DEPARTMENT OF WATER AFFAIRS & FORESTRY

PROJECT W8147/03

The Assessment of Water Availability in the Crocodile (West) River Catchment by means of Water Resource Related Models in Support of the Planned Future Licensing Process

INCEPTION REPORT

MAY 2006

BKS

ARCUS GIBB

in association

Schoeman & Vennote

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Africa Geo-Environmental Services

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LIST OF STUDY REPORTS

THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOT THE CROCODILE (WEST) WATER SUPPLY SYSTEM:	REPORT NUMBER	
	DWAF	BKS
Inception Report	**P WMA 03/000/00/3307**	**H4125-01**
Summary of Previous and Current Studies	P WMA 03/000/00/3408	H4125-02
Current and Future Water Requirements and Return Flows and Urban Water Conservation and Demand Management	P WMA 03/000/00/3508	H4125-05
Water Resource Reconciliation Strategy: Version 1	P WMA 03/000/00/3608	H4125-06
WRPM Analyses	P WMA 03/000/00/3708	H4125-07
Executive Summary	P WMA 03/000/00/3908	H4125-09
Water Requirements and Availability Scenarios for the Lephalale Area	P WMA 03/000/00/4008	H4125-10

This report is to be referred to in bibliographies as:

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The Development of a Reconciliation Strategy for the Crocodile (West) Water Supply System: Inception Report

Prepared by the Consultant: BKS (Pty) Ltd in association with Arcus Gibb (Pty) Ltd
Report No. P WMA 03/000/00/3307

Title:	***Inception Report***
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Project Name:	*The Development of a Reconciliation Strategy for the Crocodile West Water Supply System*
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THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE CROCODILE WEST WATER SUPPLY SYSTEM: INCEPTION REPORT (FINAL)

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APPENDICES

ABBREVIATIONS

CMA	Catchment Management Agency
CWMS	The Assessment of Water Availability in the Crocodile (West) River Catchment by Means of Water Resource Related Models in Support of the Planned Future Licensing Process
CWRS	The Development of a Reconciliation Strategy for the Crocodile West Water Supply System
DWAF	Department of Water Affairs and Forestry
EIS	Ecological Importance and Sensitivity
GWS	Government Water Scheme
I&APS	Interested and affected parties
ISP	Internal Strategic Perspective
IWRP	Integrated Water Resources Planning
MAP	Mean annual precipitation
MAR	Mean annual runoff
MAE	Mean annual evaporation
NWRCS	National Water Resources Classification System
NWRP	National Water Resource Planning
NWRS	National Water Resource Strategy
PES	Present Ecological status
PMC	Project Management Committee
PP	Public Participation
PSP	Professional Service Provider
RDM	Resource Directed Measures
RFS	Crocodile (West) River Return Flow Analysis Study
SDA	Sewage drainage areas
STM	Study Team Meeting
STW	Sewage Treatment Works
TOR	Terms of Reference
URV	Unit reference value
WCDM	Water conservation and demand management
WMA	Water Management Area
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSA	Water Service Authorities
WSAM	Water Situation Assessment Model

1. INTRODUCTION

BKS (Pty) Ltd (lead Consultant) and Arcus Gibb (Pty) Ltd (support Consultant) have been appointed by the Department of Water Affairs and Forestry (DWAF) to undertake a study to develop a reconciliation strategy for the Crocodile (West) River Catchment water supply system, hereafter referred to as the *Crocodile West Reconciliation Strategy* (CWRS). BKS and Arcus Gibb have also been appointed to execute a related study namely "*The Assessment of Water Availability in the Crocodile (West) River Catchment by Means of Water Resource Related Models in Support of the Planned Future Licensing Process",* hereafter referred to as the Crocodile West Modelling Study (CWMS). The CWMS will generate much of the information that is required for the execution of the CWRS, and the studies will therefore have to be executed in close liaison with each other.

2. SCOPE OF WORK

2.1 OBJECTIVE

The study follows on the National Water Resource Strategy (NWRS) and the Internal Strategic Perspective (ISP) that was developed by the DWAF for, amongst others, the Crocodile (West) River Catchment. The development of the ISP made it clear that a more detailed water resource management strategy has to be developed for the catchment to ensure that it is managed effectively and efficiently.

Cognisance is also taken of the Crocodile (West) River Return Flow Analysis Study that had earlier been undertaken in the catchment.

The objective of this CWRS is to formulate a detailed strategy for water resource management in the Crocodile (West) River Catchment, based on the best available information and knowledge. The strategy will address both water quantity and water quality.

The formulated strategy should allow decisions to be made at various levels of decision-making and at varying confidence levels as more information becomes available. This will steer the course of action for ongoing successful reconciliation of water requirements and supply.

The study will review future water requirements, including efficiency of use, and all the options available to meet those requirements. The study will identify the most favourable augmentation options and a programme of feasibility studies, actions and decisions. This will all form part of the eventually recommended Strategy to improve the operation and planning of the system, and to ensure that the necessary infrastructure or other interventions are implemented timeously so as to ensure that future water requirements can be adequately supplied.

The strategy development will be divided into two versions, i.e Version 1 and Version 2. Version 1 of the Strategy, will be based on existing information, followed by more detailed investigations to improve on the water requirement scenarios, to develop options for the Reserve, to update the most promising options, to evaluate the constraints and uncertainties that could influence the Strategy and to adapt the actual Strategy.

The Strategy will contain agreement on water requirement scenarios, potential augmentation scenarios for the CWRS area, as well as recommendations for the next supply augmentation option(s) for study and implementation. It will show the required actions, assign responsibilities and will contain an implementation programme.

The Strategy will be a living and dynamic document that will be reviewed regularly. This will be done when further investigations have been completed, making better information available, as well as when new developments are completed and come on line. The Strategy will also identify monitoring mechanisms to be put in place to guide future updates and will set out a process for updating.

2.2 STUDY TASKS

The study consists of the following tasks:

- Task 1: Project Management
- Task 2: Inception report
- Task 3: Summary of Previous and Current Studies
- Task 4: Preliminary Screening Workshop
- Task 5: Current and Future Urban Water Requirements
- Task 6: Urban Water Conservation and Demand Management (WCDM)
- Task 7: Opportunities for Water Re-use
- Task 8: Reserve Requirement Scenarios and Scheme Yields
- Task 9: Groundwater
- Task 10: Review Schemes and Update of Cost Estimates
- Task 11: Review of Assess Social and Environmental Impacts
- Task 12: Assembly of Information and Formulation of Scenarios
- Task 13: Develop and Evaluate a Strategy
- Task 14: Final Screening Workshop
- Task 15: Public Participation
- Task 16: Berg River Study Groundwater Review (discontinued)
- Task 17: Berg River Reconciliation Strategy Review
- Task 18: Co-ordination with other Consultants

In the Terms of Reference 15 tasks were originally included. During the course of the execution of the studies three additional tasks were included. Initially the PSP was requested to include "*Task 16: Berg River Study Groundwater Review*". The initial idea was that the different PSPs would review each other's work similarly as was proposed for the hydrological analyses. This task was later discontinued and the groundwater tasks will be reviewed internally by the Depertment.

"Task 3: Current and Future Urban Water Requirements" of the Terms of Reference, comprising of the following sub-tasks:

- Determine if other studies have been undertaken and can add value to the DWAF water usage database;
- Review the DWAF water usage database and update with 2001 Census data;
- Determine the need to update population and water usage projections made for the National Water Resources Strategy.

required the PSPs conducting the Reconciliation studies (i.e in the South, Central, North and East) to co-ordinate their effort and build on a uniform approach dealing with population projections and urban water usage of which the approach could be explored further and finalised in the Inception Phase of the study. It was therefore decided that to ensure uniformity, the PSPs should review each others work, hence the inclusion of "*Task 17: Berg River Reconciliation Strategy Review*".

Further, according to the Terms of Reference "Task 1: Summary of Previous and Current Studies" the PSP was required to Identify and liaise with all organisations and consultants currently engaged on studies of the affected areas of the Water Management Areas, in order to include the most up to date information. Consequently "*Task 18: Co-ordination with other Consultants*" was added.

2.3 APPROACH

The Crocodile (West) River Catchment is a complicated and complex water resource management area. Water is imported from the Vaal River for domestic and industrial use. The resultant return flows form an important part of the water balance, and also the water quality situation. Some of this water is exported to other catchments further downstream, and the whole catchment is in a delicate balance, where disturbance of one part may have far-reaching implications elsewhere in the catchment.

The approach will therefore be to take great care to determine all the relationships and interrelationships that exist in the catchment as well as linkages to adjoining Water Management Areas (WMAs). The way to do this will be in the form of a "bottoms up" (ensuring that information and details about constituent parts are accurate and complete), as well as a "top down" (ensuring that overall national and regional objectives are met).

Key issues in the catchment that will be taken into account during the study are:

- extensive and increasing urbanisation,
- growing effluent returns,
- mining developments,
- the need to synchronise water resource strategies with growth and development plans,
- large interbasin transfers - the importation of water needs to be optimised, and the potential to export to other catchments (e.g. the Mokolo River catchment) considered,
- the effect of return flows, urbanisation, industry and agriculture on the quality of water,
- the fact that the Crocodile River is part of the Limpopo River basin, which is an international river, and
- the need for monitoring, control and policing.

The Study Team is aware of the fact that the DWAF is in the process of establishing a Catchment Management Agency (CMA) for the Crocodile/Marico Water Management Area, and that a number of institutional structures have already been put in place. The Study Team intends to use these structures as far as is possible during the public consultation process. Should the CMA be established during the execution of this study, it will be the intention to involve the CMA Board and the Chief Executive Officer at the earliest possible opportunity, to the extent that they can become involved.

3. STUDY EXECUTION

3.1 TASK 1: PROJECT MANAGEMENT, CO-ORDINATION AND ADMINISTRATION

The Project Manager for the study is Mr CFB Havenga of the DWAF: National Water Resource Planning (NWRP). The Study Leader of the Consultants will report directly to the Project Manager, and in turn will be responsible for the various Task Leaders.

The Project Manager will chair the meetings of the Project Management Committee (PMC), which will be attended by the Study Leader and Project Administrator of the Consultants, the Task Leaders and any other members of the Study Team as may be required at the time. The Project Leader for the CWMS will also attend these meetings. The Study Team will be responsible for organising the meetings of the PMC and keeping minutes.

The CWMS and CWRS projects take place in the same study area over the same period and involve many of the same people (from DWAF, in the Study Teams, and in the stakeholder bodies). The two projects also interlink with each other on key aspects. In

order to utilise resources efficiently, it has therefore been agreed that, although the projects have independent contractual arrangements, the PMC meetings of the 2 studies will be combined. Only one PMC had been established. The PMC members will discuss both projects in the same meetings.

A joint PMC consisting of the following members had been established:

- Mr Beyers Havenga (DWAF: National Water Resource Planning) Project Manager
- Mr Albert Jeleni (DWAF: National Water Resource Planning)
- Mr Rens Botha (DWAF: Gauteng Regional Office)
- Mr Elias Nel (DWAF: Hydrology)
- Mr Petrus Venter (DWAF: Gauteng Regional Office)
- Ms Nana Mthethwa (DWAF: Hydrological Services)
- Dr Beason Mwaka (DWAF: Water Resource Planning Systems)
- Mr Gregory Paszczyk (DWAF: National Water Resource Planning)
- Mr Pieter Viljoen (DWAF: Water Resources Planning Systems)
- Dr Thinus Basson (Project Leader: CWRS)
- Mr Johan Rossouw (Project Leader: CWMS)
- Mr Craig Schultz (Deputy Project Leader: CWMS and CWRS)
- Ms Andriëtte Hoek (Project Administrator: CWMS and CWRS)

Some PMC meetings had already been held since the commencement of the study. A written progress report will be prepared for each PMC meeting.

In addition to the PMC meetings, Study Team Meetings (STM) consisting of the DWAF Project Manager, the Study Leader and additional team members as specifically required will be scheduled as the need arises. Some STM meetings were already held since the commencement of the study. The Study Team will arrange Project Team Meetings as required. These meetings will be attended by the members of the Study Team, but the DWAF Project Manager is welcome to attend, if required.

3.2 TASK 2: INCEPTION REPORT

The purpose of this Inception Report is to confirm, update and refine the scope of work, methodology, programme and budget as presented in the proposal, after an assessment of the available information has been completed. This Inception Report will form the basis of the Scope of Work required for the rest of the project.

3.3 TASK 3: SUMMARY OF PREVIOUS AND CURRENT STUDIES

The objective of this task is to provide a compilation of the most up to date water related information. This task overlaps with the information-gathering component of the CWMS. The core difference between the information gathering components of the two projects is that the CWMS will provide most of the historic and present day information with emphasis on the input requirements for the calibration of hydrological models. The emphasis of this task therefore shifts towards information gathering for the planning and development of integrated, sustainable schemes for bulk water supplies to reconcile imbalances between water resources and water requirements. The urban water use and projected future requirements will include rural domestic water use and requirements. Water use and projected future water requirements for industrial and mining related activities will also be obtained, where relevant.

Information listed will be abstracted from the previous and current studies with the emphasis on the present day information and projected future conditions.

Methodology

All previous studies will be identified, listed and reviewed. Organisations and consultants currently engaged in studies in the study area will be identified. The current studies and their expected outcome will be included in the study document.

The relevant previous and current studies will be used to abstract the latest present day and projected future water requirement and water use information. Attention will be given to the geographical distribution in the study area as well as adjacent areas and areas affected by inter-basin transfers. Historical water requirements will be obtained as part of the CWMS.

- Present urban (and rural, where relevant) domestic water use as well as the projected growth in domestic water requirements will be abstracted from the reports with emphasis on the Crocodile (West) River Return Flow Analysis Study. The information will include where the demand is placed on the system as well as the abstraction pattern and source of supply. Since most of the water used to satisfy domestic requirements is supplied via water transfers from adjacent areas, the amount and position of urban return flow will be extremely relevant. Special emphasis will be placed in quantifying the urban return flows. According to the Water Resources Situation Assessment (Report No. P WMA03000/00/0203), a difference exist between the capacities of some of the water treatment works of Rand Water and Magalies Water and the raw water allocated to these works. The differences will be listed.

- Present irrigation requirements and return flows, as well as projected future requirements and return flows will be abstracted from previous studies with emphasis on the Crocodile (West) River Return Flow Analysis Study. Supporting information such as the location, area and crop types and irrigation method will be obtained from Task 2: Agricultural Assessment of the CWMS. Various controlled irrigation schemes are present in the Study Area. These are either Government Water Schemes (GWS) or irrigation boards and details of the schemes will be obtained. According to the *Water Resources Situation Assessment* (Report No. P WMA03000/00/0203), a difference exists between the areas schedule for irrigation and the actual areas irrigated. These differences will be quantified. Most of the irrigation schemes distribute the water from the dams via canal systems. Potential transfer losses will also be determined.
- Present industrial and mining related activities, as well as projected future water requirements and return flows will be obtained from previous studies with emphasis on the *Crocodile (West) River Return Flow Analysis Study*. This relates only to water requirements that do not form part of the urban water supply system. If the industrial and mining activities are supplied as part of the urban water supply network, the requirements will be treated as part of the urban water requirements.
- No licensed afforestation is present in the Study Area. According to the *Internal Strategic Perspective Study* (Report No. P WMA 03/000/00/0303), licences for afforestation (streamflow reduction activity), will not be issued in the Crocodile (West) and Marico WMA, because the area is not climatically suitable for forestry. The presence or absence of forests will be confirmed as part of this study.
- The impact of invasive alien vegetation on the water resources availability of the Study Area is not well understood as mentioned in the *Internal Strategic Perspective Study* (Report No. P WMA 03/000/00/0303). The Working for Water Programme and local Water Forums have been very active in removing invasive alien vegetation along watercourses in this catchment, but not enough data have been documented. The Working for Water Programme will be contacted to obtain any new information, since the publication of the *Internal Strategic Perspective Study* Report. The catchment areas invaded by alien vegetation will be quantified and divided into riparian areas and inland catchment areas invaded by alien vegetation. Where possible the impact of the alien vegetation on the available water (streamflow reduction) in the study area will be quantified.

- A complex water infrastructure network exists, with most of the water requirements supplied by two major water boards (Rand Water and Magalies Water), which source water from the Crocodile (West) River catchment and from the Upper Vaal Water Management Area. Water is also imported from the Olifants River catchment to Cullinan for urban use and for use on the Premier Diamond mine. Information on the existing water supply infrastructure will be obtained, including Regional Water Supply schemes and sub-catchment related infrastructure (dams, controlled irrigation schemes and wastewater treatment works). Attention will be given to inter-basin and intra-basin water transfers (imports and exports) and return flows. Task 10: Review schemes and update cost estimate, will determine the effect of possible future transfer schemes from the Crocodile River WMA to neighbouring catchments.
- The latest hydrological information from the previous studies will be obtained per quaternary catchment and smaller sub-catchments as needed in the project. The CWMS will provide most of the historical information with emphasis on the input requirements for the calibration of hydrological models. This task will therefore only list the latest hydrological information (i.e. catchment areas, MAP, MAE and present day MAR).
- Groundwater resources are available throughout the entire Study Area. The quantities available are determined by the hydrogeological characteristics (prevailing lithology) of the underlying aquifer. The study area is underlain by hard rocks with aquifers developed in secondary features associated with weathering pockets and structure. The groundwater resources and issues associated with the use of groundwater will be discussed according to groups of quaternary catchments sharing similar lithology and morphological characteristics, taking cognisance of the fact that quaternary catchment boundaries were determined according to drainage regions (surface features) and do not correlate with the groundwater aquifers (The aquifers in the Crocodile West catchment are shared with adjacent WMAs). Issues and concerns raised for example the reliability of groundwater resources will also be identified. Additional information from the groundwater task (Task 5: Groundwater Assessment) of the CWMS will be obtained.
- Relevant water quality information will be obtained for surface and groundwater resources. Information obtained from the DWAF database (WMS) and previous studies will be supported, where necessary, by additional data obtained from the Metropolitan Councils, Local municipalities, mines and industries. Possible impacts

(i.e. informal settlements, irrigation, return flows) and concerns raised will be identified.

- The Reserve requirement is the quantity and quality of water required to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No.108 of 1997) for people, who are now or who will, in the reasonably near future, be supplied from the relevant water resource; and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No.36 of 1998). The National Water Act calls for water resources to be classified. DWAF developed a classification that refer to whether the river should be left in a natural state (Class 1) or whether it can be used, provided there are protection mechanisms put in place to maintain ecological integrity (Classes 2 and 3). As part of the Internal Strategic Perspective study (Report No. P WMA 03/000/00/0303), a Desktop Reserve Study has been conducted for the whole catchment. This desktop level ecological water requirement flow regime was then used to determine the available yield and the yield balance in the whole Crocodile River (West) catchment as has been reflected in the *National Water Resource Strategy*. An *Intermediate Reserve Study* was completed for the Apies/Pienaars River catchment. The study factored the Basic Human Needs Reserve into the urban and rural water requirement component. The Desktop Reserve requirements will be included in the report for this task and will be evaluated and revised as part of Task 8: Reserve requirement scenarios and impact on water availability.
- Section 3.2.3.13 of the NWRS makes provision for water use of strategic importance, according to Section 6(1) (b) (iv) of the National Water Act. These are uses that are considered to be of such critical importance to the nation that they must be authorised by the Minister rather than by a Catchment Management Agency and include the transfer of water from one water management area to another and water that is taken from a water resource for the purpose of generating electricity for the national supply or is stored at Eskom power generation facilities. Both these water uses are present within the study area and the present and future water requirements thereof will be quantified.
- Operating rules of water schemes can impact significantly on the available water (yield) in a system. The present operating rules of the regional and sub-catchment related water schemes will be identified and the total yield, transfers in and out of the study area, water requirements, return flows and water available will be abstracted

from previous reports for present day conditions. Previous reports will also be used to identify potential future operating scenarios, to optimise the operation of the system.

- Climate change (still a controversial subject) can potentially impact on the rainfall amount and variability, which will affect antecedent soil moisture, water requirements, water availability and scheme yields. The latest information available on climate change and the potential impact will be obtained. An example of the type of study that will be investigated is: Assessment of the Impact of Climate Change on Hydrology and Water Resources in South Africa: (Report to South African Country Studies for Climate Change Programme), School of Bioresources Engineering and Environmental Hydrology, University of Natal, Pietermartizburg, ACRUcons Report 33 January 2000. Schulze, RE; Perks, LA.
- The National Water Conservation and Demand Management (WCDM) Strategy is based on three principles:
    - Water institutions should strive to supply water efficiently and effectively, minimise water losses, and promote WCDM among their consumers;
    - Users should not waste water, and should strive to use it efficiently; and
    - WCDM should be an integral part of water resources and water services planning.

  Significant water losses, estimated to be as much as 30% of the total water requirements, are experienced in the WMA. WCDM strategies should strive to reduce these losses. Most of the water use in the WMA is supplied from the Vaal River system which is augmented by transfer schemes from, *inter alia*, the Orange (Lesotho Highlands), the Usutu River and the Thukela River. WCDM is therefore important to delay further costly augmentation schemes. Water conservation measures must also be concentrated on return flows from northern Johannesburg and Tshwane as well as on irrigation return flows as an important source for possible developments and for re-use in urban, industrial and mining activities. In areas of the catchment (e.g. Rustenburg) local water resources are under-utilised while water is imported via the Rand Water bulk water supply scheme. Areas where local resources are under-utilised will be identified together with possible interim and long-term development scenarios. WCDM strategies proposed in previous studies will be identified and discussed in an attempt to understand the impact of the proposed strategies. Additional supporting information will be obtained from Task 6: Urban Water Conservation and Demand Management.

- Current and potential water re-use in the study area will be identified. A distinction will be made between direct re-use (e.g. use of treated effluent from Johannesburg Northern Water Treatment Works at the Kelvin Power Station) and indirect re-use (re-use of return flows). Water re-use must be seen in conjunction with WCDM that concentrates on the re-use of return flows. The impact of current legislation, specifically the attempt to reduce discharges, on the availability of water for re-use will be quantified. Task 7: Opportunities for Water re-use, will assess opportunities for direct re-use of water.
- Unutilised water allocations, specifically irrigation and domestic allocations, will be identified, and possibilities to trade these allocations will be investigated.
- Potential interim and long-term surface and groundwater schemes will be identified, based on existing information. The development of local water resources as well as potential water transfer schemes from adjacent WMAs will be investigated. In areas where the local water resources are not optimally utilised or developed, the emphasis will be on potential local schemes. As far as possible this will include potential yields, the likely impact of the Reserve on yields, Unit Reference Values (URVs) including bulk distribution costs and adjustments for escalation, time for implementation, social and environmental impacts and mitigation measures, as well as other impacts, concerns or uncertainties. Expert opinion will be utilised to provide missing information and information on any new schemes not previously identified.
- The re-use of return flows will result in an increase in the salinity of the Crocodile River system. The possible use of desalination to solve potential problems and the costs thereof will be considered.
- Other potential importation schemes will be identified, but since the local resources are under-utilised and transfer schemes are costly, attention will rather be given to optimising the use of local resources (including groundwater) and return flows.

Shortfalls/gaps in the information abstracted will be identified. Outdated information will also be noted.

Deliverables

The information abstracted from the previous studies will be used to compile a report that will be used at the Preliminary Screening Workshop. Information obtained at the meeting and during the course of this project will be used to compile the final (second) report.

3.4 TASK 4: PRELIMINARY SCREENING WORKSHOP

A Preliminary Screening Workshop took place on 27 March 2006. The purpose of the workshop was be to present the information collected by that date, and to identify the main issues and concerns and to screen out those options that should not be given further consideration in the study.

A document consisting of a summary of the previous and current work in the study area, the key issues, possible scenarios, broad strategies, and a plan of study was produced and distributed to the participants at the workshop.

Minutes of the workshop was prepared and distributed during April 2006 to all people who were invited to attend the workshop.

3.5 TASK 5: CURRENT AND FUTURE WATER REQUIREMENTS

The objective of this task is to determine the current and future water requirements for the Crocodile (West) catchment, by completing any shortfall/gaps in the water requirement information identified in Task 3. DWAF Regional Offices, relevant Metropolitan Councils, Irrigation Boards, Mines and Industries will be contacted to ascertain, verify and/or supplement the present and projected future water requirements, where necessary.

The Terms of Reference refers to Current and Future Urban requirements. Due to the complex nature of the catchment, the Study Team, however, believes that it is necessary to consider all sectors of water use, particularly mining (and the projected growth in mining), irrigation, rural water supply and groundwater utilisation for this task. Consideration will also be given to major return flows, as these form significant contributions to the water resources of the area. This task will still emphasise urban water requirements (and the projected growth in urban requirements) and associated return flow as the urban sector provides the dominant contribution to return-flows in the study area, particularly in the southern parts. The current trends of rapid population growth and urbanisation suggest that this influence is likely to grow. Separate supporting tasks will investigate irrigation water requirements and groundwater.

An important aspect of this task will be to liaise with the Study Team of the parallel CWMS to ensure that information is packaged at an appropriate level of detail from a spatial, temporal and accuracy perspective.

3.5.1 Task 5.1: Urban, irrigation, industrial, power generation and mining water requirements and associated return flow

The urban (and rural, where relevant) domestic water requirements, irrigation water requirements and industrial, power generation and mining related water requirements will be obtained from previous and current studies and summarised as part of Task 3.

Of these studies the *Crocodile (West) River Return Flow Analysis Study* (Report No P/WMA 03/000/000/0504) used the most up to date information. This information will be used where possible.

Methodology

Shortfalls and/or gaps in the present and projected future water requirements will be addressed as follows:

- Present urban (and rural, where relevant) domestic water use as well as the projected growth in domestic water requirements obtained as part of the *Crocodile (West) River Return Flow Analysis Study*, will be verified/updated by liaising with the Water Service Authorities and water users (i.e. Metropolitan Councils).
- The *Crocodile (West) River Return Flow Analysis Study* (Report No P/WMA 03/000/000/0504) used the 1987 irrigation areas to estimate irrigation requirements. The present irrigation requirements and associated return flows, as well as projected future requirements and return flows will be updated as part of Task 2 (Agricultural Assessment) of the CWMS. The updated information will be used in conjunction with the return flow model developed as part of the *Crocodile (West) River Return Flow Analysis Study* where possible.
- Present and projected future water use for industrial, power generation and mining related activities obtained as part of the *Crocodile (West) River Return Flow Analysis Study* will be verified and updated by liaising with relevant industries, power stations and mines.
- Most of the water used to supply domestic requirements is supplied via water transfers from adjacent WMAs. It is estimated that up to 52% of the water used to supply urban water requirements returns to the water resource system as return flow (*Water Resources Situation Assessment*, Report No. P WMA03000/00/0203). This is a significant part of the total water resource, and will be investigated in more detail in order to be quantified more precisely with regards to the sources and volumes of return flow. Particular attention will be given to the reports from the *Crocodile (West) River Return Flow Analysis Study* (Report No P/WMA 03/000/000/0504). Sewage drainage areas (SDAs) were identified for the larger sewage treatment works (STWs). Seven service categories as specified in the *NWRS* were used to determine effluent and wastewater runoff for each SDA. Estimates of return flow amounts were made up to 2020. Return flow models were developed for the urban, mining, industrial and irrigation sectors. These models will be used, where appropriate. The models do not cover some parts of the current study area, and will be extended to provide full coverage. Lack of access to complete and consistent data sets was identified as a source of considerable difficulty in developing the return flow models initially, and it is anticipated that it will require substantial resources to develop them for the additional areas. In addition, interviews will be conducted with the Metropolitan Councils and

Water Service Authorities to establish the return flow volume that can be anticipated over the planning horizon of the study. Interviews will be conducted where there is a high degree of uncertainty in order to determine the degree of variation that needs to be incorporated in the reconciliation scenarios. A structured database of return flow information will be developed, in order to link this with the DWAF water requirements database, as future return flows must relate to the populations in the different categories related to water use. It is recognised that this information is an important input to the modelling study, and different scenarios will need to be investigated over the course of the study.

It is expected that a linkage will need to be developed between the water use database and the outputs from the water conservation and demand management task, in order to provide consistent information at the appropriate resolution for the modelling study.

Deliverables

The updated/verified current and projected future water requirements and return flows per water user sector will be summarised in the task report.

A structured water use and return flow database will be produced. The information will be consolidated at an appropriate level for use in hydrological modelling.

3.5.3 Task 5.2: Review the Crocodile (West) River Return Flow Analysis Study (RFS) and update with 2001 Census Data

The objective of this task is to review, revise and update as necessary the *Crocodile (West) River Return Flow Analysis Study* (RFS) for urban and industrial/commercial water requirements drawing on population data from the census of 2001, and water requirements obtained from the census, Metropolitan Councils, Irrigation Boards, Mines and Industries. The RFS database will also be updated for the Crocodile (West) River catchment, if necessary.

This task will focus on comparing and then reconciling the estimates (population and water use) for 2001 that are currently in the RFS with the actual population figures and associated water use for 2001. Comparing population growth and water use projections will form part of Task 5.3.

Methodology

The RFS related the 1996 census Enumerator Areas (EAs) to the consumption centres used in the DWAF water use database. A detailed review, including a GIS analysis, of the Return Flow Study database, in relation to the census of 2001 for the Crocodile (West) River catchment will be performed as follows:

- The RFS population estimates were made available at five -year intervals starting in 2001
- Boundaries of some densely populated urban areas are known to have changed between 1996 and 2001, and there are incompatibilities in the coding and naming systems used between the censuses of 1996 and 2001. The boundaries, coding and naming system differences will be resolved.
- Information at enumerator area level was not released for the census of 2001 due to issues of confidentiality. The most detailed information is at "sub-place name" level. This may introduce uncertainties into the reconciliation process. Data obtained at a "sub-place name" level will be reconciled with the data used in the IWRP population estimates (enumerator area level). This will require substantial manual adjustments. Should enumerator area level information become available timeously, it will be used.
- Use will be made of the GIS analysis of the consumption centres from the *Crocodile (West) Return Flow Analysis Study* (P WMA 03/000/00/0804), where the "consumption centres" were related to the 1996 census boundaries.
- The population and water use projections for 2001, currently included in the DWAF water usage database, and the estimates generated by the *Crocodile (West) Return Flow Analysis Study* (P WMA 03/000/00/0804), will be compared with the actual population figures and associated water use for 2001.
- A recommendation on the need to update the population and water usage (i.e. to update the base year information in the RFS database) will be made based on the outcome of the actions listed above.

The RFS water usage database will be updated with population data from the 2001 census, if an update was the outcome of the recommendation given after reviewing the database.

Deliverables

Updated/verified IWRP population and water use estimates for 2001, for the Crocodile (West) River Catchment, focussing specifically on data that is relevant to this project. The processes followed and assumptions made will be detailed in the task report.

3.5.4 Task 5.3: Determine the need to update population and water usage projections made for the RFS

The RFS compared the figures used for the NWRS with population figures from the DWAF Chief Directorate: Water Services and provincial population projections obtained from the Development Bank of Southern Africa (DBSA, 2000). It was recommended that the NWRS population figures be used, however, the results of Census 2001 has become

available since. The purpose of this task is to review the population growth and associated water requirement projections used for the Crocodile (West) River catchment in the RFS (projections using 2001 as base year).

Water Usage Projections

Water requirements were determined for direct (domestic/residential) and indirect (non-residential) uses and projections were made for high and low population growth scenarios and base and high water use scenarios in the NWRS. These were compared with provincial population projections from the DBSA in the RFS, and the high scenario from the NWRS was found to correlate closely with the projection of the DBSA.

Direct (domestic) water requirements

The RFS followed the same conceptual framework as the NWRS, projecting domestic water use based on seven categories of direct domestic water use. The categories were originally determined based on four criteria, namely economic strata; types of housing; level of service provided and the extent of local authority records category. Per capita water use in the same category was regarded as uniform in different consumption centres (unless site-specific information was available), and water use projections were based on changes in population and the proportion of the population in the various categories.

Default water requirements were assigned to each of the categories (see **Table 3.1**). The water requirements were refined for areas where the Water Resources Situation Assessment Studies were able to obtain additional information. These categories were used in the assessment undertaken in the RFS. For comparison purposes, it is envisaged that the same categories will be used in **Task 5.3**.

Table 3.1: Population Categories and Default Water Requirements Supporting The Development of The NWRS and the RFS

Category number	Category description	Default water requirement (litre per capita per day)
1	Full Service: Houses on large erven >500m^2	320
2	Flats, Town Houses, Cluster Houses with full service	320
3	Full Service: Houses on small erven <500m^2	160
4	Basic RDP houses and informal houses with water connection to site only but no or minimal sewerage service	90
5	Informal houses and shacks with service by communal tap only	10
6	No service from any water distribution system	6
7	Other/Miscellaneous (includes hostels, military camps, hospitals, schools etc).	90

Report P WMA 03/000/00/0804 also made an estimate of a more detailed spatial distribution of population based on the 1996 census Enumerator Areas, and correlated to Sewage Drainage Areas (SDAs). Land use information per SDA was then used to estimate the proportion of population in each of the seven categories. The "people per household" factors were adjusted until the population derived from the land use information correlated with the NWRS figures.

The RFS generated five scenarios of water requirements and return flows for the urban sector, incorporating both direct and indirect use. These scenarios were developed to provide an indication of the impact of the government policies with regard to poverty alleviation and service delivery as well as water conservation and demand management on water requirements and return flows. The scenarios are as follows:

- Scenario A: Growth in population according to the National Water Resources Strategy with no other changes in water requirements or factors except for growth in water requirements of the other land use at the same rate as the population growth;
- Scenario B (Intermediate): The same as Scenario A except for increase in levels of service of Categories 4, 5 and 6 to at least Category 3 by 2020;

- Scenario C: The same as Scenario B except for the improvement of services in some previously disadvantaged areas mainly through infrastructure improvement that will have an influence on the unit water requirement;

- Scenario D: The same as Scenario B with water conservation and demand management measures being implemented through for example increased tariffs; and

- Scenario E: The same as Scenario B except for increase in levels of service of Categories 4, 5 and 6 to at least Category 3 already by 2010.

Methodology

Census 2001 variables will be identified that can be used as proxies for water requirements, and will be used to perform an analysis of the distribution of population into the different water requirement categories. This will be input to the RFS scenarios.

The long-term population figures will be updated based on the best available long-term estimates of population e.g. the ASSA 2000 model. High and low population growth scenarios will be modelled based on the available information regarding recent relevant trends and processes. The figures will be distributed in detail to Census 2001 sub-place names based on a pro-rata modification of the RFS projections, as long-term population models provide information at provincial scale at best. An estimate of the distribution to Enumerator Areas can be made, but this lengthy process would add limited value as the Census 1996 has the recent information at this level.

Methods to refine the projection of domestic water requirements will be considered. The appropriateness of the categories of water requirement used in the NWRS and RFS will be re-examined. Another methodology that might be explored is to use the same proportional allocation of population to each water requirement category as in the IWRP projections. If the Census 2001 analysis indicates significant differences in the distribution of population into water requirement categories, this will be revisited. Another method is to link water requirements to economic groups rather than housing categories. If an alternative method is found to be more appropriate in relation to this study, the method will be adopted to update the estimates of water requirements in the RFS database.

The domestic water use projections based on the 2001 census will be compared with the domestic water use projections of the *NWRS* and the *Crocodile (West) Return Flow Analysis Study* (P WMA 03/000/00/0804). A recommendation on the need to update the domestic water use projections will be made.

Indirect Requirements Methodology

Indirect requirements are considered to be the sum of industrial, commercial, institutional and municipal requirements. The water usage projections used in the NWRS were

based on a linear relationship between the Gross Geographical Product (GGP) and the indirect water requirements. Growth of indirect water requirements was limited to a proportion of direct water requirements.

In the RFS, the indirect water usage projections were incorporated with the direct water use projections, citing the lack of separately available data. This approach will be re-examined as it constrains all projections to the assumption that direct and indirect water requirement growth will follow the same patterns. This is unlikely to be the case, particularly in scenarios B and C where service levels increase due to policy interventions.

Methodology

The most appropriate relationships for an indirect water requirements model will be considered. A literature review will be carried out. The RFS model will be examined, and its sensitivity to the use of the default NWRS per capita water requirements will be investigated as a first estimate of the possible contribution of indirect urban water requirements. If a suitable methodology is identified, the feasibility of implementation will be investigated with a view to updating the RFS if this is indicated.

Relevant literature on population growth, migration trends and on HIV/AIDS in the study catchment area will be reviewed. Available documents on development initiatives and service delivery planning will also be reviewed (e.g. Provincial Growth and Development Plans). These will be compared with the assumptions adopted in the preparation of the RFS scenarios, and the results of **Task 5.2** in order to develop a recommendation regarding the need to update the population and water usage projections.

Deliverables

The processes, assumptions, outcome of the review as well as recommendations on the need to update the domestic and indirect water usage projections in the NWRS will be included in the Task report.

3.6 TASK 6: URBAN WATER CONSERVATION AND DEMAND MANAGEMENT

The goal of Water Conservation and Demand Management is the efficient use of water by institutions and consumers in South Africa. The principles underlying the Water Conservation and Demand Management National Strategy framework are the principles governing the National Water Act (36 of 1998) and the Water Services Act (108 of 1997). These are Equity, Optimal Use and Sustainable Use. An additional principle relevant to this framework is Responsibility and Accountability.

The National Water Conservation and Demand Management (WCDM) Strategy is based on the following three principles:

1) Water institutions should strive to supply water efficiently and effectively, minimise water losses, and promote WCDM among their consumers.

2) Users should not waste water, and should strive to use it efficiently.

3) WCDM should be an integral part of water resources and water services planning.

Significant water losses, estimated to be 30% of the total water requirements, are experienced in the study area. Most of the water use in the study area is supplied from the Vaal River system which is augmented by transfer schemes from, *inter alia*, the Orange (Lesotho Highlands), the Usutu and the Thukela Rivers. Applying WCDM strategies in this WMA is therefore important to delay further costly augmentation schemes. It is important to bear in mind that return flows could be reduced by the implementation of these strategies. Most of the water used to satisfy domestic requirements in the Crocodile (West) River catchment is supplied via water transfers from adjacent areas and return flows from urban water use make up a significant portion of the water resource that is utilised by downstream water users.

This task will evaluate implemented and potential urban WCDM strategies for the Crocodile River (West) catchment. Task 2 (Agricultural Assessment) of the CWMS will determine potential agricultural WCDM strategies. The task will provide input to Task 12 (Formulate Scenarios) and overlaps with Task 13 (Reconciliation plan).

The sub-tasks with regard to assessing the WCDM will be as follows:

1) Assess WCDM strategies implemented within the Crocodile (West) River Catchment.
2) Liaise with the Municipalities (where appropriate) and the other water service authorities (WSAs) concerning the costs and benefits of the various WCDM interventions implemented to date, including the potential diminishing returns of extending some of the interventions (the 80/20 principle).
3) Update the costs and benefits of all interventions previously investigated by the WSA, including the implications of reduced effluent flows to wastewater treatment works.
4) Assess the costs and benefits of the interventions for other WSAs.
5) Assess the likely impacts of the various WCDM interventions on Metros and the other WSA's ability to apply various restriction measures during droughts (taking account of their recent experiences and proposed future WCDM measures).

3.6.1 Task 6.1: Assess WCDM strategies implemented within the Crocodile (West) River Catchment

The purpose of this task is to assess the relevant WCDM strategies within the Crocodile (West) River Catchment.

Methodology

WCDM strategies proposed in previous studies will be assessed in an attempt to understand the impact of the proposed strategies. In addition, it will be determined whether the Water Service Authorities (WSAs) have implemented WCDM interventions and whether the WSAs are monitoring and assessing the benefits of the various interventions on an ongoing basis. Interventions will be subdivided into three categories:

- Administration: Strategies such as pricing adjustments (including the decrease of subsidies), allocation (concerning prioritised users) and sales.
- Physical water supply scheme: Measures to address leakages and pipe bursts, controlling water pressures in the pipes and changing the supply from water purification plants.
- Household water usage: Strategies to ensure responsible domestic water use by means of educating the general public and dealing with household leaks.

3.6.2 Task 6.2: Liaise with the Municipalities (where appropriate) and the other water service authorities (WSAs) concerning the costs and benefits of the various WCDM interventions implemented to date, including the potential diminishing returns of extending some of the interventions (the 80/20 principle)

This task will concentrate on liaisons with Metropolitan Councils, local municipalities and Water Service Authorities to obtain information on costs and benefits of implemented WCDM strategies. Attention will be given to the current status of WCDM as well as intended and realistically expected future conditions.

Methodology

Appropriate questionnaires will be developed to supplement the information obtained as part of the Crocodile (West) River Return Flow Analysis Study (Report No P/WMA 03/000/000/0504), where necessary. Direct liaisons with relevant authorities will complement the questionnaires. Information, relating to the management of water from the raw abstraction point through the treatment process, bulk distribution and reticulation to the end use will be necessary, including the following:

- Population served in the district.
- Number of properties served (household connections)
- Assessment of the per capita consumption.

- Quantifying the amount of water lost through leakage.
- Actual and projected water demand figures, including the anticipated change in the demand due to improved efficiencies.
- Length of mains, age and pipe materials (well aged pipes of certain materials leak more than others)
- Zone boundaries including metered water supply zones, discrete pressure zones, reservoir distribution zones
- Pressure distribution in the water reticulation networks, including the use of pressure reducing valves and other pressure management strategies.
- Amount of minimum night flows.
- Accuracy of water meters.
- Adequacy of water supply.
- Leakage statistics (i.e. frequencies of pipe bursts and leaks and the location thereof)
- Costs and benefits of implemented and planned/proposed WCDM strategies.

It will also be determined whether the WSAs, local municipalities and Metropolitan Councils have Water Conservation Plans, stating their strategy, policy and proposed actions for implementation.

3.6.3 Task 6.3: Update the costs and benefits of all interventions previously investigated by the WSA, including the implications of reduced effluent flows to wastewater treatment works.

The purpose of this task is to identify and update the associated costs and benefits of interventions previously investigated by the WSAs.

Methodology

Information and cost estimates on interventions previously identified as part of Tasks 6.1 and 6.2 will be used to update cost-benefit analysis to 2005 monetary values.

3.6.4 Task 6.4: Assess the costs and benefits of the interventions for other WSAs

WCDM strategies will result in surplus water, due to smaller abstraction rates, in some areas of the Crocodile River (West) catchment. In other areas (mainly around Johannesburg and Tshwane), less effluent return flow will result in less available water for re-use. In the areas where surplus water will be available once effective WCDM strategies are implemented, infrastructure will have to be upgraded or developed to utilise the surplus water. Where the WCDM strategies will result in less available effluent return flow for re-use, infrastructure will have to be upgraded or developed to

import more water into the catchment. WCDM must be seen as a regional approach aiming at supplying water for economic growth. The costs and benefits associated with WCDM will be assessed as part of this Task.

Methodology

Information on interventions previously identified by the WSAs was obtained as part of **Tasks 6.1** and **6.2**. The cost estimates were updated to 2005 monetary values as part of **Task 6.3**. The updated information will be used to perform cost-benefit analysis of all the identified interventions for the various WSAs to compare total benefits to total costs involved.

The volume of water saved through the previous interventions will be quantified. Monetary savings due to less water being treated by water purification and treatment operations will be calculated.

Present water tariff structures will be evaluated to calculate income and loss in revenue as a result of concessions for certain users (cross-subsidising).

Implemented and potential WCDM measures will be used to formulate WCDM scenarios as input to **Task 12** (Formulate Scenarios). The scenarios will be modelled as part of **Task 13** (Reconciliation strategies) to assess the effectiveness of the WCDM measures.

As far as the effectiveness of the intervention is concerned, careful consideration will be given to the following aspects:

- Sustainability of the proposed intervention (keeping in mind population projections and increasing economic growth leading also to increasing sophistication of lower consumer groups).
- Usage of groundwater resources.
- Reliability of water supply.

3.6.5 Task 6.5: Assess the likely impacts of the various WCDM interventions on Municipalities and the other WSA's ability to apply various restriction measures during droughts (taking account of their recent experiences and proposed future WCDM measures).

The implementation of effective WCDM strategies, such as the re-use and recycling of water by industries, leave little scope for restriction measures without adversely affecting productivity during periods of severe droughts. Dams are generally sized to meet water demands during droughts. WSA's must therefore have an accurate indication of the capabilities of their storage systems and the extent to which restriction measures can be implemented during severe droughts without adversely affecting water users. **Task 6.5**

will assess and evaluate the impacts of water restriction measures during periods of droughts.

Methodology

A study of past experiences will be undertaken to assess the WSA's ability to effectively apply restrictive measures during droughts. The following historical data will be obtained:

- Periods of drought.
- Restriction measures implemented during drought periods.
- Potential WCDM measures/restrictions that were identified but not implemented.

A risk profile, indicating the likely impact of water restrictions on the ability of the industry to maintain productivity, will be compiled for every major strategic industry in the catchment.

The historical information, potential WCDM measures and risk profiles will be used to formulate WCDM scenarios as input to **Task 12** (Formulate Scenarios).

The scenarios will be modelled as part of **Task 13** (Reconciliation plan) to assess the effectiveness of the implemented and proposed future WCDM measures during droughts.

Deliverables

A document (task report) describing the potential and implemented WCDM measures, including those that have been implemented in affected areas of the adjacent WMAs will be produced.

3.7 TASK 7: OPPORTUNITIES FOR WATER RE-USE

Importation of water from neighbouring catchments forms a significant part of the water use in the upper parts of the catchment, and the indirect re-use of treated effluent forms an important part of the water balance in the lower parts of the catchment. At present direct re-use is however limited to isolated cases, such as the use of treated effluent from the Johannesburg Northern WWTW at the Kelvin Power Station for cooling water.

The re-use of effluent was considered in the Return Flow Study, the results of which will form the starting point for this task. Opportunities for direct re-use of effluent will be investigated, specifically at the mines in the Rustenburg area and the re-use of treated domestic waste water at Rustenburg itself. Not only will the water balance be taken into account, but also the impact on water quality. The task will be undertaken in the following manner:

- Obtain from the Local Municipalities and Metropolitan Councils their most up to date information on current and future effluent returns flows and their quality, and on existing and potential re-use (taking quality into account, e.g. domestic or industrial effluent, the latter perhaps containing carcogenic heavy metals), their policy on re-use and pricing thereof (this will essentially be done as part of **Task 3**)1
- Provide informed comment on the environmental benefits (including the re-instatement of seasonality) and lower costs of maintaining rivers and vleis if effluent return flows are reduced.
- Obtain the same information from other municipalities in the study area.
- Update the costs and benefits of options for re-use previously investigated by the Metros, water boards or WSA.
- Assess the costs and benefits of effluent re-use for other Water Service Authorities (WSAs) in the study area.
- Investigate the water quality impact of the re-use of effluent on the water resource as a whole, including from the Crocodile River to the Limpopo River.

3.8 TASK 8: RESERVE REQUIREMENT SCENARIOS AND IMPACTS ON WATER AVAILABILITY

3.8.1 Historic instream flow requirement (IFR) and Reserve determination studies

IFR studies

The Upper Crocodile sub-catchment was used as a testing site for the development of the 1999 Resource Directed Measures (RDM) methodologies. Three key sites were identified and Reserve determinations were conducted at these sites. These included sites upstream and downstream of the Roodeplaat Dam. This study also included a groundwater component and a wetland downstream of the Roodeplaat Dam. The results of this study can be considered to be at the Rapid Reserve determination level. The results were unfortunately only generated for a single recommended ecological category.

Desktop Reserve determinations were done for the Crocodile (West) catchment utilising the Desktop Decision Support model developed by Hughes to populate the Water Situation Assessment Model (WSAM), then referred to as the Water Balance Model, during 1999.

A Reserve determination study was initiated by the Regional Offices of the DWAF to determine the Reserve requirements for the Apies/Pienaars Rivers that form part of the Crocodile (West) catchment.

The results of the above-mentioned studies are summarised in **Table 3.2**.

Table 3.2: Summary of historic IFR and Reserve determination studies in the Crocodile (West) catchment

Year	Component	Location of study sites	Level of confidence in results	Scenarios
1999 (Method development study)	River River Wetland Groundwater River Quality	Upstream RPD Downstream RPD Wetland Catchment are related to surface water sites Upstream and downstream of RPD	Rapid level 3 Rapid level 3 Rapid Rapid Rapid	No No No No No
1999 (WSAM)	River	All quaternary catchments	Desktop level (WSAM)	No
2003 (NWRP)	River River River River River River	Pienaars Apies Tolwane Plat Kutswane Rietspruit	Intermediate Intermediate Intermediate Rapid level 3 Rapid level 3 Rapid level 3	Yes Yes Yes No No No

Rapid and higher Reserve determination studies done by the RDM Directorate

Table 3.3 provides a summary of the Reserve determination studies which have been conducted by the RDM Directorate since October 1999 (when Chapter 3 of the National Water Act was implemented).

Desktop Reserve determination studies listed on the RDM database

Another 37 Desktop Reserve determination studies (representing 19 quaternary catchments) are listed on the RDM database of which 17 are indicated as approved by the Department. Groundwater studies are listed for 10 catchment/sub-catchment areas.

Table 3.3: Summary of ad hoc preliminary determination of the Reserve (rapid level and higher) conducted in the Crocodile (West) catchment since 1999.

Quaternary catchment	Resource name	Component	Level of confidence	Date of approval
A21K	Brakspruit-Sterkstroom	River	Rapid 1	2001
A21K	Sterkstroom	River	Rapid 1	2001
A22A	Elands River	River	Rapid 1	2001
A22B	Koster River	River	Rapid 1	2001
A22F	Elands River	River	Rapid 3	2001
A22H	Hex	River	Rapid 1	2001
A23A	Pienaars	River	Rapid 1	2001

A23A	Pienaars	River	Rapid 1	2001

Note: It is acknowledged that the above dataset is most likely incomplete and requires updating in terms of the legal status of various results captured.

Compilation of Reserve scenario results

It is proposed that the Spatsim model be used to generate Reserve scenario results. The accuracy of the results will need to be evaluated in terms of the accuracy of the model to predict the Reserve requirements in this part of the country for the various flow requirements specified by the model. This task is of critical importance, as decisions will need to be taken in terms of the data used as baseline as this catchment is highly modified in terms of the returns flows from various sewage treatment facilities.

Important note: It is important to note that the study team will not undertake field verified Reserve determination studies nor will each of the generated results be evaluated in terms of the accuracy of the model.

Generation of additional and alternative resource protection measures

The classic Reserve determination and implementation approach will most likely not have the desired effect in this catchment, which is largely modified in terms of the deviation from natural flow and natural flow variability. In this case the problem is mostly that of increased flows due to waste discharge, rather than decreased flows due to abstraction. This would require the generation of a flow management plan and the consideration of resources and ecological protection measures unique to this system. It is suggested that capping flows are considered in those areas/river reaches where increased flows are the result of constant discharges from, amongst others, sewage treatment works. Seasonal variability in the flows should also be investigated to ensure the maintenance of ecological integrity for a selected scenario.

Specific approach

(i) Updated hydrology is available for the Apies/Pienaars system and will be utilised for the Reserve scenarios. Capping flows will also be considered for each of these scenarios as the runoff increased considerately due to discharges from *inter alia* sewage treatment works and increased runoff from urban areas. The determination of the capping flows needs to be carefully considered and discussions with the relevant specialists (Dr Neels Kleynhans, Ms Christa Thirion) is important before finalisation. The existing IFR results will be utilised and scaled or extrapolated to other areas in the catchment where applicable. The Ecological

Importance and Sensitivity (EIS) as well as the Eco-regions will be considered with the scaling and/or extrapolation.

(ii) The upper reaches of the Crocodile River and its tributaries also have increased flow due to sewage treatment work discharges, increased urban runoff and industrial discharges. The WR90 virgin flows are thus not suitable for the purposes of Reserve scenario generation. However, no updated hydrology is available for this area. The Reserve scenario generation, including capping flows will commence as soon as the updated hydrology is available.

(iii) For those catchments in the study area with very little or no changes in the hydrology, the WR90 data, together with the desktop EIS will be utilised for Reserve scenario generation.

The Reserve scenarios will be done at the outlet of each quaternary catchment where applicable. No Reserve scenarios will be generated in urban or other areas where the river is canalised.

The inclusion of this component to the study will require careful consideration and discussion.

Operationalising the Reserve

The physical and operational limitations in the catchment in terms of giving effect to the Reserve requirements need to be considered to evaluate the feasibility of implementation of the proposed Reserve scenarios. The inclusion of this component also requires careful discussion.

3.8.2 Related studies which are currently being undertaken

National biodiversity planning and conservation

The RDM Directorate initiated a national biodiversity planning project in 2002. The purpose of the project was to develop a dual policy for biodiversity conservation. This initiative will enter its second phase during 2005 and the Crocodile (West) catchment is a key pilot testing area. Although an initial national assessment of the biodiversity status has been undertaken, it requires updating as the assessment utilised the present ecological status (PES) and ecological importance and sensitivity (EIS) data set of 1999, and is therefore subjected to the current updating initiative.

Updating of the PES and EIS data

The RDM Directorate, in collaboration with the Directorate Resource Quality Services, initiated a study in April 2005 to update the PES and EIS for all quaternary catchments in South Africa.

This study has updated the data, which was generated by Dr Neels Kleynhans in 1999. The data should logically replace the ecological category data, which was originally used in the Water Situation Assessment Model (WSAM).

The Crocodile (West) catchment is a priority due to the development of the National Biodiversity conservation and planning project. The updating of the data will therefore be undertaken during 2005. The updated data is also essential in terms of the possible Reserve scenarios to be generated by the Crocodile West Reconciliation Study (CWRS) project team.

National water resources classification system development

The RDM Directorate has initiated the development of a National Water Resources Classification System (NWRCS) and although various technical issues are under discussion and the exact nature and implementation is not yet final, the Crocodile (West) catchment will be a focus area for the following phases of the development of the NWRCS.

The above-mentioned three initiatives are of critical importance in terms of deciding the most likely Reserve scenario to be used in the CWRS. The time frame of the CWRS and the abovementioned project will require careful consideration to allow adequate synchronisation with the CWRS.

Additional time is added for the project team to allow sufficient synchronisation between these various initiatives.

3.8.3 Recommendations (additional to the proposal)

In terms of the consideration of the abovementioned initial findings, the following can additionally be recommended in terms of modification to the original tasks and budget requirements:

- Liaison with the project teams undertaking the PES and EIS updating, biodiversity planning initiative and NWRCS.

This addition will be funded by savings on other tasks.

Once the Reserve requirements have been determined, these requirements will be included in the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM) input data files. The effect of the implementation of the Reserve on

water availability will be determined with the WRYM in the CWMS. The water supply to the different users, as well as the yields at different points in the system, can be determined with and without the Reserve included. The difference in the water supply to the different users with and without the Reserve will indicate the effect of the Reserve on the users.

3.9 TASK 9: GROUNDWATER

Once the status quo situation has been established in terms of the available water balance (as part of the CWMS), the following scenarios will be assessed for the quaternary sub-catchments in the study area:

- The effect of urban growth and water demand on the groundwater balance,
- The effect of droughts on the groundwater balance and the ability of the aquifer to buffer the drought period, and
- The effect of increases in the mining, agricultural and industrial sectors.

Output water balances with time under different scenarios over 5 year intervals (20 year period).

The three areas that will be modelled in more detail are:

- the dolomite aquifer along Maloney's eye, in the Magalies area,
- the alluvial aquifers along the Lower Crocodile River, Makoppa and
- the Koedoeskop area.

3.10 TASK 10: REVIEW SCHEMES AND UPDATE COST ESTIMATE

3.10.1 Task 10.1: Review schemes

Possible schemes of the Crocodile (West) River catchment can be summarised and be related to the following:

- Importation of water into the catchment from neighbouring catchments;
- Exportation of water from the catchment to neighbouring catchments e.g. from the Apies/ Pienaars sub-catchment to the Olifants WMA or the Limpopo WMA;
- New surface water schemes, if applicable, e.g. dams;
- New groundwater schemes;
- Bulk water supply schemes e.g. pipeline schemes to the mines and plants in the Rustenburg area;
- Desalination and/or dilution of water to improve quality; and

The direct re-use of water e.g. treated domestic waste water at Rustenburg is already being implemented.

The identified schemes will be reviewed after completion of the previous tasks e.g. **Task 4** the screening of existing schemes, and tasks on re-use, **Task 7**. The schemes will be reviewed in terms of their purposes, having an effect on the to-be formulated strategy, their phases of investigations as well as basis and details of cost estimate. Furthermore, the effect of schemes on existing water users will be determined by modelling water availability and water quality, where applicable. The effect of the Reserve requirement on existing and new schemes, where applicable, will also be considered. If necessary site visits will be undertaken to assess local site conditions.

The number of schemes to be included as part of this study is currently uncertain. The finally selected schemes will be discussed with the Client before commencement of the updating of the cost estimates of the schemes.

3.10.2 Task 10.2: Update of cost estimates of schemes

Updating of cost estimates of the selected schemes will be carried out. The quantities, the base date as well as the prices will be updated and upgraded to the same level of accuracy so that they can be compared. It is anticipated that the year 2005 will be taken as the base year. The Department of Water Affairs' cost models as well as rates from recent available tenders will be used. Costs for transfer schemes into the catchment and for the Lesotho Highland Water Project Phase II will not be checked or recalculated, but the costs as determined in other studies will be used as is (adjusted for inflation to 2005).

3.10.3 Deliverables

A report describing the locality and details of all identified and reviewed schemes, the effect of new schemes on water availability and water quality, the effect of the inclusion of the Reserve requirements as well as the updated cost estimates of the selected schemes will be produced. This information will be used as input to **Task 12** to determine the unit reference values of the schemes and to formulate scenarios.

3.11 TASK 11: REVIEW AND ASSESS SOCIAL AND ENVIRONMENTAL IMPACTS

In implementing this task the environmental team will interact with and be informed by team members working on a number of other Tasks, specifically, the Summary of Previous and Current Studies the Formulation of Scenarios.

The inputs from this task will be investigated with regard to the impact they may have on the social and environmental aspects in the study. A list of issues will be compiled to summarise and categorise all key social and environmental concerns together with their document sources. A desktop assessment will be undertaken to determine the social and environmental impacts of proposed schemes (using DWAF's most recent colour aerial photography). Site visits will be done, if necessary, to assess the potential social and environmental impacts that have not been assessed in previous studies. The

results of these site visits will then be used to update the list of issues, indicating the sources of the new data.

3.12 TASK 12: COMPILATION OF INFORMATION AND FORMULATION OF SCENARIOS

The various models (quantity and quality) that will be developed as part of the CWMS, will be used to investigate different water resource development and management scenarios for the catchment, and the associated water availability in the catchment. The following sub-tasks will be undertaken:

3.12.1: Task 12.1: Model development scenarios

It is anticipated that there will be more than one development scenario in terms of land use changes and/or economic activities or each of the sub-catchments, which will affect water use. This could lead to a large number of combinations for the catchment as a whole, and in order to rationalise the investigation the catchment will be divided into four sub-catchments, namely the Upper Crocodile sub-catchment, the Apies/Pienaars sub-catchment, the Elands sub-catchment and the Lower Crocodile sub-catchment. Each of these will be investigated as discrete units, before combining them in a comprehensive scenario for the catchment as a whole.

Three scenarios will be investigated, namely a low development scenario, a high development scenario and a most likely development scenario. Within each of these there will also be a number of permutations, and it will be necessary to use some sound judgement to establish a rational scenario. This will be done in consultation with the Client. It is likely that a number of "what-if" scenarios, resulting from interpretation of results from other scenarios, will also have to be analysed. The scope of this task is uncertain at this stage and will be discussed in more detail with the Client after the models have been completed, in order to update the time required for this specific task.

Each modelled scenario will consider existing as well as future demand scenarios, and will seek to optimise the available as well as potential new water supply schemes with respect to operating rules. The requirements for the Reserve will also be taken into account.

3.12.2: Task 12.2: Investigate impacts of each scenario

For each of the scenarios investigated under **Task 12.1**, the resultant impacts will be investigated, with respect to:

- impacts on the water resource in terms of resource quality objectives, and
- social impacts.

3.12.3: Task 12.3: Determine Unit Reference Values (URV)

For each of the possible new sources or new schemes that can be developed, the URV will be determined.

3.12.4: Task 12.4: Compile report

A report on the results of the scenario investigations will be compiled. The report will present information in a user-friendly way in order to facilitate dialogue with stakeholders at the final screening workshops.

3.13 TASK 13: DEVELOP AND EVALUATE A STRATEGY

An initial (Version 1) Reconciliation Strategy will be prepared based on the outline presented and discussed at the Preliminary Screening Workshop. the draft of Version 1 should be completed by the end of September 2006. This will be discussed with different stakeholders during the course of the study to get their comments and inputs and comments to be included in the Final Reconciliation Strategy.

The results of the scenarios generated (as part of Task 12 above) will be used to generate strategies for an upper and a lower scenario, and how to change from one to the other, should there be principle differences. The PSP will strive to develop strategies that are robust, but flexible.

The strategy will in essence be a plan of how to achieve the desired result in the catchment under different conditions. The strategy will consider the use of the different "tools" that the DWAF has at its disposal to on the one hand encourage users to change their behaviour, and on the other hand to enforce compliance with the National Water Act. Examples would be a pricing strategy, as well as policing of water abstractions.

The strategy will also contain a monitoring system. This monitoring system should on the one hand yield information on whether or not objectives are being met, and on the other hand on whether or not conditions in the catchment (population growth, industrial development, etc) have changed to such an extent from what was predicted that the strategy has to be revisited.

This task forms the core of the assignment, and will combine the results from all the previous tasks.

3.14 TASK 14: FINAL SCREENING WORKSHOP

The final screening workshop is scheduled for April 2007. The purpose of the final screening workshop will be to obtain the views and, if possible, agreement of key stakeholders on the most favourable future strategy.

3.15 TASK 15: PUBLIC PARTICIPATION

The CWMS and CWRS projects take place in the same study area at the same time and, in addition to the same client and PSP, involve many of the same stakeholders. The two projects also interlink with each other on key aspects. In order to use resources efficiently, it has therefore been agreed that, the public participation process will be combined.

The overall purpose of the public participation (PP) process is to provide information to and receive inputs from interested and affected parties (I&APs). The information and inputs will include the identification and discussion of alternatives that should be considered as well as issues and impacts related to the project.

Three types of meetings are being planned:

- Public Meetings
- Stakeholder Committee Meetings and
- Technical Working Committee Meetings.

Two pamphlets will also be produced.

3.15.1 Public Meetings

Two rounds of public meetings are planned. The first round of public meetings was held on 26, 27 and 28 July 2005 in Pretoria, Rustenburg and Thabazimbi respectively. The purpose of these meetings was to introduce the public to the project.

The second round of meetings will be held towards the end of the project to present the findings of the project.

3.15.2 Stakeholder Committee Meetings

The Co-ordinating and Liaison Committee established as part of the process of establishing a Catchment Management Agency (CMA) for the Crocodile (West) and Marico Water Management Area will be used as the basis for this Committee. Three Stakeholder Committee Meetings are planned.

The first meeting took place on 13 April 2005 in Rustenburg. At this meeting the studies were introduced to the Stakeholder Committee; background information regarding the study area, issues already identified, and the planned execution of the study were presented; and the Committee was given an opportunity to raise specific issues related to water availability and requirements in the study area that should be considered in the execution of the study.

The second meeting is scheduled to take place in April 2006 and the third in May 2007.

3.15.3 Technical Working Committee

A Technical Working Committee consisting of the following members has been established:

- Mr Beyers Havenga (DWAF: National Water Resources Planning) Project Manager
- Mr Albert Jeleni (DWAF: National Water Resources Planning)
- Mr Rens Botha (DWAF: Gauteng Regional Office)
- Mr Elias Nel (DWAF: Hydrology)
- Ms Nana Mthethwa (DWAF: Hydrological Services)
- Mr Beason Mwaka (DWAF: Water Resource Planning Systems)
- Mr Pieter Viljoen (DWAF: Water Resources Planning Systems)
- Dr Thinus Basson (BKS, PSP: Project Leader: Reconciliation Strategy)
- Mr Johan Rossouw (BKS, PSP: Project Leader: Crocodile West Modelling Study)
- Mr Craig Schultz (Arcus Gibb, PSP: Deputy Project Leader)
- Dr Martin van Veelen (Task Leader)
- Mr Pieter Buys (Madibeng Council)
- Mr Alastair Galt (Johannesburg Water)
- Mr Roelf le Roux / Mr Johann St Arnaud (Magalies Water)
- Mr L Lotter (CTMM: Water and Sanitation)
- Mr J Mulder (Department of Agriculture)
- Mr Roy Thompson (Rand Water)
- Mr Ockie van den Berg (DWAF: Options Analysis)

The purpose of the Technical Working Committee is to discuss specific technical issues at key specific points in the project. Provision has been made for four Technical Working Committee Meetings. The first Technical Working Committee Meeting took place on 8 April 2005 in Pretoria. Further meetings will be arranged as required.

3.15.4 Pamphlets

Two pamphlets will be produced as part of the project. The first, with the aim of informing stakeholders of the project, its intentions and programme, is scheduled for April 2006. The second will be produced at the end of the project, to provide feedback on the findings.

3.15.5 Ad hoc meetings

In addition to the general public participation, and the two Screening Workshops specified as separate tasks, specific business meetings with key stakeholders such as municipalities, Water Boards and Water User Associations will also be necessary to

complete the project. Where necessary, such as in the case of the Rustenburg Water Management Committee, the PSP will attend meetings as and when required. Provision has been made to attend 4 such meetings.

3.16 TASK 16: BERG RIVER STUDY GROUNDWATER REVIEW

This task has been discontinued.

3.17 TASK 17: BERG RIVER RECONCILIATION STRATEGY REVIEW

This task was not included in the original scope of work. DWAF has requested the study team to include this task to the project. Thinus Basson, with the support from Johan Rossouw and Craig Schultz, will be responsible for the review of the reconciliation strategy for the Berg River Study.

3.18 TASK 18: CO-ORDINATION WITH OTHER CONSULTANTS

This task was not included in the original scope of work. DWAF has requested the study team to include this task to the project. It is foreseen that more in-depth discussions between the study teams of the Crocodile (West) Studies and the Vaal River Study will be necessary. Strategies for the Vaal River will have an effect on the Crocodile (West) River. Similarly strategies for the Crocodile (West) River will have an effect on the Vaal River. WRP Consulting Engineers are responsible for the execution of the Vaal River Studies.

WRP has also been appointed for the updating of the hydrology and yield analysis of the Mokolo River Catchment. Due to the possible future link between the Crocodile (West) River and the Mokolo River (transfer of water to the Ellisras area for future Eskom and mining activities) it is foreseen that some in-depth discussions between the study teams of the Crocodile and Mokolo studies will be necessary.

4. DELIVERABLES

The deliverables, and their expected due dates, are summarised in **Table 4.1**. Draft reports will be submitted to DWAF, and it is expected that they will comment within 4 weeks. Final reports will be submitted within 2 weeks after receiving comments from DWAF.

The list of deliverables will be updated, together with the study programme, on a continuous basis as the study progresses.

5. STUDY PROGRAMME

The study programme is included as **Appendix A**.

6. STUDY TEAM

The task leaders for the individual tasks, as discussed previously, are listed in **Table 6.1**.

Table 4.1: List of deliverables and due dates

Deliverable	Due date of draft
Minutes of Project Management Committee, Study Team, Public, Technical Working Committee and Stakeholder Committee Meetings	2 weeks after meeting
Progress reports	1 week before PMC
Inception Report	July 2006
Summary of Previous and Current Studies Report	July 2006
Proceedings of the Preliminary Screening Workshop	April 2006
Current and Future Urban Requirements Report	July 2006
Urban Water Conservation and Demand Management Report	May 2006
Version 1 of the Reconciliation Strategy Report	September 2006
Opportunities for water re-use Report	September 2006
Reserve Classification Report	July 2007
Groundwater Report	January 2008
Review of schemes and update of cost estimate Report	September 2007
Social and environmental impacts Report	November 2007
Scenarios Report	January 2008
Strategy Report	April 2008
Proceedings of the Final Screening Workshop	May 2008
Stakeholder Database	May 2008
Review of Berg River Study Reconciliation Strategy	#
Final Reconciliation Strategy Report	May 2008

Subject to completion of work by Berg River Study Team

Note: The PSP will allow 4 weeks for comments from DWAF, and then will submit a final report 2 weeks later.

The proposed study team is listed in **Table 6.2**. The detailed manhours are included as **Appendix B** and the detailed costs are included in **Appendix C**.

Table 6.1: Task Leaders for the Study

Task	Name	Profession	Company
1. Project Management	MS Basson	Civil Engineer	BKS
2. Inception Report	JD Rossouw	Civil Engineer	BKS
3. Summary of Previous and Current Studies	CB Schultz	Hydrologist	Arcus Gibb
4. Preliminary Screening Workshop	MS Basson	Civil Engineer	BKS
5. Current and Future Water Requirements	CB Schultz	Scientist	Arcus Gibb
6. Urban Water Conservation and Demand Management	CB Schultz	Hydrologist	Arcus Gibb
7. Opportunities for water re-use	M van Veelen	Civil Engineer	Iliso
8. Reserve Requirement Scenarios and Impact of Water Availability	JD Rossouw	Civil Engineer	BKS
9. Groundwater	JJP Vivier	Geohydrologist	AGES
10. Review Schemes and update of cost estimates	DB Badenhorst	Civil Engineer	BKS
11. Review and Assess Social and Environmental Impacts	E Mashau	Social Scientist	BKS
12. Assembly of Information and Formulation of Scenarios	MS Basson	Civil Engineer	BKS
13. Develop and evaluate a Strategy	MS Basson	Civil Engineer	BKS
14. Final Screening Workshop	A Hoek	Civil Engineer	BKS
15. Public Participation	E Mashau	Social Scientist	BKS
16. Review of Berg River Study Groundwater task	Task discontinued		
17. Review of Berg River Study Reconciliation Strategy	MS Basson	Civil Engineer	BKS
18. Co-ordination with other Consultants	JD Rossouw	Civil Engineer	BKS

Table 6.2: Study Team

Name	Profession	Position	HDI	Company
Basson, MS	Civil Engineer	Study Leader	N	BKS
Schultz, CB	Hydrologist	Deputy Study Leader	N	Arcus Gibb
Rossouw, JD	Civil Engineer	Study Manager	N	BKS
van Veelen, M	Civil Engineer	Task Leader	N	Iliso
Vivier, JJP	Geohydrologist	Task Leader	N	AGES
Badenhorst, DB	Civil Engineer	Specialist	N	BKS
Turton, AR	Scientist	Specialist	N	Arcus Gibb
Ball, JM	Environmental Scientist	Key Support	Y	ARCUS GIBB
Boonzaaier, J	Hydrologist	Key Support	Y	Arcus Gibb
Grobler, D	Ecologist	Key Support	N	Blue Science
Khumalo, N	Chemical engineer	Key Support	Y	Arcus Gibb
Mashau, E	Social Scientist	Key Support	Y	BKS
Stassen, R	Scientist	Key Support	Y	Blue Science
van Niekerk, E	Hydrologist	Key Support	Y	BKS
Vivier, JC	Environmental Specialist	Key Support	Y	AGES
Wiethoff, A	Geologist	Key Support	N	AGES
Crafford, I	Project Administrator	Support	Y	Arcus Gibb
De Wet, C	Civil Engineer	Support	Y	BKS
Dippenaar, R	Civil Engineering Technician	Support	N	Arcus Gibb
Enslin, E	Project Administrator	Support	N	BKS
Espach, E	Project Administrator	Support	Y	Blue Science
Faul, F	Scientist	Support	N	AGES
Gerber, A	Hydrologist	Support	Y	Arcus Gibb
Gallagher, LC	Senior Graphic Artist	Support	Y	BKS
Grobler, M	GIS Specialist	Support	N	AGES
Hoek, A	Civil Engineer	Support	Y	BKS
Mafanya, T	Hydrogeologist	Support	Y	AGES
Marijnen, M	Civil Engineer	Support	Y	Arcus Gibb
Ejigayehu, N	Scientist	Support	N	Arcus Gibb
Phalafala, MR	Civil Engineer	Support	Y	Arcus Gibb
Pienaar, R	Civil Engineer	Support	N	BKS
Steenkamp, JM	GIS Specialist	Support	N	BKS
Swanepoel, M	Project Administration	Support	Y	Arcus Gibb
Versveld, K	Scientist	Support	Y	Iliso
Wilson, O	Scientist	Support	Y	Arcus Gibb
Wolff-Piggott, BB	Scientist	Support	N	Arcus Gibb

7. STUDY BUDGET

The total budget for the project is R 4 772 500 (including VAT). This is about R 619 000 more than the approved contract amount of R 4 153 500. The increase is mainly due to the addition of Tasks 16, 17 and 18 (R 207 600 excluding VAT) as well as increase in fees and project management costs due to the extension of the project with an expected 11 months. A summary of the study budget is given in **Table 7.1**, with a projected cash flow in **Appendix D**.

Table 7.1: Study Budget

Task	Amount (R)
Task 1: Project Management	794 400
Task 2: Inception Report	83 900
Task 3: Summary of Previous and Current Studies	190 700
Task 4: Preliminary Screening Workshop	96 600
Task 5: Current and Future Urban Requirements	173 300
Task 6: Urban Water Conservation and Demand Management	241 600
Task 7: Opportunities for water re-use	96 600
Task 8: Reserve Requirements Scenarios and Scheme Yields	235 300
Task 9: Groundwater	191 600
Task 10: Review of schemes and update of cost estimate	335 900
Task 11: Review and assess social and environmental impacts	222 700
Task 12: Assembly of information and formulation of scenarios	309 000
Task 13: Develop and Evaluate a Strategy	280 900
Task 14: Final Screening Workshop	94 400
Task 15: Public Participation	467 000
Task 16: Review of Berg River Study Groundwater task	0
Task 17: Review of Berg River Study Reconciliation Strategy	112 400
Task 18: Co-ordination with other Consultants	95 100
Total Fees	**4 021 400**
Disbursements	127 200
Sub-total	**4 148 600**
VAT (14%)	580 800
Travel costs (VAT included)	43 100
TOTAL	**4 772 500**

8. HDI INVOLVEMENT

The HDI involvement in the study is included in **Table 8.1**, with reflects the actual (until June 2006) and the projected figures for the duration of the study. The total projected HDI component of the hours is 56,7% and HDI component of the fees is 39,5%.

Table 8.1: HDI involvement in the study

Month		Hours			Fees (R 000)		
		Total	HDI	HDI %	Total	HDI	HDI %
1	Jan-05	300	205	68.2	117.4	63.1	53.8
2	Feb-05	465	323	69.5	178.4	95.1	53.3
3	Mar-05	142	118	83.4	50.1	33.8	67.4
4	Apr-05	318	256	80.5	117.7	79.1	67.2
5	May-05	357	244	68.3	142.8	79.3	55.5
6	Jun-05	187	108	57.8	84.3	34.7	41.1
7	Jul-05	407	337	82.8	146.3	95.7	65.4
8	Aug-05	181	105	57.9	82.2	31.3	38.1
9	Sep-05	177	90	50.7	73.9	24.5	33.1
10	Oct-05	143	106	74.0	53.3	30.1	56.5
11	Nov-05	190	124	65.0	75.0	28.1	37.4
12	Dec-05	0	0		0.0	0.0	
13	Jan-06	78	33	42.3	44.8	9.7	21.6
14	Feb-06	163	96	58.8	82.4	29.8	36.2
15	Mar-06	500	264	52.8	232.2	86.9	37.4
16	Apr-06	40	6	15.0	25.0	1.4	5.4
17	May-06	89	20	22.6	50.7	4.6	9.0
18	Jun-06	56	20	35.7	25.3	4.5	17.9
19	Jul-06	208	53	25.2	110.2	13.8	12.6
20	Aug-06	308	33	10.8	164.2	8.3	5.1
21	Sep-06	24	10	41.7	13.2	2.7	20.2
22	Oct-06	24	10	41.7	13.4	2.8	21.2
23	Nov-06	24	10	41.7	13.4	2.8	21.2
24	Dec-06	19	10	52.6	9.5	2.8	29.9
25	Jan-07	28	14	50.0	14.4	3.8	26.6
26	Feb-07	28	14	50.0	14.4	3.8	26.6
27	Mar-07	26	14	53.8	12.8	3.8	29.9
28	Apr-07	130	78	60.0	53.9	23.2	43.1
29	May-07	142	82	57.7	59.9	26.4	44.0
30	Jun-07	381	252	66.1	167.8	87.1	51.9
31	Jul-07	265	192	72.5	119.4	65.8	55.1
32	Aug-07	404	268	66.3	210.5	106.7	50.7
33	Sep-07	255	133	52.2	126.6	60.7	47.9
34	Oct-07	395	208	52.7	208.2	88.9	42.7
35	Nov-07	307	141	45.9	151.5	50.9	33.6
36	Dec-07	398	172	43.2	220.4	67.4	30.6
37	Jan-08	118	14	11.9	93.0	4.1	4.4
38	Feb-08	118	14	11.9	93.0	4.1	4.4
39	Mar-08	206	14	6.8	155.9	4.1	2.6
40	Apr-08	455	332	73.0	228.3	127.8	56.0
41	May-08	330	218	66.1	185.4	93.9	50.7
Total		**8 382**	**4 737**	**56.5**	**4 021.4**	**1 587.6**	**39.5**

9. REFERENCES

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APPENDIX A

Study programme

THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE CROCODILE WEST WATER SUPPLY SYSTEM: PROGRAMME

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07
Task 1: Project Management																														
Task 2: Inception Report																														
Task 3: Summary of Previous and Current Studies																														
Task 4: Preliminary Screening Workshop																														
Distribute documentation																														
Proceedings																														
Task 5: Current and Future Urban Requirements																														
Task 6: Urban Water Conservation and Demand Management																														
Task 7: Opportunities for water re-use																														
Task 8: Reserve Requirements Scenarios and Scheme Yields																														
Task 9: Groundwater																														
Task 10: Review of schemes and update of cost estimate																														
Task 11: Review and assess social and environmental impacts																														
Task 12: Assembly of information and formulation of scenarios																														
Task 13: develop and Evaluate Strategies																														
Task 14: Final Screening Workshop																														
Task 15: Public Participation																														
Identiication of key stakeholders																														
Newsletters																														
Stakeholder Committee Meetings (3)																														
Technical Working Committee Meetings																														
Public Meetings																														
Deliverables																														
Inception Report																														
Progress Reports																														
Summary of previous and current studies																														
Proceedings of Preliminary Screening Workshop																														
WCDM Report																														
Water Re-use Report																														
Summary of Reserve Classification																														
Groundwater Report																														
Social and Environmental Impacts Report																														
Scenarios Report																														
Strategy (draft and final)																														
Meetings, Workshops, Discussions																														
Project Management Committee Meetings																														
Stakeholder meetings in modelling proposal					x									x																x

Current date

Models set up

APPENDIX B

Detailed manhours

Name	Company	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Total
Badenhorst, D	BKS																													24	24	32										**80**
Baker, T	ILISO	41	89.5	35	80.5	54.5	11.5	60			9	3.5																														**385**
Ball, JM	AG																															60	60	60									**180**
Basson, MS	BKS		3	3		1	4	18	14	13	4	24		28	43	4		6	11	77	13	5	5	5	5	3	4	4	4	8	8	16	12	38	32	63	48	84	64	64	72	44	44	**898**
Boonzaaier, J	AG				40	83	47	37	52	12	12				10	150				1	1	1	1	1	1	1	1	1	1	1	17	17	17	1	1	1	1	1	1	1	9	1	**523**
Cuku, MC	BKS		43	2																																						**45**
De Wet, C	BKS											1																														**1**
Engelbrecht, F	BKS		3.5			1									34				2																				10		**51**
Enslin, E	BKS											1.5																														**2**
Espach, E	BS		8							16	2.5									4									24	20	24										**99**
Faul, F	AGES		10																															20	20	20	20					**90**
Gallagher, LC	BKS			2	8	3	4	18	2			16		13	14			14		4									4	4	20	12	12		12	12	16				16	16	**222**
Gerber, A	AG	50	23			7	5	10	16	10																				40	30	30								15		**236**
Grobler, D	BS		18							34	8	4								4									24	32	40										**164**
Grobler, M	AGES																																	26	26	26	25					**103**
Hoek, A	BKS								24.5	17.5	19	10			17.5	17		6	5	12	12	12	12	12	12	8	12	12	12	12	12	12	12	12	12	36	44	32	12	12	12	169	112	**734**
Khumalo, N	AG					15																																		4		**19**
Kirstein, R	AG				25	28		20																						10	20	10								20		**133**
Mafanya, T	AGES		10																															21	20	21	20					**92**
Mashau, E	BKS																															16	16	16						80	80	**208**
Mathoma, C	BKS	25	23.5	46	63	40	35.5	100	3.5		35																															**372**
Phalafala, MR	AG	50	47					80																						20	40	50										**287**
Pienaar, R	BKS			1																																						**1**
Rossouw, JD	BKS	3	2	1.5	14	5		2	28	32	9	33		15	22	13		28	17	56	14	6	10	6	6	3	5	5	5	17	17	41	29	45	13	37	29	60	29	29	65	61	41	**854**
Schultz, CB	AG	45	41		10	59	63	12	34	8	3			2	2	100			38	29	3	3	3	3	3	3	3	3	3	3	3	8	8	21	15	25	27	21	11	11	55	18	27	**726**
Stassen, R	BS		12							32	24	16		20	20					4									20	20	24										**192**
Steenkamp, JM	BKS																	2.5																								**3**
van Niekerk, E	BKS	2	2	2			2		3									1	1	9	1	1	1	1	1	1	1	1	17	25	85	61	61	1	41	41	81	1	1	1	9	9	**464**
van Veelen, M	ILISO	19	62	18	28	18	12	38			13	4							68																								**280**
Van Zyl, A	ILISO	10.5	29.5	31	39	12	3	12	3.5	2	4	2																														**149**
Versveld, K	ILISO											75							32																								**107**
Vivier, JC	AGES	26	12																															22	22	22	22					**126**
Vivier, JJP	AGES	11.5	6																															16	16	16	16					**82**
Wiethoff, A	AGES		20																																							**20**
Wolff-Piggott, BB	AG	17			10	30										35			45	128																						**265**
TOTAL		**300**	**465**	**141.5**	**317.5**	**356.5**	**187**	**407**	**180.5**	**176.5**	**142.5**	**190**		**78**	**162.5**	**319**		**40**	**88.5**	**323**	**196**	**28**	**32**	**28**	**28**	**19**	**26**	**26**	**26**	**130**	**142**	**381**	**265**	**404**	**255**	**395**	**307**	**398**	**118**	**118**	**206**	**455**	**330**	**8 188**

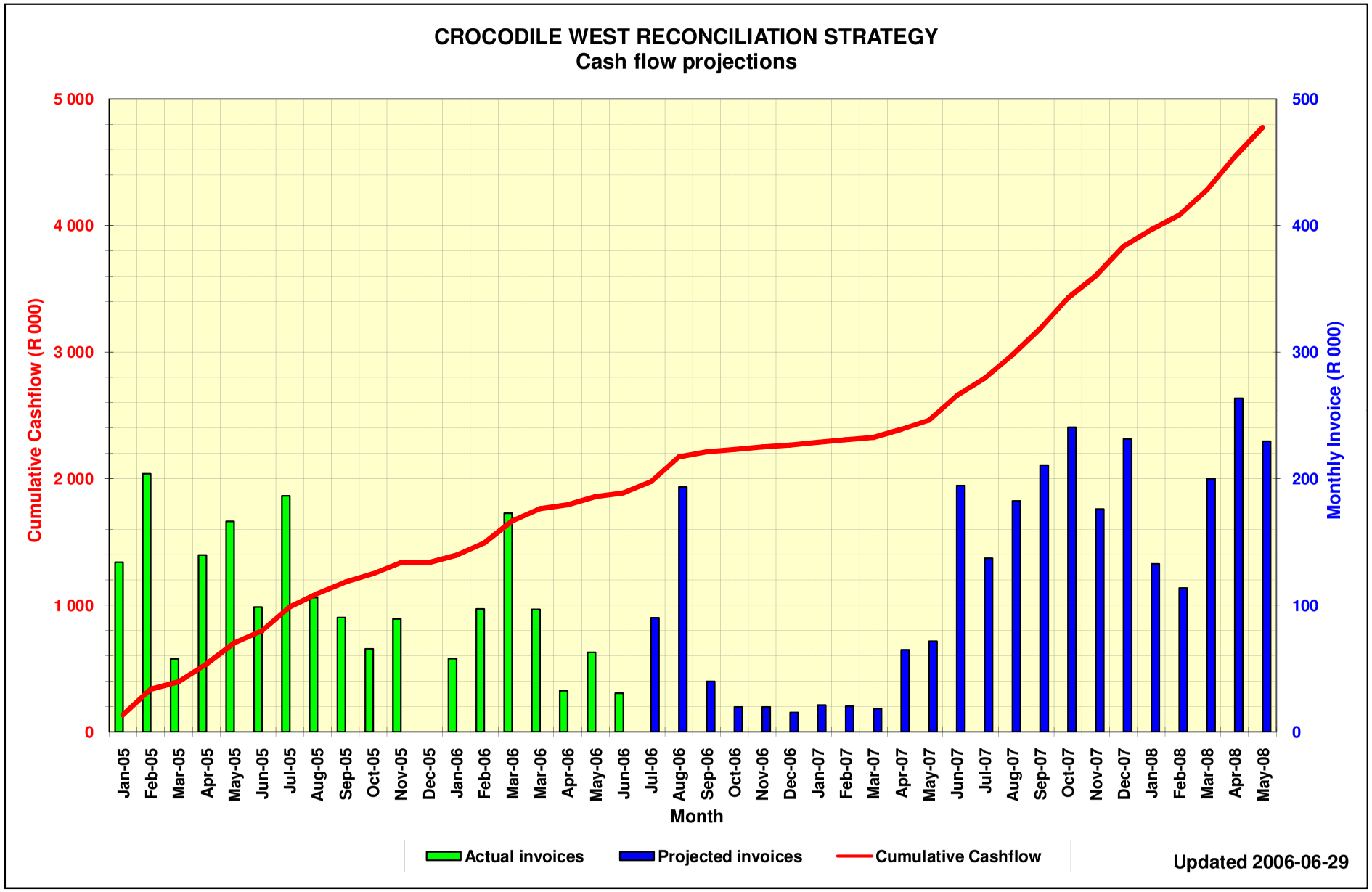
APPENDIX C

Detailed costs

Name	Company	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Total
Badenhorst, D	BKS																													15.9	15.9	10.6	10.6									52.9
Baker, T	ILISO	17.8	38.8	15.2	34.9	23.6	5.0	26.0			3.9	1.5																														166.8
Ball, JM	AG																															29.8	29.8	29.8								89.4
Basson, MS	BKS		2.6	2.6		0.9	3.4	15.4	12.0	11.2	3.4	20.6		24.0	36.9	3.4	19.7	5.1	9.4	1.7	12.9	47.2	11.7	4.5	4.5	2.7	4.5	4.5	3.6	7.6	7.6	15.1	11.4	30.3	35.9	59.6	45.4	77.6	62.4	**64.3**	75.7	43.7	43.7	848.8
Boonzaaier, J	AG				15.0	31.1	17.6	13.9	19.5	4.5	4.5				4.1	60.8					0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	7.4	7.4	3.9	3.9	0.5	0.5	0.5	0.5	**0.5**	0.5	4.3	0.5	205.9
Cuku, MC	BKS		6.5	0.3																																						6.8
De Wet, C	BKS											0.2																															0.2
Dippenaar, R	AG																																										
Engelbrecht, F	BKS		1.2			0.4									11.9		1.9					1.5																			4.1		21.0
Enslin, E	BKS											0.3																															0.3
Espach, E	BS		1.3							2.7	0.4											1.0							4.0	3.3	4.0											16.8
Faul, F	AGES		2.0																														4.0	4.0	4.0	2.0	2.0					18.0
Gallagher, LC	BKS			0.4	1.7	0.6	0.9	3.9	0.4			3.4		2.8	3.0		7.1		3.0	0.2		0.9							0.9	0.9	4.6	2.8	1.4	1.4	3.0	3.0	4.0				4.0	4.0	58.3
Gerber, A	AG	12.0	5.5			1.7	1.2	2.4	3.8	2.4																					12.4	9.3	6.2	3.1							5.0		65.2
Grobler, D	BS		6.6							12.4	2.9	1.5										1.5							8.7	11.6	14.6											59.7
Grobler, M	AGES																																4.6	4.6	4.6	1.6	2.8					18.0
Hoek, A	BKS								4.9	3.5	3.8	2.0			4.0	3.9	13.3	1.4	1.1	4.3	2.7	2.3	1.8	2.0	2.0	2.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	9.5	11.6	8.5	3.2	**3.2**	3.2	44.7	29.6	194.6
Khumalo, N	AG					4.5																																			1.4		5.9
Kirstein, R	AG				4.8	5.3		3.8																							2.1	2.1	2.1	2.1							4.4		26.5
Mafanya, T	AGES		2.8																															5.9	5.6	5.9	2.8	2.8					25.8
Marijnen, M	AG																																									
Mashau, E	BKS																															10.6	10.6	10.6						55.6	55.6	142.9
Mathoma, C	BKS	6.1	5.7	11.2	15.3	9.7	8.6	24.3	0.9		8.5																															90.3
Phalafala, MR	AG	12.0	11.3					19.2																							5.2	10.4	8.3	4.7								71.0
Pienaar, R	BKS			0.2																																						0.2
Rossouw, JD	BKS	2.0	1.3	1.0	9.2	3.3		1.3	18.5	21.1	5.9	21.8		9.9	14.5	8.6	40.3	18.5	11.2	17.8	7.9	27.0	4.2	4.2	4.2	2.1	4.2	4.2	3.5	12.4	12.4	29.8	21.1	21.1	21.1	26.9	21.1	43.7	21.1	**21.1**	47.3	44.3	29.1	639.9
Schultz, CB	AG	27.0	24.6		6.0	35.4	37.8	7.2	20.4	4.8	1.8			1.2	1.2	60.0			18.0		10.6	14.4	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.0	2.0	5.3	5.3	10.6	13.2	16.5	17.9	12.6	8.6	**7.3**	36.4	12.5	18.8	452.4
Stassen, R	BS		4.1							11.0	8.3	5.5		6.9	6.9							1.4							6.9	6.9	8.3											66.2
Steenkamp, JM	BKS																	7.4	1.2																								8.6
Swanepoel, M	AG																																										
Turton, AR	AG																																									
van Niekerk, E	BKS	0.8	0.8	0.8			0.8		1.2									0.5		0.5	4.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	8.0	11.8	40.2	28.8	19.4	9.9	19.4	19.4	38.3	0.5	**0.5**	0.5	4.3	4.3	218.2
van Veelen, M	ILISO	13.3	43.4	12.6	19.6	12.6	8.4	26.6			9.1	2.8								19.6	22.4																			5.6			196.0
Van Zyl, A	ILISO	2.0	5.6	5.9	7.4	2.3	0.6	2.3	0.7	0.4	0.8	0.4																														28.2
Versveld, K	ILISO											15.0								3.2	3.2																						21.4
Vivier, JC	AGES	12.5	5.8																														10.6	10.6	10.6	4.8	5.8					60.5
Vivier, JJP	AGES	5.5	2.9																														7.7	7.7	7.7	3.8	3.8					39.1
Wiethoff, A	AGES		5.6																																							5.6
Wolff-Piggott, BB	AG	6.5			3.8	11.4										13.3				17.5	38.0	10.6																					101.1
TOTAL		117.4	178.4	50.1	117.7	142.8	84.3	146.3	82.2	73.9	53.3	75.0		44.8	82.4	149.9	82.3	25.0	50.7	25.3	75.2	165.8	31.1	13.4	13.4	9.5	14.4	14.4	12.8	53.9	59.9	167.8	117.3	157.1	181.9	208.2	151.5	200.0	113.5	96.8	169.1	228.3	185.4	4 022.8

APPENDIX D

Projected cash flow


CROCODILE WEST RECONCILIATION STRATEGY
Cash flow projections
Cumulative Cashflow (R 000)
Monthly Invoice (R 000)
5 000
4 000
3 000
2 000
1 000
0
500
400
300
200
100
0
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Jan-06
Feb-06
Mar-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Month
Actual invoices
Projected invoices
Cumulative Cashflow
Updated 2006-06-29