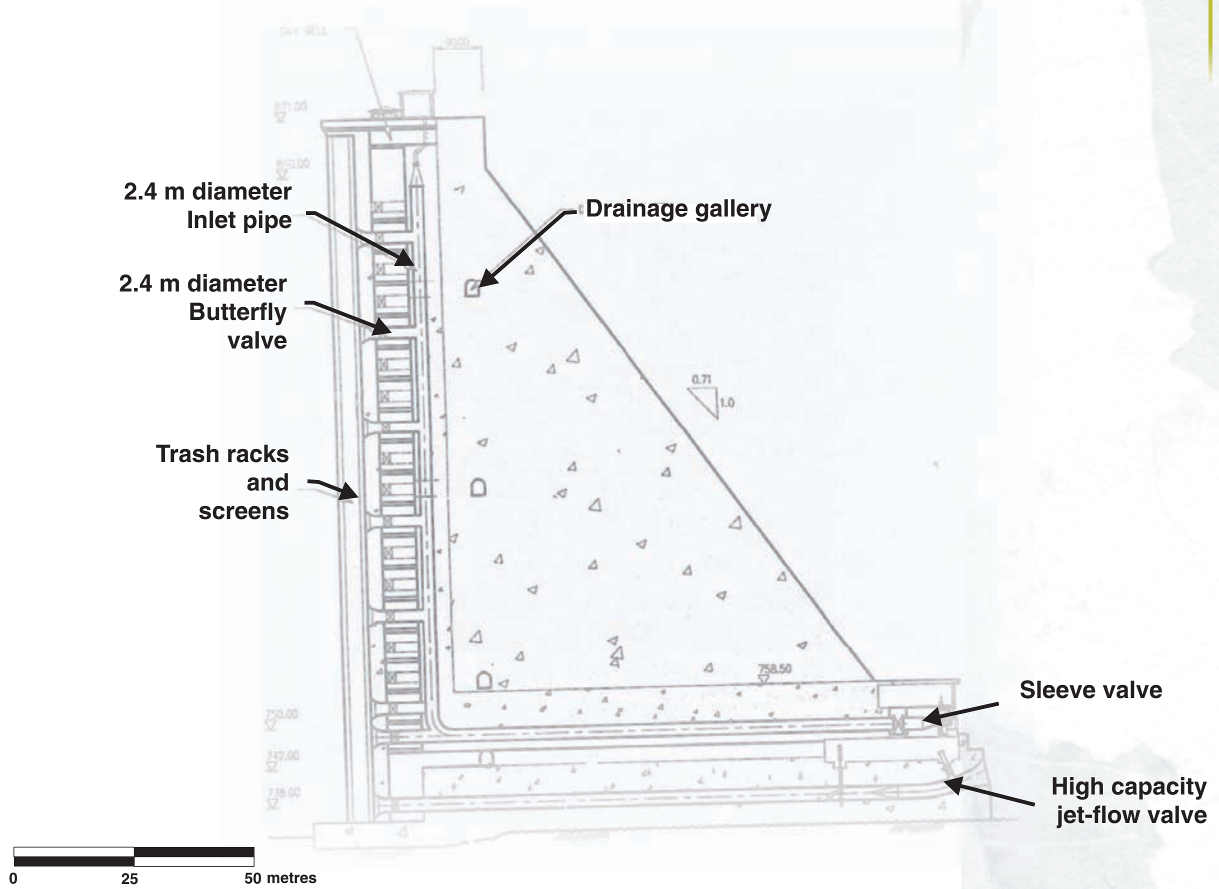
Importantly, because of spare capacity at Eskom's Drakensberg Pumped Storage Scheme, no additional pumping capacity is required to transfer water from Kilburn Dam to the VRS. Not only does this increase the efficiency of the use of existing infrastructure, it represents a significant capital saving.

Construction of the TWP could take eight to ten years to complete. The date of commencement would depend on the growth in water demand in the VRS, and the suitability of the TWP when compared to other strategic alternatives. At this stage, indications are that construction of ancillary infrastructure, for example, access roads and electrical power supply could start in 2003 at the earliest.

If a decision is made to proceed with construction of the TWP, the timing of detailed investigations, design and construction, is based on the assumption that the



Plan of dam at Jana and tailpond



Typical section through outlet works

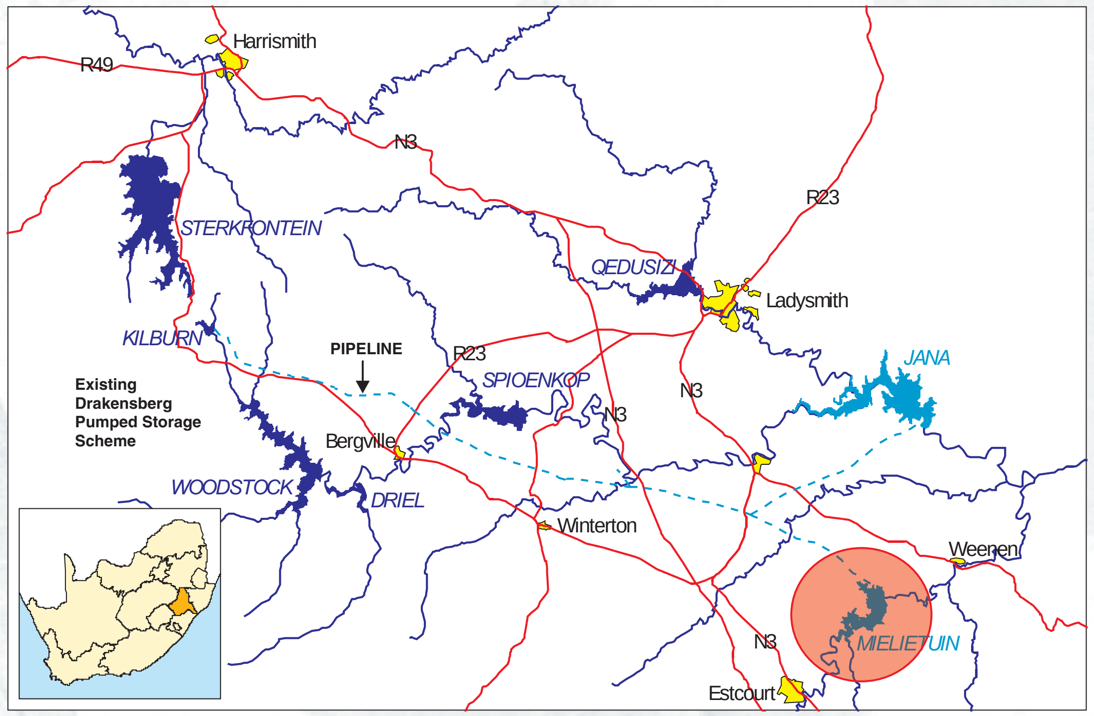
Mielietuin Dam

Proposed Mielietuin Dam site

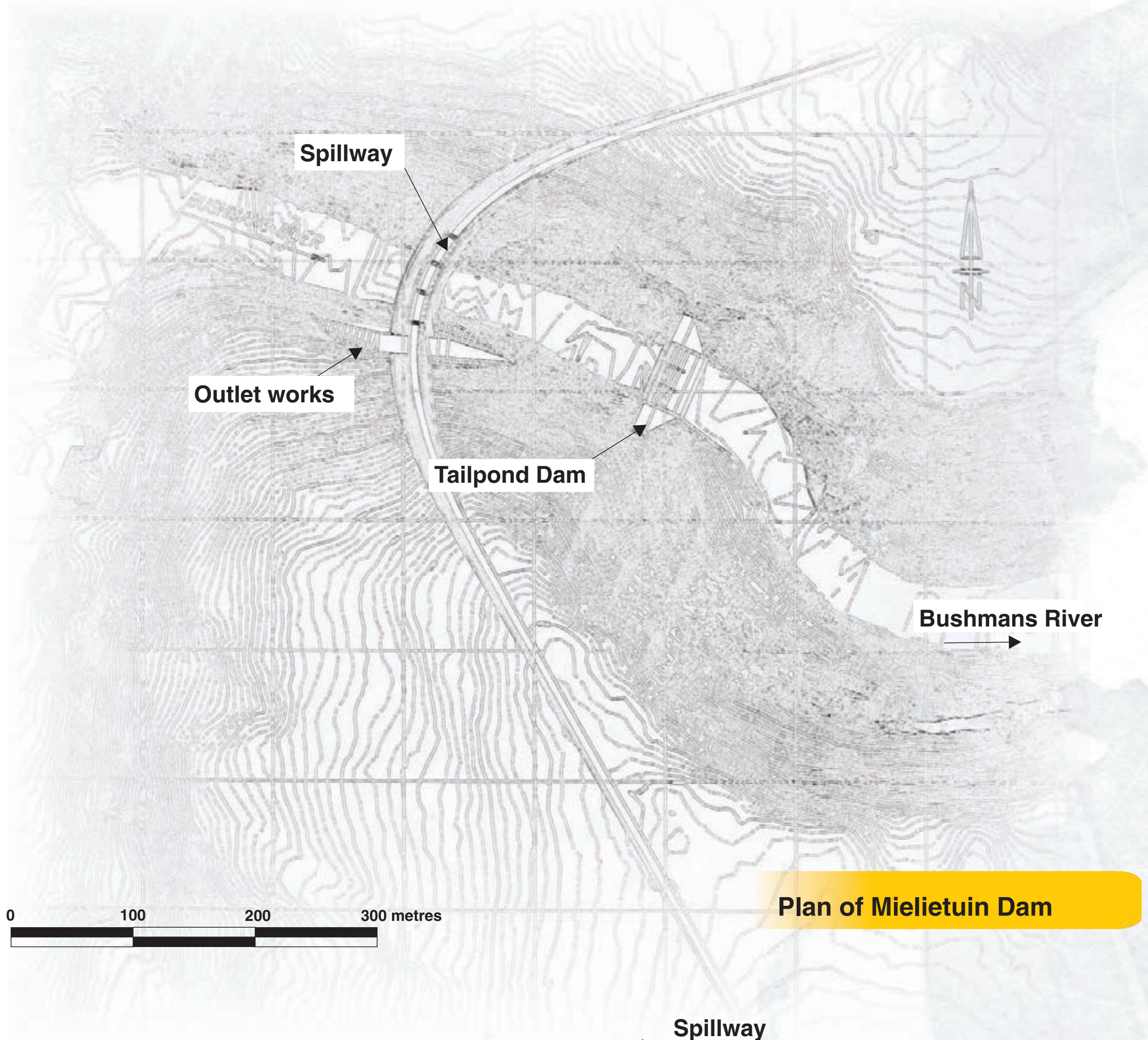
The Mielietuin site is situated between Weenen and Estcourt at a narrowing of the Bushmans River valley immediately to the west and upstream of the Weenen Nature Reserve. The area in which the site is located is reasonably accessible and the basin is relatively flat. The gradients of the valley sides are only steep in the immediate vicinity of the wall site.

Exploration drilling has revealed a massive, competent, unweathered dolerite sill underlying the wall site. Once out of the 90 m deep gorge, the more gently sloping flanks are capped with shallow sandstone. Rock formations suitable for construction aggregates are readily available to construct a Roller Compacted Concrete Arch dam, with an uncontrolled central ogee spillway and Roberts splitters discharging into a tail pond. Although outlet works will be included in the wall itself, intake works for transferring water will be in a separate tower situated about 1 km upstream of the wall.

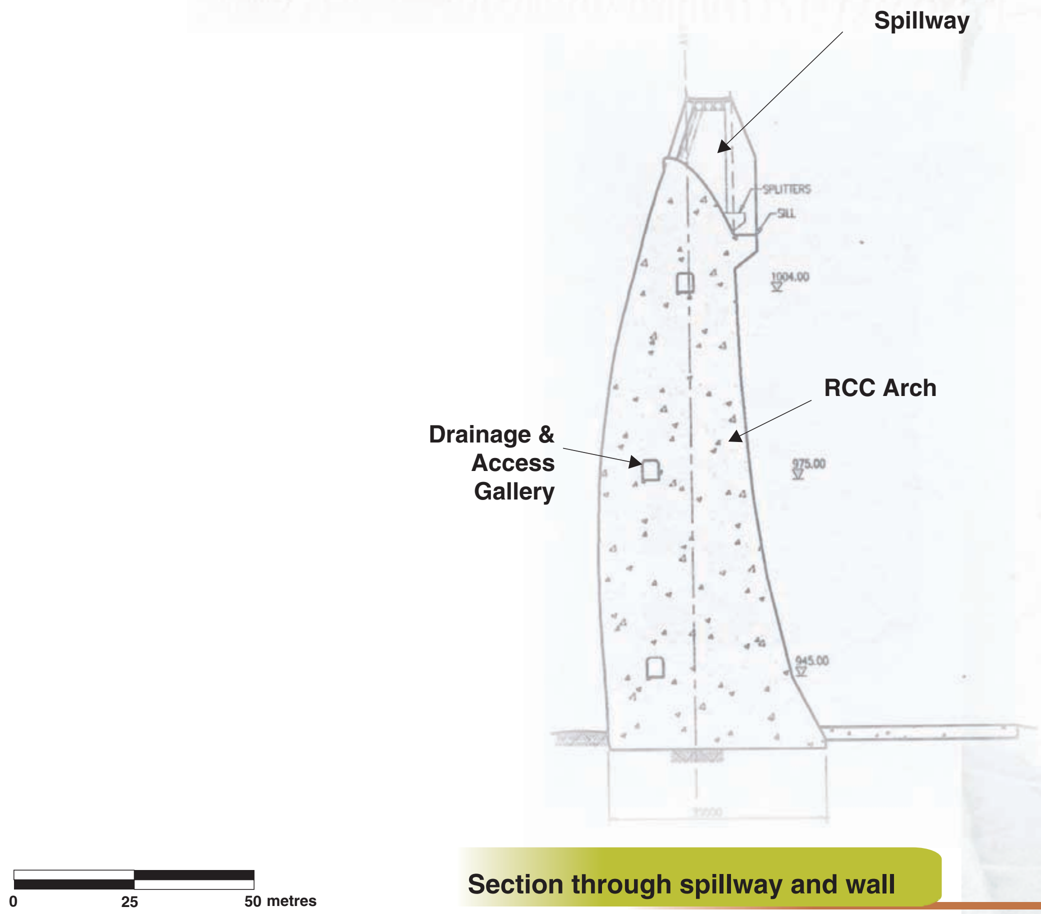
The capital cost, i.e. excluding design, supervision, compensation and environmental costs, of Mielietuin Dam has been estimated at between R300 and R400 million, depending on the final size of dam to be constructed.



Mielietuin Dam Locality Map



Plan of Mielietuin Dam



Section through spillway and wall