



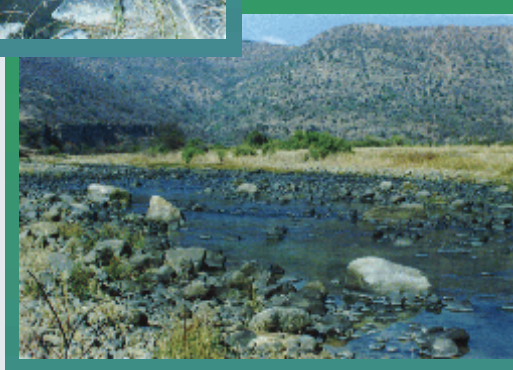
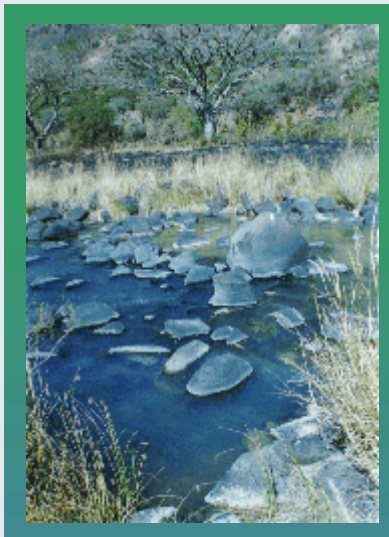
Republic of South Africa
Department of Water Affairs and Forestry

**THUKELA WATER PROJECT
DECISION SUPPORT PHASE**

RESERVE DETERMINATION MODEL

**ECOLOGICAL RESERVE
CATEGORY REPORT**

January 2003



Prepared by
IWR Environmental



THUKELA WATER PROJECT DECISION SUPPORT PHASE

RESERVE DETERMINATION STUDY ECOLOGICAL RESERVE CATEGORY REPORT

January 2003

Prepared by: IWR ENVIRONMENTAL
PO Box 122
Persequor Park
PRETORIA
0020

For: The Director
Directorate Water Resources Planning
Department of Water Affairs and Forestry
Private Bag X313
PRETORIA
0001

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The report was prepared by:

Ms Delana Louw
IWR Environmental
PO Box 122
Persequor Park
0020

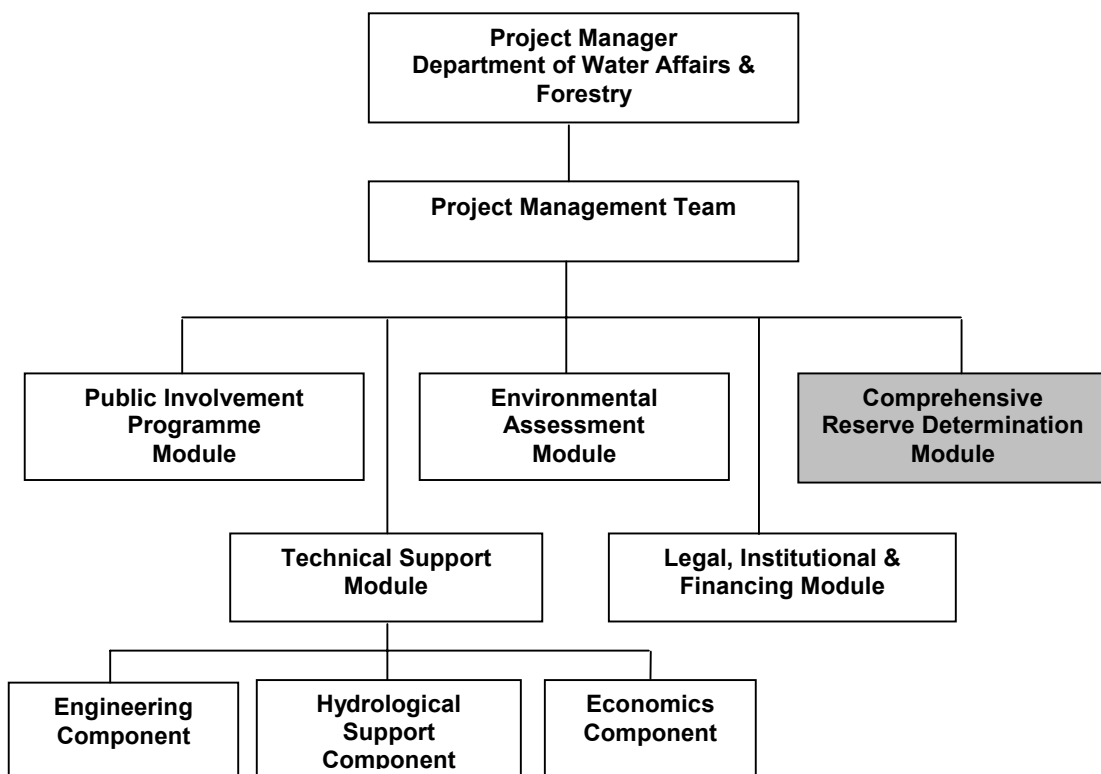
and

Dr Mandy Uys
Laughing Waters
PO Box 889
Gonubie
East London
5256

and

Shael Koekemoer
IWR Environmental
PO Box 122
Persequor Park
0020

STRUCTURE OF DECISION SUPPORT PHASE



**DEPARTMENT OF WATER AFFAIRS & FORESTRY
DIRECTORATE WATER RESOURCES PLANNING**

**THUKELA WATER PROJECT DECISION SUPPORT PHASE
RESERVE DETERMINATION STUDY
RESOURCE UNIT REPORT (FINAL REPORT)**

IWRE

JANUARY 2003

Approved for IWRE by

.....
Greg Huggins
Administrative Project Leader

.....
Delana Louw
Technical Project Leader

Approved for the Project Management Team by:

.....
JC Cooke PrEng
Project Co-ordinator

.....
RA Pullen PrEng
Study Leader

Approved for the Directorate Water Resources Planning by:

.....
NJ van Wyk PrEng
Project Manager

.....
JA van Rooyen
Director: Water Resources Planning

ACKNOWLEDGMENTS

The following specialists contributed to and participated in the Ecological Reserve Category specialist meeting:

Mr Mike Coke	Private
Dr Chris Dickens	Umgeni Water Services
Mr Greg Huggins	IWR Environmental
Mr Nigel Kemper	IWR Environmental
Dr Neels Kleynhans	DWAF, Institute for Water Quality Services
Ms Delana Louw	IWR Environmental
Mr Myles Mander	Institute for Natural Resources
Prof Jay O'Keeffe	Institute for Water Research
Dr Patsy Scherman	CAT-IWR
Ms Christa Thirion	DWAF, Institute for Water Quality Services
Dr Mandy Uys	Laughing Waters
Dr Roy Wadeson	IWR Environmental
Mr Jerry Bouwer	DWAF Kwa-Zulu Natal Region
Mr Darius Nguni	Water Resources Planning

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Ms Liesl Hill	DWAF
Mr Bob Pullen	BKS
Mr Toriso Thlou	DWAF
Mr Niel van Wyk	DWAF
Ms Barbara Weston	DWAF

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Mr Tobile Bokwe	Umgeni Water Services
Ms Dumis Sejamoholo	WRP
Mr Malesele Papu	DWAF, IWQS
Mr Malixole Soviti	Rhodes University

Program, design and presentation of graphs and integration of specialist documents:

Ms Delana Louw	IWR Environmental
Dr Mandy Uys	Laughing Waters
Ms Shael Koekemoer	IWR Environmental

Report review	Dr Heather MacKay
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EXECUTIVE SUMMARY

INTRODUCTION

The Reserve Determination Module (Module 3 of 5 for the Thukela Water Project Decision Support Phase) is designed, inter alia, to meet the requirements of the *National Water Act* No 36 of 1998. As such the study has been guided by three major parameters. These are:

- The objectives of Chapter 3 of the *National Water Act* No 108 of 1998 for a comprehensive reserve determination and the subsequent RDM protocols released by the DWAF.
- The specific requirements of the Terms of Reference as supplied by Department of Water Affairs and Forestry (Tender WF7405).
- The needs of the Thukela Water Project and associated organs of the Department of Water Affairs and Forestry. These include broad based planning required to meet overall water resource management objectives in the catchment.

The Reserve Determination module involves quantification of the water resource required to meet objectives for the Thukela system under a series of scenarios (Reserve scenarios) that are being defined during the course of the study.

THIS REPORT

The aim in the quantification of the Reserve is to provide Reserve scenarios, i.e. flow regimes that would result in a variety of river state categories, Ecological Reserve Categories (ERCs). Prior to the quantification of the Reserve scenarios, these categories must therefore be defined.

A technical recommendation on the ERC which should represent the ecological aim for the river must also be made. This represents the ecological component of the Management Class.

In the absence of a classification system, the principles of such a system, as described in the Policy, the Water Act and the RDM documentation, were used to design an approach. The step by step procedure is as follows:

- **Determine the reference conditions.**
- **Determine the PES.**
- **Determine the River Importance.**
- **Recommend and motivate an ERC.**
- **Provide ERCs that would result in other ecological states than the recommended ERC.**
- Define the ERCs in detail, i.e. as quantitatively as possible.
- Provide the quantity and quality required for each of the ERCs.
- Include the quantity requirements within a yield model to determine the consequences of supply.
- Evaluate other scenarios and provide resulting ERCs.
- Provide information to stakeholders and obtain their input.
- Provide the technical ecological information as well as the stakeholder requirements to the DWAF in a briefing document. The DWAF must also obtain information regarding the other components of the Management Class.
- The DWAF to recommend the most likely Management Class.
- Derive the ecological Category associated with the Management Class.
- Provide Resource Quality Objectives (RQOs) and a monitoring programme for the relevant ecological Category.

This report deals with the first 5 bullets above.

INFORMATION USED TO GENERATE RESULTS

The determination of the ERCs are supported by the following specialist appendices:

- Appendix A : Hydrology
- Appendix B : Water quality
- Appendix C : Fluvial geomorphology
- Appendix D : Riparian vegetation
- Appendix E : Fish
- Appendix F : Aquatic invertebrates
- Appendix G : Social importance

The data that were used are:

Aerial photographs, historical and recent.

Video

All historical and recent survey information on bio-physical aspects.

Habitat integrity

Water quality information

Hydrology information

Information on the present operation of the system.

SUMMARY OF RESULTS

Thukela River

The least modified section of the Thukela River is the most upstream section (due to little development) and the section in the gorge upstream of the Bloukrans River confluence (due to inaccessibility). The proposed Jana Dam site is situated in this gorge.

The most modified sections in the Thukela River lie between Driel and Spioenkop Dams (due to the operation of the dams) and the downstream section around Mandini (due to water quality and sedimentation problems).

The only sections with high ecological importance is the gorge section in which the Jana Dam site is situated, and the river downstream of the Buffalo River. The aim and resulting ERC for the Jana section is therefore an improvement on the PES. The ERC for the river downstream of the Buffalo section is not an improvement on the PES as there is not sufficient motivation.

The section downstream from the Klip River has a higher SI than the EIS. No improvement is however warranted as the PES is a B and the recommended ERC is already a B. A Section of the river downstream of the Bushmans River also has a high SI compared to the moderate EIS. The improvement that will have to be undertaken to halt the negative trajectory of change should ensure that the present resource utilisation would improve.

Little Thukela River

The Little Thukela is in a moderately modified to modified state (C and C/D category) mostly due to informal and formal landuse. The importance is moderate and no improvement except to halt negative trajectories are required.

Bushmans River

The Bushmans is presently in a moderately modified to largely natural PES above Wagendrift Dam and in the gorge sections downstream of Wagendrift Dam. In the more accessible areas there are extensive irrigation activities which results in a D PES. The importance is high in the gorge section. Improvement is however not required as maintaining the gorge sections will

result in improvement in the other sections.

Sundays River

The Sundays River is largely modified due to both informal and formal land use as well as specifically water quality problems. The ecological importance is moderate with a high social importance in the lower section. This does not however warrant improvement on the PES as improvement to address the negative trajectory of change will improve the social utilisation aspects.

Mooi River

The specific section of the Mooi River which forms part of the study area varies from a high PES in the gorge sections to seriously modified areas in the irrigation and rural areas. The Ecological Importance is moderate with high social importance in the downstream areas. Improvement is again not required as addressing the trajectory of change will address the social issues.

Buffalo River

The Buffalo River ranges from D category in the upper ranges (mostly due to formal agriculture and water quality problems) to a high PES in the gorge sections (mostly due to its inaccessibility). The high ecological importance in this section warrants improvement and the ERC was therefore set as a half a category higher than the PES.

Summary of the PES, EIS, SI and ERC results

RU	PES	EIS	SI	ERC (Short term ERC)
THUKELA RIVER				
A	B/C	Moderate	Moderate	B/C
B	D	Moderate	Low	D
C	C	Moderate	Moderate	C
D	C	Moderate	Moderate	C
E	B	Moderate	High	B
F	B/C	High	High	B (B/C)
G	C/D	Moderate	High	C/D
H	D	Moderate	Moderate	D
I	C	High	High	C (C/D)
J	C/D	Moderate	Moderate	C/D (D)
KLEIN THUKELA				
L	C	Moderate	Moderate	C (C/D)
M	C/D	Moderate	Moderate	C/D (D)
BUSHMANS				
N	B/C	Moderate	Moderate	B/C
O	D	Moderate	Moderate	D
P	B/C	High	Moderate	B/C
SUNDAYS				
Q	C/D	Moderate	Moderate	C/D
R	D	Moderate	High	D
MOOI				
S	C	Moderate	Moderate	C
T	B/C	Moderate	High	B/C
BUFFALO				
U	D	Moderate	Moderate	D (D/E)
V	B/C	High	High	B (B/C)

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ACRONYMS AND ABBREVIATIONS

ASPT	Average Score Per Taxon
BBM	Building Block Methodology
CAT	Centre for Aquatic Toxicology
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
EIS	Ecological Importance and Sensitivity
ERC	Ecological Reserve Category
FAI	Fish Assemblage Integrity Index
Imp	Importance
IWQS	Institute for Water Quality Services
MAR	Mean Annual Runoff
N:P	Nitrogen:Phosphorus
NWA	National Water Act
OREWRA	Olifants River Ecological Water Requirements Assessment
PES	Present Ecological State
PO ₄ -P	Orthophosphate
PMT	Project Management Team
RC	Reserve Consultant
RDM	Resource Directed Measures
RQO	Resource Quality Objectives
RU	Resource units
SASS	South African Scoring System
SDC	Source Directed Controls
SI	Social Importance
TDS	Total Dissolved Solids
Traj	Trajectory
TWPDSP	Thukela Water Project Decision Support Phase

1 INTRODUCTION

1.1 BACKGROUND

The Reserve Determination Module (Module 3 of 5 for the Thukela Water Project Decision Support Phase) is designed, inter alia, to meet the requirements of the National Water Act No 36 of 1998. As such the study has been guided by three major parameters. These are:

- \$ The objectives of Chapter 3 of the National Water Act No 36 of 1998 for a comprehensive Reserve Determination and the subsequent RDM protocols released by the DWAF.
- \$ The specific requirements of the Terms of Reference as supplied by the Department of Water Affairs and Forestry (Tender WF7405).
- \$ The needs of the Thukela Water Project and associated organs of the Department of Water Affairs and Forestry. These include broad based planning required to meet overall water resource management objectives in the catchment.

The Reserve Determination module involves quantification of the water resource required to meet objectives for the Thukela system under a series of scenarios will be defined during the course of the study. This need for a scenario based approach was mooted so as to enable recommendations regarding water resource planning based on a suite of alternatives with regard to the needs of the Reserve and stipulated management classes for the Thukela system. Out of the Reserve Determination study information will be made available in a manner that will allow the Project Management Team (PMT) of the TWPDSP to make informed recommendations and decisions for the way forward. The specific objectives of this Reserve Determination Module are, therefore:

- \$ Develop scenarios and test these with the DWAF and stakeholders;
- \$ recommend one of these scenarios to represent the Ecological Reserve for the quality, quantity components for the river and estuary;
- \$ determine the impact of the recommended Reserve on the allocatable yield;
- \$ determine whether it is possible to supply the Reserve from existing and proposed schemes;
- \$ and to provide mitigation measures if it is not.

One of the objectives above is to develop Reserve scenarios for each of the Resource Units (RUs) in the study area. Each Reserve scenario is designed to achieve or result in a specific river state which could be different from the present state (i.e. the Present Ecological State (PES). In order to develop the Reserve scenarios one, therefore has to understand past and present ecological function of the system, i.e.

- \$ How it used to function/look like;
- \$ the present ecological state and why;
- \$ future aims and why.

This process forms part of establishing the ecological component (referred to as the Ecological Reserve Category) which forms part of the Resource Classification of the system.

1.2 PURPOSE OF THIS REPORT

The report consists of two sections as follows:

- \$ Main report providing the results.
- \$ Appendix which provides all the specialist appendices.

The appendix consists of the specialist appendices generated as part of this task and used to generate the results provided in the main report.

The purpose of the main report is to document the methods followed:

- \$ Summarise the information base used for recommending an ERC;

- \$ provide the specific actions undertaken during this study;
- \$ provide all the integrated results and the relevant rationale and motivations.

1.3 STRUCTURE OF THE REPORT

This report combines all the information bulleted above into two sections Chapters 1 to 5 provides the introduction, describes the methods and the information used to provide results. Chapters 6 to 26 provide the results per RU generated during the specialist meeting. The chapters are summarised as follows:

1.3.1 Chapter 1: Introduction

This chapter.

1.3.2 Chapter 2: The Ecological Reserve and the Classification System

The work undertaken during this task provides information for use in classifying the Resource as specified in the Water Act. This chapter provides information regarding the relevant aspects in the Water Act and Policy and how it relates to the Thukela Reserve study.

1.3.3 Chapter 3: Determining Ecological Reserve Classification

This chapter describes the concepts and the method followed to recommend ERCs.

1.3.4 Chapter 4: Information utilised to recommend ERCs

As part of this task, various specialists undertook specialist studies to enable the generation of the ERCs at a specialist meeting. This chapter summarises the process used and the information generated during each specialist study. The specialist studies are provided in detail in the appendix to the main document.

1.3.5 Chapter 5: Presentation of the results

All the specialist appendices were used to generate integrated results prior to the specialist meeting. The process followed to generate these summarised and integrated results are documented in this chapter. During the specialist meeting, these results were verified and additional information generated. The chapter describes the graphs used as aids, and the procedure that was followed per RU during the specialist meeting.

1.3.6 Chapter 6 to 26

These chapters provide all the summarised and integrated information and results generated during the specialist meeting per RU. The structure of each chapter is the same for each RU.

2. THE ECOLOGICAL RESERVE AND THE CLASSIFICATION SYSTEM

2.1 THE NATIONAL WATER ACT AND CLASSIFICATION

The National Water Act (No. 36 of 1998) (NWA) is based on the central guiding principles of sustainability and equity (NWA: Chapter 1, Introduction). Sustainability of resource use is ensured by the implementation of resource protection (NWA: Chapter 3), through the application of the ecological Reserve (the quality, quantity and reliability of water required to maintain the ecological functioning of aquatic ecosystems (Principle 7, National Water Policy, DWAF, 1997)). However, since different levels of resource use, resource protection, and ecosystem health are possible, it is clear that it would be necessary to **classify each water resource for which the Reserve is to be determined**. The classification system describes levels of ecosystem health, and from these, tolerable degrees of risk to ecosystem health, and levels of acceptable use of the resource can be derived. The volume and quality of water allocated to the Ecological Reserve therefore depends on the level of classification.

Classification is explained in the following extract from the White Paper on a National Water Policy for South Africa (Department of Water Affairs and Forestry, April 1997):

“6.3.3 Resource Protection

A national resource protection classification system will be introduced. Through a process of consensus-seeking among water users and other stakeholders, the level of protection for a resource will be decided by setting objectives for each aspect of the Reserve (water quality, quantity and assurance, habitat structure, and living organisms). The objectives for each aspect of the Reserve will show what degree of change or impact is considered acceptable and unlikely to damage a water resource beyond repair. Resources will be grouped into a number of protection classes, with each class representing a certain level of protection. Where a high level of protection is required, the objectives will be strict, demanding a low risk of damage and the use of great caution. In other cases, the need for short to medium term use may be more pressing and the need for protection lower. Some resources may already need action to restore them to a healthy state, and, in future, no resources should be allowed to become irreversibly degraded.”

Chapter 3 of the National Water Act - Protection of Water Resources - describes how resource protection must be achieved by:

- the establishment of a system for classifying water resources (resource classification);
- the determination of:
 - * the class of significant water resources;
 - * resource quality objectives (water quantity, water quality, habitat and biotic integrity);
 - * the Reserve.

A system to classify the resources into Management Classes is being developed. The Management Class will consist of various components, **each within a category of its own**. These components are amongst others ecology, domestic use, recreation, agriculture.

2.2 ECOLOGICAL COMPONENT

The aim in the quantification of the Reserve is to provide Reserve scenarios, i.e. flow regimes that would result in a variety of river state categories, Ecological Reserve Categories (ERCs). Prior to the quantification of the Reserve scenarios, these categories must therefore be defined.

A technical recommendation on the ERC which should represent the ecological aim for the river must also be made. This represents the ecological component of the Management Class.

2.3 PROCESS WITHIN THE THUKELA RESERVE STUDY

In the absence of a classification system, the principles of such a system as described in the Policy (White paper on the national water policy for SA, April 1997), the Act (No. 36, 1998) and the RDM documentation (DWAF, 1999 - Volume 3) were used to design an approach. The step by step procedure is as follows:

- **Determine the reference conditions.**
- **Determine the PES.**
- **Determine the River Importance**
- **Recommend and motivate an ERC**
- **Provide ERCs that would result in other ecological states than the recommended ERC.**
- Define the ERCs in detail, i.e. as quantitatively as possible.
- Provide the quantity and quality required for each of the ERCs.
- Include the quantity requirements within a yield model to determine the consequences of supply.
- Evaluate other scenarios and provide resulting ERCs.
- Provide information to stakeholders and obtain their input.
- Provide the technical ecological information as well as the stakeholder requirements to the DWAF in a briefing document. The DWAF must also obtain information regarding the other components of the Management Class.
- The DWAF to recommend the most likely Management Class.
- Derive the ERC associated with the Management Class.
- Provide Resource Quality Objectives (RQOs) and a monitoring programme for the relevant ERC.

This report deals with the first 5 bullets above.

3. DETERMINING ECOLOGICAL RESERVE CATEGORIES

3.1 PROCESS TO RECOMMEND ERCs

Definitions of terms used in this document (EPA 2000)

EFFECT: A biological change traceable to a cause.

CAUSE (no change): A stressor that occurs at an intensity, duration and frequency of exposure that results in a change in the ecological conditions.

SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor into the waterbody.

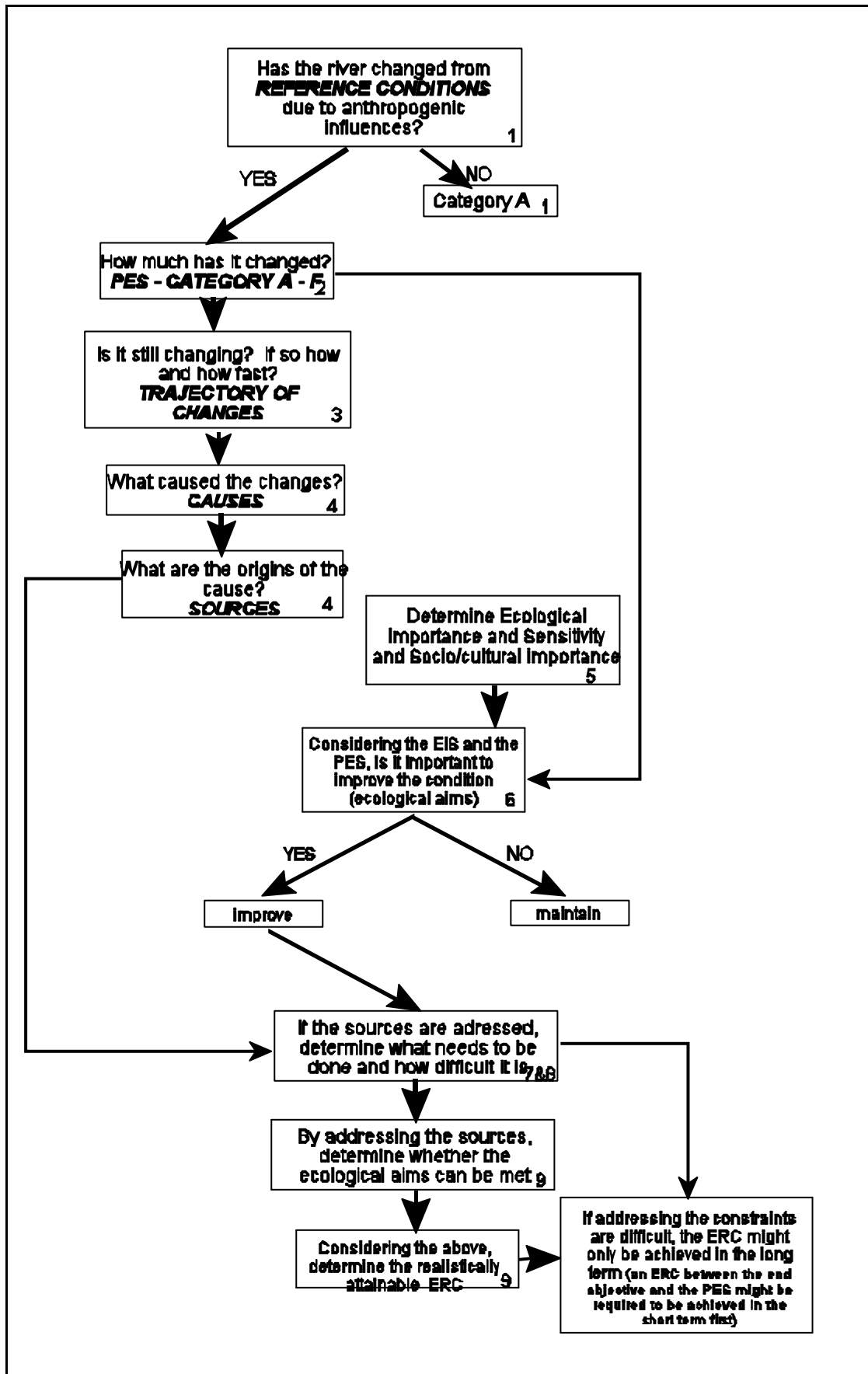
A sequence of questions, addressed during the ERC process is shown in Table 3.1. The left column illustrates simple questions, and the equivalent, more technical version is given in the right column.

Table 3.1 The sequence of actions required for providing technical information on the ERC

How did the river used to look.	1. DETERMINE REFERENCE CONDITIONS.
Compared to how the river used to look like, what does it look like now?	2. DETERMINE PES. (Category A-F).
Is the river changing, and if so, how severely? how fast?	3. DETERMINE TRAJECTORY OF CHANGE (FOR EACH COMPONENT WITH REASONS) IF THE STATUS QUO IS MAINTAINED. Trajectory (None, negative, positive). Short term and long term (Category A - F).
What is the main cause for the change?	4. DETERMINE CRITICAL CAUSE FOR THE PES and/or the TRAJECTORY OF CHANGE.
What are the source of the causes?	AND GIVE THE SOURCE OF THE CAUSE.
How ecologically and socially important is the river?	5. DETERMINE IMPORTANCE AND SENSITIVITY CATEGORIES (Low, Moderate, High, Very High) AND STATE CONFIDENCE IN EVALUATIONS.
What would the ecological aims be for the river?	6. CONSIDERING THE IMPORTANCE AND THE PRESENT ECOLOGICAL STATE; SHOULD THE PES BE IMPROVED (if so, by how much) OR MAINTAINED (NOTE: MAINTAINING THE PES COULD STILL REQUIRE RESTORATION MANAGEMENT, DEPENDING ON THE TRAJECTORY OF CHANGE) (Category A - D).
Can the main cause realistically be addressed to achieve the ecological aims?	7. DETERMINE WHAT WOULD BE REQUIRED TO ADDRESS THE CAUSES. 8. DETERMINE HOW DIFFICULT IT WOULD BE TO ADDRESS THE SOURCE. (RESTORATION / REVERSIBILITY POTENTIAL). (Easy, reasonable, difficult, very difficult). PROVIDE REASONS.
What should the ecological category be for the river?	9. CONSIDERING THE ECOLOGICAL AIMS, AND THE DIFFICULTY OF ACHIEVING THE AIMS, DETERMINE THE ATTAINABLE ECOLOGICAL CATEGORY FOR EACH COMPONENT.

The way in which the above questions were addressed is described in the flow-diagram below. The steps in the flow-diagram are discussed according to the numbers within the flow-diagram.

Figure 3.1 Flow diagram illustrating the information generated to determine the ERC



1.1 Has the river changed from reference conditions due to anthropogenic changes?

Guidelines are provided by the DWAF (DWAF, 1999 - Volume 8) for the determination of reference conditions for both quantity and quality aspects of a Reserve determination. The reference condition describes the natural condition prior to anthropogenic change. The reference conditions are described for each specialist component using the information below.

- Search for the least-impacted sites, either in the same or in comparable river zones.
- Use the results of historical surveys before major human impacts.
- Use aerial photographs.
- Use expert judgement.

Historical information and data, and/or data from reference sites (minimally impacted sites) are used to describe the reference conditions for the channel, hydrology, biota, and the water quality. Due to data limitations and/or the absence of any existing A category resource unit, the reference condition may not represent a natural river state, but rather the best estimate of a minimally impaired baseline state. If the river has not changed, then the present ecological state can be described as in an A category condition, and the resource is in a natural, near to pristine, or minimally impacted state. For such a resource, the present state equals the reference condition. If the river has changed, it leads to the next step.

2. How much has it changed (Categories B - F)?

The PES is derived from, or described as a change for the worse from a described reference condition, which ideally relates to an A category condition - the historically natural condition (DWAF, 1999 - Volume 8). The degree of change is described by one of a range of categories (Table 3.2). The PES of the river is expressed in the components: habitat (habitat integrity), biophysical (fish, riparian vegetation, aquatic invertebrates and geomorphology) and water quality (chemistry) integrity. Each component is assigned a category level (A-F), where categories A-D are judged to be ecologically sustainable, and categories E and F indicate a current state that is ecologically unsustainable. The PES is compared with the reference conditions using:

- Surveys during the project.
- Results of historical surveys/databases.
- Aerial photographs.
- Expert judgement.

No integration of the different PES components in one value is required, as this would detract from the specific details provided. However an overall 'Ecostatus' is provided which consists of a subjective evaluation of all the information provided in an overall value for this river. The Ecostatus evaluation is also important for the determination of an ERC for the river, as an ERC is determined for each of the different components, as well as for an overall Ecostatus ERC for the river². The factors which contribute to an overall classification of the ecological status of a resource unit are complex and interactive. The best information that the specialists have, is the motivations for the individual components, as these are data-based and individually argued and motivated. *It is therefore not possible to define a rigorous process, since conditions and the interactions between different processes and components differ markedly in different rivers, but the following guidelines may be useful:*

¹ These numbers refer to the numbers on the flow diagram.

² Note: "Ecostatus" is the term used for the integration of the component categories into one category - the Ecostatus. When dealing with the PES value, the Ecostatus value is either referred to as "the PES" or the "Ecostatus PES". When dealing with the ERC value it is either referred to as "the ERC" or the "Ecostatus ERC".

- First examine the driving processes (flow, water quality, geomorphology)
- If one of these is in a lower class than the biota:
 - Examine the causes, sources and trajectories of change.
If the biota is likely to follow the critical driving process, then the Ecstatus class will usually be set in the same class as the driver.
If not, then the Ecstatus may be set in the same class as the critical biotic component.
- If the biotic classes are in the same as or lower classes than the drivers:
 - Examine the causes, origins and trajectories of change, and the confidence in the assessment of each component.
The Ecstatus class will usually be set in the same class as the critical biotic component.

Note: Each reach is assessed individually by best expert judgement, taking into account the above steps, but also the specialists' holistic assessments of the state of the riverine ecosystem, and of their experience and knowledge of the system.

Table 3.2 Definitions of generic PES categories (DWAF, 1999 - Volume 3)

CATEGORY	DESCRIPTION
A	Natural; ! The resource base has not been decreased. ! The resource capability has not been exploited.
B	Largely natural with few modification; ! The resource base has been decreased to a small extent. ! A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified; ! The resource base has been decreased to a moderate extent. ! A change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified; ! The resource base has been decreased to a large extent. ! Large changes in natural habitat, biota and basic ecosystem functions have occurred.
E	Seriously modified; ! The resource base has been seriously decreased and regularly exceeds the resource base. ! The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically modified; ! The resource base has been critically decreased and permanently exceeds the resource base. ! Modifications have reached a critical level and the resource has been modified completely with an almost total loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

3. Is it still changing, if so, how, and how fast? (Trajectory of Change)

The Trajectory of Change describes how fast the changes (as a result of the causes and sources described below in 4 below) are taking place. The trajectory can be stable, negative or positive. The trajectory is described for each of the components for which a PES is determined, and from this information it is therefore possible to derive whether the PES evaluation reflects

a stable state, or whether it is still changing under present conditions. The Trajectory of Change evaluation is provided as '0' for stable, '+' for improving, and '-' for degrading.

The Trajectory of Change describes the current trend of changes in the river in present conditions. The changes can happen at different rates, which are reflected by short term and

long term changes. The results of the 'do nothing' scenario are presented by illustrating the Category in which the river would be in the short term (less than 5 years) and the long term (more than 20 years). This information is derived from the Trajectory of Change. The short and long term changes are provided for each resource unit of the river for which an ERC will be generated and for each component for which a PES was determined.

4. What caused the changes and what are the sources of the causes?

The impacts on the river are listed and separated into flow-related and non-flow related activities and are referred to as causes. Proximal causes observed in the system due to changes in water quality, flow and external factors are for example higher salinity, sedimentation, loss of indigenous riparian plants, flow reduction, low abundance of indigenous fish, etc.

Certain causes may be related to changes in flow, for example a decrease in fish population. Loss of indigenous riparian vegetation could however be caused by catchment related activities such as deforestation for purposes of fire wood. The determination of whether the causes are flow or non-flow related is important, as this influences the decision of whether mitigation solely by flow manipulation is possible and appropriate, or whether source-directed measures are necessary. For example: Flow reduction due to abstraction for irrigation could be mitigated by flow measures; loss of indigenous riparian vegetation due to overgrazing could not be mitigated by flow manipulation; water quality problems due to sewage treatment works could be mitigated by increasing flows for dilution, but it would not be appropriate to recommend Reserve flows for this purpose. This could be a valid management option.

Best judgement of the activities which have been responsible for the changes from the reference state to the PES, such as: overgrazing, irrigation, mining effluent, sewage treatment works, etc is used.

5. Determine the Ecological Importance and Sensitivity (EIS) and Socio/cultural Importance (SI)

EIS: The ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (DWAF, 1999 - Volume 3).

SI: Specific methods to determine importance have not yet been determined. A study consisting of workshops and meetings with stakeholders as well as making use of questionnaires are undertaken. The results are used to answer a simple set of questions to determine the dependency of people on a healthy functioning river and also to assess the cultural and tourism potential.

Considering Socio/cultural Importance, within the context of Ecological Importance and Sensitivity. The underlying assumptions in the process are the following:

- If the EIS is High or Very High, the ERC should be an improvement of the PES.
- If the EIS is Low or Moderate, the SI is also considered, and if also Moderate or Low, the ERC should be a Category that equals the PES.
- If the EIS is Low or Moderate, but the SI is High or Very High, the ERC should be an improvement of the PES.

6. Considering the EIS, SI and PES, determine the ecological aims for the river.

If the ecological importance or social importance are high or very high, the ecological aims should be to improve the river. However, the PES should also be considered to determine whether improvement is realistic. If the EIS and SI evaluation is moderate or low, the ecological aims should be to maintain the river in its PES.

7. If the sources are addressed, what needs to be done to achieve the aim.

The recommended ERC must be attainable and it must therefore be considered whether the problems in the catchment can be addressed to ensure that the ecological aims are achieved. The specialists decide to the best of their ability what would have to be done to address the causes of degradation, how effective such remedial actions might be, and how difficult they might be to achieve (e.g. if a major supply dam had to be demolished to improve the river, this would be classed as 'very difficult') (O'Keeffe & Louw, 1999). It is acknowledged that this process is subjective and that evaluations are undertaken on technical possibilities by ecological specialists.

8. Consider the difficulty of addressing the source of critical causes.

In general it can be accepted that if the PES is in a C or D category or lower and the importance is High or Very High, more effort would be required to attain an ERC which is an improvement on the PES. However, the kind of change(s) that resulted in a particular PES may vary in terms of the possibility of reducing their impact in order to achieve restoration of the system. It follows that each of the attributes will have to be assessed in terms of the perceived possibility of restoring them to a condition where such an improvement will lead to an improvement of the PES (DWAF, 1999 - Volume 8). Some changes may be practically irreversible within the limits of time and effort (including financial resources) required to achieve this. While five years is a commonly used time frame for many institutions and is considered a realistic period for attempting to estimate future conditions (Gonzalez 1996), it is difficult to put limits to what can be regarded as realistic efforts.

9. Recommend attainable ERC.

The role of the technical recommendations made by the specialists must be emphasized. These are technical recommendations concerning what is possible and what is considered to be the most realistic option from an ecological viewpoint. The long term ERC recommended by the specialists can be a interpretation of what the DWAF might ideally aim for in terms of maximum achievable protection of the resource base, but this would still be open to modification on the basis of the other socio-economic and macro-economic factors.

The long term ERC recommended, ***indicates the ERC which should be the end target for the river.*** This ERC, even though considered attainable, might only be achieved in the long term, due to the present constraints in the system. Several causes of change are landscape-based, and even immediate improvements in management practice would not show immediate improvements in river condition. This means that in the short term, an intermediate, short term ERC might need to be achieved first, and that ongoing efforts to achieve improvement of the system would be required to achieve the long term ERC. This will require a long term catchment strategy, as one of the aims of the NWA is to protect the water resource for future generations.

The PES and the difficulty of addressing the sources are assessed. As the ERC must be realistic and attainable, even if only in the long term, an assessment must now be made whether the aims (i.e. improvement or maintenance) can be met (see 6 above). For each component, an ERC is set on this basis and then the component ERCs are integrated into one value, i.e. the Ecostatus ERC and if necessary, a long term ERC. The integration process is the same as followed when determining the PES for the Ecostatus.

3.2 DEFINING THE ERCs

This process is intended to provide detailed criteria for each ERC for which an Ecological Reserve will be determined. Each specialist should define the following:

- The ERC (as described above).
- General flow criteria. For example, maintenance of perennial flow; early wet season high flows; the ratio of wet to dry season base flows; an annual bankfull flow; etc, according to the importance of different flows for the particular component.
- General criteria for the particular component. For example, invertebrate SASS scores greater than 120 for wet seasons except during droughts; removal of silt and sand from riffle areas during the wet season; maintenance of a target number of fish species, and increased abundance of flow dependent fish species; etc.
- Identification of target species/variables: Each specialist will select one or a few key flow-dependent indicators on which to concentrate the assessment of flow requirements. There is no limit to the number of species/groups/components which can be accommodated, if the specialist understands their flow requirements and considers that each will contribute to the overall assessment of flow requirements. Written reasons and justification for the choice of the target indicators selected above must be provided.
- Objectives for target organisms: For example, reduced salinity to below 100 mS/m for more than 90% of the time; habitat maintenance for *Chiloglanis anoterus* (rock catlet) in terms of velocities, depths and substrate type; seeding of critical flow dependent riparian trees.

NOTE: The above must be related to the individual indices which describe the different categories.

This “objectives hierarchy” is intended to convert the general criteria of the ERC to specific measurable objectives, for which particular flow regimes can be designed, and which will form the basis of monitoring activities. For these reasons, it is important that the detailed criteria (at the component and target species level), should be quantified as far as possible. This information will then form the basis of the Resource Quality Objectives.

4. INFORMATION UTILISED TO RECOMMEND ERCs

In this chapter a summary of the information utilised to prepare for the ERC specialist meeting is provided. Details regarding the specialist input is provided in specialist appendices which forms a separate document with the same reference number as this document. The process which specialists had to follow to provide the specialist appendices is also provided. This is followed by a summary of the approach followed within each specialist appendix.

4.1 INTERPRETATION OF AVAILABLE DATA

4.1.1 Specialist appendices

The determination of the ERCs are supported by the following specialist appendices:

Appendix A: Hydrology
Appendix B: Water quality
Appendix C: Fluvial geomorphology
Appendix D: Riparian vegetation
Appendix E: Fish
Appendix F: Aquatic invertebrates
Appendix G: Social importance

The data that were used are:

Aerial photographs, historical and recent.
Aerial Video.
All historical and recent survey information on bio-physical aspects.
Habitat integrity.
Water quality information.
Hydrology information.
Information on the present operation of the system.
Land cover assessment.

Guidelines as follows were provided regarding the specialist appendix contents:

Introduction

Methods

Reference conditions.
PES (indexes - basis etc.).
Modifying determinants.

Assessment per resource unit

Reference conditions (include species diversity, abundances and lists (confidence scale of 0-5 and reason).
PES (Category).
Modifying determinants.
Trajectory of change (0, -, + and Category in 5 yr (short term) and 20 yr (long term)).
Reasons for trajectory of change (if stable, i.e. 0, it ALSO requires a reason)
Confidence scale of 0-5 and reasons - note : one confidence scale for PES and
Trajectory of change.

References

4.1.2 Specialist appendix summaries¹

The specialists were requested to summarise in a separate table provided to them information regarding the PES. This information will be used to integrate the information generated for the various components into one table per RU which is incorporated in this report and was presented and modified at the specialist meeting.

Specialists were requested to split their 'modifying' determinants into the following 3-tier assessments. The 3 tiers refer to three questions of why, starting with the immediate effect and ending with the origins. Fish is used as an example:

Why is fish in a C (e.g.) category (column 1)? EFFECT

Answer relates to the description of the different indexes, but the dominant factor must be picked out. For example, a C category for fish could be described as some species missing from reference column, abundances decreased, alien species present.

Answer could be: Fish species numbers decreased significantly even though all species still present.

Why have the numbers decreased? - relate to the causes (column 2) CAUSE

Answer refers to direct cause (water quality, hydrology, physical habitat (could include both geomorphological issues and riparian/marginal vegetation issues)

Answer could be : Hydrology (unseasonal flow patterns).
Habitats - excessive siltation.

Why are there problems with the hydrology and habitats? - relate to sources (column 3) SOURCES

Answer could be : Operation of Dam X for agriculture - flow related.
Overgrazing in the catchment - non-flow related.

The following question is then asked

What action would be required (if necessary) to address the sources?: (column 4)

Answer could be: Operating rule that supplies the Reserve.
Catchment management.

4.1.3 Interpretations of results

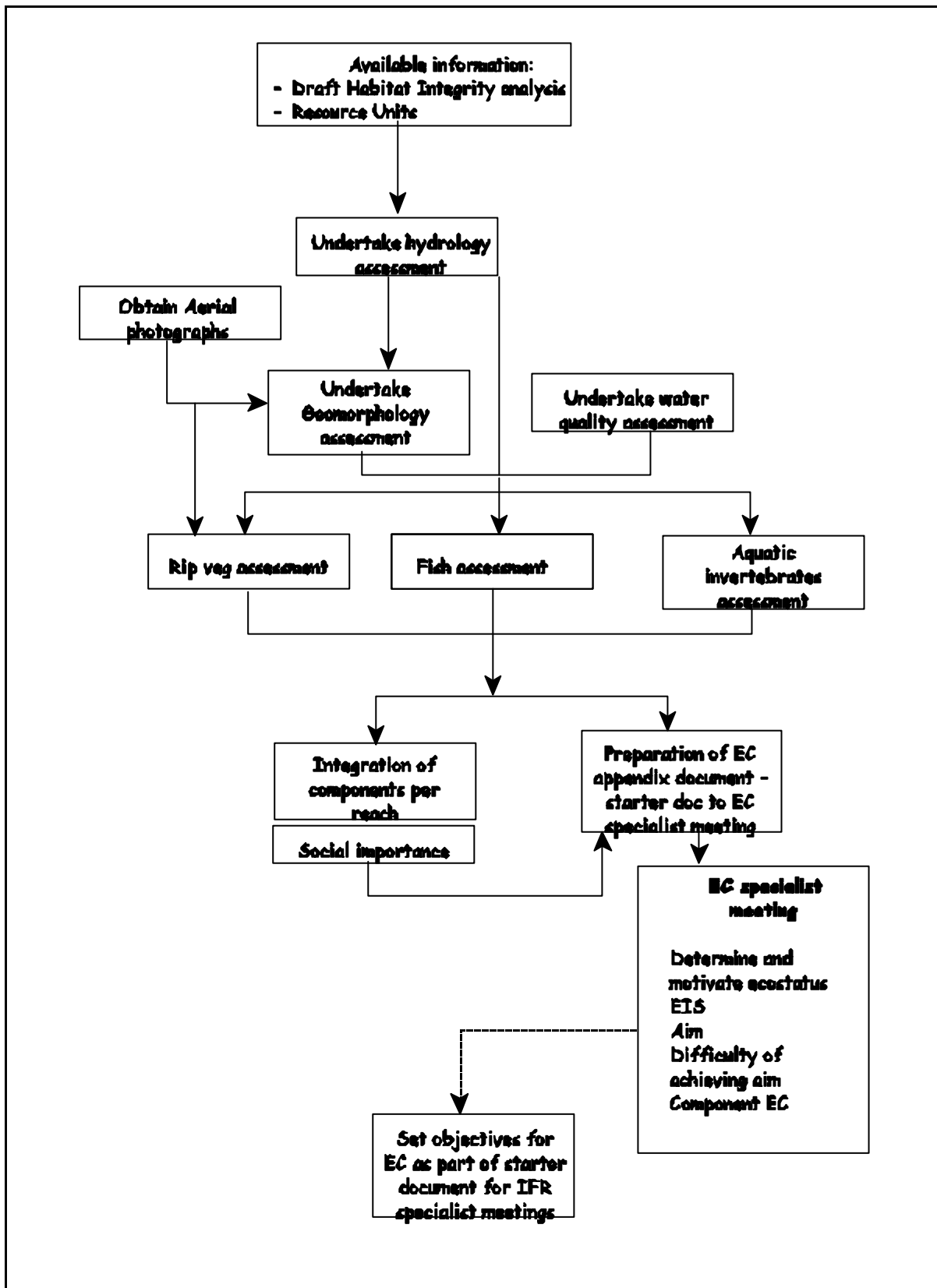
To enable informed assessments to be made, certain of the appendices and/or results should be made available to some of the specialists to aid in their assessments. The following sequential process (Figure 4.1) therefore needed to be followed to ensure that specialists can use the results of the 'driver components' (hydrology, water quality, geomorphology) to interpret their results and attach reasons for the PES category. A document describing (mostly qualitatively) the operation of the system was also provided up front to specialists.

All the results were then integrated by the IFR coordinator to provide the template and initial integrated results as the basis for the ERC specialist meeting. These steps are also provided in Figure 4.1.

¹ All references are illustrated in the Appendix document.

Fig 4.1

Sequential events and interaction as preparation for the ERC specialist meeting



4.2 PRESENT OPERATION OF THE SYSTEM (WRP,DMM. 2002)

The Thukela River Catchment is not largely regulated due to low industrial and economic activities in its immediate surround. Abstractions for irrigation and urban/domestic water purposes are directly made from the system to service in-catchment requirements. However, the biggest abstractions from the system are those made to satisfy the transfer water requirements through the Drakensberg Transfer Scheme, Zaaihoek Dam Transfer Scheme and Middledrift Transfer Scheme.

There are eight dams in the Thukela River System that have been developed to date. Three of these, Kilburn, Woodstock and Driel Barrage, form the Drakensberg Transfer Scheme. The runoff characteristics of these dams were provided to the specialists.

The existing dams and their operating rules are discussed with the aim of assisting the specialists in interpreting the PES for their relevant components of the study. The focus of the operations report is on the Thukela River System flows as impacted by compensation releases operating rules, releases infrastructure capacity, spills from dams and ad hoc releases requests.

4.3 HYDROLOGY (APPENDIX A)

The method was developed by Hughes for the Olifants Reserve Project and modified for use in this project.

The method is based on the comparison of natural and present day 1-month annual duration curves (i.e. flow duration curves constructed from monthly volumes for all months of the year). The first step is to calculate the positive relative difference between the two duration curves at 5 percentage point values (10, 30, 50, 70 and 90%) using:

$$DIFF_i = | NAT_i - PDAY_i | / NAT_i$$

Where i represents the 10, 30, 50, 70 and 90% exceedence points on the duration curve and $DIFF_i$ is constrained to be less than or equal to 1.0.

Each of the $DIFF$ values is then multiplied by a weight that is designed to represent the importance of modifications to the flow regime at different flow levels:

$$WT_{10} = 3, WT_{30} = 2, WT_{50} = 2, WT_{70} = 3 \text{ and}$$

$$\begin{array}{ll} \text{If } DIFF_{90} > 0.75 & \text{then } WT_{90} = 4.0 + (1.5 * DIFF_{90})^{4.6} \\ \text{Else if } DIFF_{90} \leq 0.75 & \text{then } WT_{90} = 4.5 + (1.4 * DIFF_{90})^{3.0} \end{array}$$

If the difference for the 90% exceedence point is positive (natural greater than present day) then an additional weight (referred to as SIGN) is set to 1.0, while if the present day flows are greater than natural, the SIGN value is set to 1.5. SIGN is set to 1.0 for all the other exceedence points. This allows the deleterious effect of elevated low flows to be incorporated into the evaluation.

For example, the weight for a relative difference of 0.5 is equal to 4.84, while for a relative difference of 0.9 (i.e. a 90% reduction in low flows) is equal to 7.98. Thus for low flow reductions (or increases) of about 50% and less, the weight is double that for the 30 and 50% exceeded flows and about 1.5 times that for the 10 and 70% exceeded flows. However, when the low flows are reduced (or increased) substantially, the 90% weight dominates the whole calculation. If the low flows at the 90% exceedence level are reduced to zero then the weight becomes 10.46 and the overall present state can only be a D or lower (see below). One of the main problems with this attempt to account for the importance of changing from perennial to non-perennial conditions is the sensitivity of the weight calculation for rivers which are only just perennial. For example, if a river has naturally very low flows at the 90% exceedence level and these are removed

through afforestation, the present state class would be at least a D and probably (due to reductions at other levels) an E or F.

In developing the index of present day hydrological conditions, the authors have tried to be consistent with the range of flows that would be set using the BBM approach for different categories. Experience suggests that the focus is often on the low flows at the high % exceedence end of the flow duration curves; hence this is where the largest weighting factors have been applied.

It should also be noted that the hydrological present day categories are estimated independently of any ecological information on the conditions in the rivers and not accounting for the length of time that the rivers have existed in the 'present state'. Therefore no account has been taken of any possible lag effects between hydrological conditions and ecological response (trajectories of change), nor of the sensitivity of the biological components of the systems to changes in flow patterns.

The initial total weighted score is calculated as:

$$\text{INITIAL TOTAL SCORE} = \sum (DIFF_i * \text{SIGN} * WT_i)$$

It has been noted that the initial total score does not account for reversals, or major changes, to the seasonality of baseflows. Therefore an additional score is added which attempts to account for differences between natural and present day low flows in the wet and dry seasons. The first part of the process is to identify the wettest (W) and driest (D) months in the natural time series based on the 90% exceedence point of the calendar month duration curves. The following two ratios are then calculated:

$$\text{RAT90} = (\text{NAT90}_W - \text{NAT90}_D) / (\text{PDY90}_W - \text{PDY90}_D)$$

$$\text{RAT70} = (\text{NAT70}_W - \text{NAT70}_D) / (\text{PDY70}_W - \text{PDY70}_D)$$

Where NAT90_W is the flow volume for the 90% exceedence point on the natural duration curve for the wettest month and PDY90_D is the equivalent flow volume for present day conditions.

The initial ratio score is taken as the maximum of these two ratios and then the following rules applied to determine the final ratio score SRAT:

If $WT_{90} > 8$	then	SRAT = 0
If $8 > WT_{90} > 6$	then	SRAT = Max(RAT90, RAT70) / 2
If $WT_{90} < 6$	then	SRAT = Max(RAT90, RAT70)
If SRAT > 3	then	SRAT = 3

The rules are applied to ensure that large present day impacts already accounted for in the initial total score are not duplicated with the addition of the ratio score. The total score then becomes:

$$\text{TOTAL SCORE} = \text{INITIAL TOTAL SCORE} + \text{SRAT}$$

And the present hydrological state category given by:

TOTAL SCORE	CATEGORY
0 to 3	A
>3 to 6	B
>6 to 8	C
>8 to 11	D

>11 to 14
>14

E
F

Monthly time series of natural and present day (1995 conditions) were supplied by WRP Consulting Engineers for the hydrological years 1925 to 1994. Of the 22 (A to V) Resource Units identified by the Reserve Determination Team, present day flows were available for 16 (B&C, E&F, H to K, M to R, T and U).

4.4 WATER QUALITY (APPENDIX B)

4.4.1 Data and methods used to determine reference condition and PES

Present Ecological State (PES) categories could only be determined for Total Dissolved Salts (TDS) and Electrical Conductivity (EC) (using toxicity tables as in Table 4.1), and nutrients. The only nutrient data available were for orthophosphate (PO₄-P), and Nitrogen:Phosphorus (N:P) ratios. Dissolved oxygen and temperature data were not available for this study. Toxics information was also not available.

Note that additional water quality data was collected for the purposes of this project. Areas lacking in water quality data were identified (6 sites), and an 8-week monitoring programme initiated (as per the requirements of the RDM manuals (DWAF, 1999) for comprehensive Reserve assessments) from August - October 2001. Water samples are collected weekly by Tobile Bokwe and analysed for a specified list of variables at the Umgeni Water Laboratories.

On the basis of the foregoing, the toxicity tables (Table 4.1) were used to determine TDS and EC for RC and PES. Nutrient status was allocated according to Table E8 in the RDM documents (DWAF1999). The overall water quality class (PES) was derived according to the integration method of the *Olifants River Ecological Water Requirements Assessment*. (OREWRA, DWAF 2000a). Categories were not allocated to pH, as pH is only used in the assignment of overall water quality class if it is outside the general standard range, i.e. < 5.5 or > 9.5. In terms of toxic substances, problem areas were dealt with where applicable, e.g. where pesticide use was occurring. Likewise, suspended sediments and sulphate concentrations were mentioned where and when necessary.

Expert judgement was employed where there were discrepancies between water quality categories and biotic categories.

4.4.2 Indices used

Table 2.1 is the classification table for Total Dissolved Solids (TDS) and Electrical Conductivity (EC) - as a measure of in-stream salinity - based on laboratory-generated toxicity data using macroinvertebrates from the Thukela River system and NaCl as toxicant. The selection of NaCl as toxicant was related to the primary cause of increasing TDS in this catchment, i.e. agricultural return flows. Testing was conducted in recirculating artificial streams - see DWAF (2000b) for general methods - in the CAT laboratories in Grahamstown.

Table 4.1 Classification table for TDS and EC based on toxicity data from *Afronurus peringeyi* (Heptageniidae) from the Bushmans River (upper Thukela), and *Euthraulus elegans* (Leptophlebiidae) from the Mooi River (lower Thukela).

CATEGORY	TDS (mg/l)	EC (mS/m)	DATA CONFIDENCE*
A	< 200	< 30	2
B	200 - 600	30- 90	2
C	600 - 1000	90 - 150	4
D	1000 - 1900	150 - 300	4
E	> 1900	> 300	4

* 0 = no confidence 5 = high confidence

4.5 FLUVIAL GEOMORPHOLOGY (APPENDIX C)

4.5.1 Data and methods used in determination of reference condition

In an attempt to determine a reference state for which the present Thukela River can be compared, use was made of three data sources:

- A river zonal classification system based on work carried out on a number of different rivers around South Africa using log profile gradient;
- a system which relies on interpretation of historical aerial photographs for selected lengths of river;
- a system which requires an interpretation of the historical hydrological record.

River Zonation

Rowntree and Wadeson (1998) have developed a zonal classification system for South African rivers modified from Noble and Hemens (1978). An attempt was made to give each river zone a geomorphological definition in terms of distinctive channel morphological units and reach types. After working in a number of different rivers around the country, Rowntree and Wadeson (1998) noted that channel gradient is a good indicator of channel characteristics and that differences down the profile can be identified from an analysis of gradients.

Using the 1:50 000 topographic map series for the Thukela basin, a zonal classification was carried out. This information was used to determine a reference condition for the different river segments within the catchment.

Aerial Photography

The method utilised in this study was to obtain a succession of aerial photographs for the study area and to compare the physical form of the channel over time. Three sets of photographs were obtained: 1940's (earliest available); 1964 and 1992 (most recent). The records were photographically adjusted to an approximate scale of 1:10 000 to allow the recognition of various morphological features in the channel.

Hydrology

A hydrological assessment has been produced by Hughes and O'Keeffe which compares the natural and present day 1-month annual duration curves. The authors have used this information to produce an index of present day hydrological conditions based on low flows. This information is used on a fairly superficial level to help categorise the present geomorphological state.

4.5.2 Methods used for determining PES

A desktop study was carried out to determine the present state of the river using video footage together with historical aerial photography. Aspects of the river that were of particular interest included :

- Morphology and habitat - riffles, pools, rapids, bars etc.
- Boundary condition - erosion, vegetation, stability.
- Instream disturbance - bridges, weirs, pumps.
- Valley form - confined, unconfined.
- Pattern - single thread, anastomosing, meandering.
- Morphometry - width, depth (incision).
- Sediment - bars, suspended etc.

With the above criteria in mind, the geomorphological consultant used all available data to determine a present geomorphological state for each zone of the river. A classification of present geomorphological state uses six categories A-F. A description of these categories follow in Table 4.2.

Table 4.2 Definition of Geomorphological PES categories (Wadeson and Rowntree, *pers corr*, 1998)

CATEGORY	DESCRIPTION
A	! Unmodified, natural;
B	! Largely natural with few modifications; ! A small change in geomorphology and natural habitats as a result of occasional in channel structures and/or limited sediment inputs related to human activity.
C	! Moderately modified; ! A change in geomorphology and in-stream habitat but geomorphic thresholds do not appear to have been crossed. ! Local impact of in-channel structures, presence and/or clearance of alien vegetation in the riparian zone, frequent sediment sources related to human activity.
D	! Largely modified; ! Large changes in geomorphology and in -stream habitat, geomorphic thresholds appear to have been crossed with the river moving towards a new equilibrium. ! One or more of the following: localised channel straightening, sediment extraction, numerous in-channel structures, indigenous vegetation clearance from the riparian zone, extensive sediment sources.
E	! Seriously modified; ! The loss of natural in-stream habitat is extensive. The system appears to be extremely unstable. ! The river has extensive channel straightening, and/or numerous anthropogenic influences are apparent.
F	! Critically modified; ! Channel Modifications have reached a critical level with an almost total loss of natural in-stream habitat. Geomorphological changes are virtually irreversible. ! The river has been canalised and/or numerous anthropogenic influences are apparent.

4.6 RIPARIAN VEGETATION (APPENDIX D)

4.6.1 Data and methods used to determine reference condition

For the sake of simplicity the reference condition of riparian vegetation has been assumed to be a category A (undisturbed / natural) for all resource units. However, in order to compare this condition relative to that of the present day it is essential to understand the characteristics of the reference state. These characteristics obviously vary from resource unit to resource unit and have therefore been considered independently in this exercise. The resource units within the Thukela system were selected on geomorphological, eco-regional, hydrological and operational considerations and it has also been assumed that the reference characteristics within these units are relatively homogeneous.

In an attempt to understand the reference characteristics of the various resource units three data sources were used:

- Geomorphological stream classification,
- historical hydrological records, and
- historical aerial photographs.

Geomorphological River Zonation

Wadeson (2001) described the geomorphological characteristics of the reference state which have direct relevance to the reference state of riparian vegetation.

Historical hydrological records

Hughes and O'Keeffe (2001) produced a hydrological assessment which provides the natural hydrological conditions of the resource units using 1 month annual duration curves.

Aerial photography

A series of aerial photographs of the study area was used to establish a reference condition for riparian vegetation. Due to the scale of the photography and the limited vegetation detail available, this method provides only basic information such as the extent of vegetation cover, distribution relative to river channel and adjacent areas, tree size and dominant species composition.

4.6.2 Methods used to determine PES

The approach used to describe the present ecological state of the riparian vegetation of the Thukela system therefore considers available information on the geomorphology, hydrology and land use within the various resource units provided. The PES is described relative to a pre-determined "natural state" or reference condition which is a qualitative condition based on our limited understanding of the template conditions present before anthropogenic influences were responsible for changes in geomorphological and hydrological conditions within the catchment.

The following data sources were considered during the compilation of the PES for riparian vegetation:

- Available aerial photographs and videos.
- Geomorphological stream classification.
- Hydrological assessment.
- Current operations report.
- Land cover assessment.

The present ecological state of riparian vegetation and trajectory of change was then assessed for the various resource units in the study area.

Geomorphological zone assessment

Wadeson (2001) described the geomorphological present state, present characteristics, modifying determinants and trajectory of change for each of the resource units in the study area. These have direct relevance to riparian vegetation and were therefore used to derive riparian vegetation present state.

Hydrological assessment

Hughes and O'Keeffe (2001) undertook a hydrological assessment which compared the natural and present day duration curves to derive a hydrological present state for the resource units in the study area. Since hydrological conditions serve as a template for vegetation condition this was also used in the assessment of riparian vegetation present state.

Current operation

The current operation of the various structures within the Thukela system were described in a report (Anon, 2001). The operation of instream structures have a significant impact on the present state of riparian vegetation. This was thus considered with regard to the affected reaches of the river, to assist with present state assessment of riparian vegetation.

Land cover assessment

The assessment of land cover (DWAF, 2001) indicates the extent to which various classes of natural and man-made cover types exist within the tertiary and quaternary catchments of the Thukela system. This assessment provided a good picture of the proportions of natural vegetation still remaining in the system and the extent to which various anthropogenic pressures have impacted on riparian vegetation. The percentages of the land cover types were scrutinized to assess the extent of change from the reference condition.

Aerial photographs and videos

Both aerial photos and videos were carefully assessed. These were useful for directly indicating the present state of riparian vegetation. The trajectory of change was also derived using a series or historical set of aerial photographs to present day.

Aspects of the riparian vegetation compared were vegetation distribution and type, dominant species, tree sizes and density.

The modifying determinants for observed changes in the riparian vegetation state from the reference state were identified mainly from the land-cover assessment and the aerial photographs and videos. These determinants were described as the critical causes for observed changes. The origins of these causes were then considered, given the extent and nature of the critical causes.

After the data sources were investigated and modifying determinants considered, the present state categories for riparian vegetation were assessed for each resource unit based on the definitions presented in Table 4.3.

Table 4.3 Definition of Riparian Vegetation PES categories (from Kleynhans, 1996)

CATEGORY	DESCRIPTION
A	! Unmodified, natural.
B	! Largely natural with few modifications. ! Small change in vegetation state is evident as a result of anthropogenic pressure.
C	! Moderately modified. ! A moderate change in vegetation state is evident either as a slight change in more than one component simultaneously or as a larger change in a single component only. ! Changes are visible but the vegetation zone maintains a natural character and remains more natural than impacted / artificial.
D	! Largely modified. ! Large changes in vegetation state are visible for more than one component simultaneously. Changes are obvious and the vegetation appears to be more impacted / artificial than natural. ! The extent of riparian zone degradation is visible either in definite patches or generally throughout.
E	! Seriously modified. ! The change in vegetation state is extensive in most or all of the components simultaneously. ! The vegetation is seriously impacted or replaced throughout. ! The riparian zone is highly degraded throughout and natural recovery is unlikely in the short to medium term.
F	! Critically modified. ! Little to no natural vegetation remains and changes are likely to be irreversible. ! The riparian zone is critically degraded and no natural recovery is likely even in the long term

Note: Vegetation state comprises four components, viz. species composition, structure, cover and distribution.

Species composition: describes the species compositional make-up of the vegetation present. The removal of one or more species and/or the introduction of others (such as exotic species) will result in a shift in species composition.

Structure: describes the physical structure and size/age class of vegetation present. The death or removal of specific size classes of trees will lead to a corresponding shift in structure.

Cover: describes the extent of vegetational cover. The removal of vegetation either due to utilisation or erosion will result in corresponding changes in the extent of vegetation cover.

Distribution: describes the location of vegetation within the riparian zone. Removal of vegetation in specific areas will lead to corresponding changes in the distribution of remaining vegetation.

4.7 FISH (APPENDIX E)

4.7.1 Data and methods used to determine reference conditions

Fish population sampling by means of electro-shocker, gill nets, seine nets, rotenone poisoning and observation has been conducted in the Thukela basin over the past 40 years, resulting in the compilation of an extensive database which formed the basis for the analyses presented here. Fish species noted at each site, as well as their size ranges and abundances were recorded, as were health problems when these were noticed.

Historical fish distributions in the Thukela system, as well as the general habits, habitat and food preferences of various species were investigated through the publications of Crass (1964), Jubb (1967) and Pienaar (1978). Recent distributions and IFR analyses were also referred to (Coke 1995, 1998a, 1998b). The impact of pollution on Natal fish was examined in the publications of Crass (1968) and Kemp *et al.* (1970).

For this study 'current' or present day fish species distributions, including both indigenous and alien species, were regarded as those pertaining at the time of the most recent surveys conducted within each of the 22 Resource Units. Each Resource Unit comprises a number of 5km long river segments of fairly uniform ecological type. From the current distributions, 'Reference' or pristine condition fish distributions were estimated, taking into consideration probable in-stream habitat changes since historic times (Appendix E). Where species were not actually collected in given Units, but were *expected* to occur there, on grounds of their proven occurrence further upstream or in the adjacent downstream Unit, their distribution was recorded as "E". Because of access difficulty, Resource Units E and G were not sampled. However, since the 'Ganna Hoek' and 'Thukela Estates' sites in Unit F were situated close to the boundaries of Units E and G respectively the species found there were taken as being expected to be present also in those Units.

4.7.2 Methods used to determine fish PES

The Present Ecological State (PES) of the fish population within each RU was assessed qualitatively according to the fish index method of Kleynhans (*pers. comm.*). In this process species richness, the presence of intolerant and introduced species, the abundance of native species, the frequency of occurrence and health of all species as well as riverine habitat condition were evaluated for each Resource Unit, based on the results of surveys conducted during the current study as well as on historical collection data in the KZN Wildlife records. Present Ecological State categories from A to F were assigned according to the category descriptions given in Table 4.4 (Kleynhans *pers. comm.*).

Table 4.4 Generic Fish Assemblage Integrity Index (FAII) assessment categories

CATEGORY	DESCRIPTION
A	! Unmodified, or approximates natural conditions closely.
B	! Largely natural with few modifications. ! A change in community characteristics may have taken place, but species richness and presence of intolerant species indicate little modification.
C	! Moderately modified. ! A lower than expected species richness and presence of most intolerant species. ! Some impairment of health may be evident at the lower end of this scale.
D	! Largely modified. ! A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderately intolerant species. ! Impairment of health may become more evident at the lower end of this class.
E	! Seriously modified. ! A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. ! Impairment of health may become very evident.
F	! Critically modified. ! An extremely lowered species richness and an absence of intolerant and moderately intolerant species. ! Only tolerant species may be present with a complete loss of species at the lower end of the class. ! Impairment of health generally very evident.

4.8 AQUATIC INVERTEBRATES (APPENDIX F)

4.8.1 Data and methods used in determination of reference condition

This assessment has been based to some extent on the considerable work done on the Thukela River, commencing in the early 1950s with the work of Oliff (Oliff, 1960), and subsequent to that, work done by Brand and his colleagues (Brand *et al.* 1967), and most recently by de Moor (1999). The detailed species information that was produced by de Moor (using his and Fowles' surveys, and interpreting Oliffs' 1960s work) was published as a review in Dickens *et al.* (1999) and provides an important reference. Information has been drawn extensively from this report. As no data was available for the Little Thukela River, data from the Thukela in the comparable zone (as described by Oliff, 1960) was used.

The assessment of reference conditions was not done on a purely quantitative basis, largely as the data available was of variable quality and samples were not collected in a uniform way. Because of this, the assessments were based on the quantitative data but with a large input of professional judgement.

4.8.2 Methods used to determine PES

The determination of the flow requirements of the invertebrates in a river is complex and uncertain. The state of knowledge of the aquatic invertebrates in South Africa is at a low level, where not even all of the species have been discovered, and little if anything is known about their

ecological requirements. The work which has been done on the ecological requirements of some species serves to provide the necessary information for this type of investigation.

Where information was lacking, it was necessary to fall back on “landscape ecology”, which suggests that if the diversity of habitats is projected, then the species will automatically be taken care of, without having to understand the process. Using this approach is considered valid and may provide a much higher level of confidence in the results than deficient information on the species of the river.

Invertebrate samples collected by Fowles in 1985 (data analysed and reported by de Moor, 1999), by Chutter in 1995 (Heinsohn, 1995) and de Moor in 1999, and by Dickens and Bokwe in 2001 were used to develop the Present Ecological Status. These surveys cover a wide range of conditions including the recovery period in 1985 after a severe drought (1982-4) and subsequent flood by the Demoina hurricane in 1984.

In addition, field surveys were conducted at IFR sites in a number of RUs (B,C,I,F,J,M,Q, R,U,V), to assist with the determination of the PES. At these sites, available habitats were sampled using the South African Scoring System version 5 (SASS5) methodology. This method assesses river condition on the basis of the sensitivity of the aquatic macroinvertebrates present in the various habitats at the time. Invertebrates are scored between 1 (tolerant) and 15 (highly sensitive) and the cumulative score, together with the average score per taxon (ASPT) provides an interpretable picture of present state of the river. It should be noted that in this study, “extra” sampling effort was used in the SASS sampling. This was important as an inventory was considered to be as important as the final SASS score. This additional effort should not affect the ASPT scores significantly.

The SASS technique is of particular relevance when used to compare present with previous SASS scores. In this study, historical SASS scores were derived from existing data. These scores should not be considered accurate as different sampling techniques were used to collect these data, and also the data were often in a form where SASS could not be properly applied. No numeric or other specific procedure (e.g. index) was used to assess the SASS5 scores, as the historical data were considered inadequate.

The PES data (from the single sample collection of 2001) were also considered inadequate to derive accurate figures. PES categories were thus assigned using professional judgement.

Modifying determinants:

Modifying determinants for this study were assessed on the basis of the following reports, which form part of the Thukela study and document the status of the ‘driver’ variables:

- Water quality (Appendix B).
- Hydrology (Appendix A).
- Geomorphology (Appendix C).

5. PRESENTATION OF THE RESULTS

The rest of the chapters in this document provide results of the specialist meeting per RU. For each of the RU, the same procedure was followed during the specialist meeting. This chapter explains the preparatory work undertaken for each RU as well as the procedure followed during the specialist meeting. No results are provided for RU K as the estuary forms the larger proportion of RU K and the estuary results will be applicable for RU K.

Note: All confidence evaluations in this document are provided according to the following scale:

<i>0 - no confidence</i>	<i>1 - low confidence</i>
<i>2 - low to medium confidence</i>	<i>3 - medium confidence</i>
<i>4 - medium to high confidence</i>	<i>5 - high confidence</i>

Note: All colour related to categories used in this document must be interpreted as follows:

<i>Category A - Light Blue</i>	<i>Category A/B - shading from Light Blue to Dark Blue</i>
<i>Category B - Dark Blue</i>	<i>Category B/C - shading from Dark Blue to Light Green</i>
<i>Category C - Light Green</i>	<i>Category C/D - shading from Light Green to Dark Green</i>
<i>Category D - Dark Green</i>	<i>Category D/E - shading from Dark Green to Yellow</i>
<i>Category E - Yellow</i>	<i>Category E/F - shading from Yellow to Red</i>
<i>Category F - Red</i>	

5.1 INTEGRATION OF SPECIALIST APPENDICES PRIOR TO SPECIALIST MEETING

5.1.1 Reference conditions

Each specialist provided reference conditions per RU in his/her specialist appendices. These reference conditions were summarised and provided in the draft chapters per RU to be discussed in the meeting. Confidence evaluations in the reference conditions were also extracted from the specialist appendices and summarised in a table (See 6.1 as an example).

5.1.2 PES, causes and sources

Each relevant specialist provided a summary table of his/her PES information in the specialist appendix in the format described in 4.1.2 (Chapter 4). A copy of the individual summary tables is illustrated as an example in Figure 5.1.

Fig 5.1 Example of PES summary sheet provided by each specialist for all the RUs

Effect	Causes	Sources	Flow related?	Requirements to address
RU: A PES Category: _____				
RU: A PES Category: _____				

The coordinator then took all the information provided in the separate summary sheets and integrated the information to provide a combined table that summarises the PES categories for each component, the effects, causes, sources and the requirements to address the problems in the RU. A confidence evaluation was also provided. (Illustrated in Figure 5.2)

Fig 5.2 Example of table integrated prior to specialist meeting using information provided in the PES summary sheets per RU

RU A:

Effect	Causes	Sources	Flow related?	Requirements to address	Confidence
Geomorphology PES: ____					
Riparian vegetation PES: ____					
Fish PES: ____					
Aquatic invertebrates PES: ____					
Riparian vegetation PES: ____					

5.1.3 Trajectory of change

Specialists were requested to provide information for each RU in their specialist appendices on the *Trajectory of Change* of the PES. The trajectory of change refers to whether the PES category as provided is likely to change, either negatively or positively, in the future if the present conditions in the catchment continues. This relates specifically to changes caused by anthropogenic interventions, not natural change such as disturbance caused by large floods. Specialists also provided an estimate of how severe the change (if any) would be in the short term (5 years) and in the long term (20 years plus). The severity of the change is described according to the change in category, i.e. a change from a PES C to a PES D in five years must be interpreted as quite a severe/fast change. It must be noted that a slow negative trajectory can also occur *WITHIN A CATEGORY*. This indicates a very slow and negligible change. (See chapter 3 for more information)

It must also be noted that especially with the geomorphology and riparian vegetation components, natural fluctuations occur continuously and this could also be perceived to be a trajectory of change. For example, when a large flood such as Demoina occurs, it will reset the system. The system will then naturally attempt to reach an equilibrium and in this period, one could interpret that a positive trajectory of change is taking place. This is however NOT how the trajectory of change is used in this context. The trajectory of change due to anthropogenic circumstances must be evaluated. Positive natural fluctuations could for example have negative trajectory of change as the positive changes are happening at for example a different rate than it would have happened under natural circumstances. It is acknowledged that interpretation of these long term fluctuations with the limited data available is problematic.

The information as provided by the specialists were integrated in a table (See Figure 5.3)

Fig 5.3 Example of the summary and integration of Trajectory of Change information per RU

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D/E	3
	Sediment accumulation and bank pressure (bank instability, overgrazing) from anthropogenic causes; structures (bridges and weirs) in channel.				
Riparian vegetation	Negative	E	E	E/F	3
	Continuing grazing pressure etc (same as previous unit).				
Fish	Negative	B	B	C	4
	Continuing informal river bank agriculture and minor abstraction.				
Aquatic invertebrates	Stable	C	C	C	2
	Geomorphological changes have already altered the condition of the habitats to a C, no significant further change anticipated.				

5.1.4 Summary of critical sources (and related causes), actions required, and the degree of difficulty

The PES integrated tables as well as the trajectory of change tables are studied by the IFR coordinator who then identifies the most critical and common sources and causes. These are stipulated in a table, the action identified, which would be required to address the source and the degree of difficulty associated with the action identified. The degree of difficulty is described in the following terms: Easy, reasonably, difficult, very difficult. (See Chapter 3 for more information). An example of a summary is provided below.

Fig 5.4 Example of the summary table of critical/main sources and causes

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (siltation) 	<ul style="list-style-type: none"> Catchment land-use management 	<ul style="list-style-type: none"> Very difficult

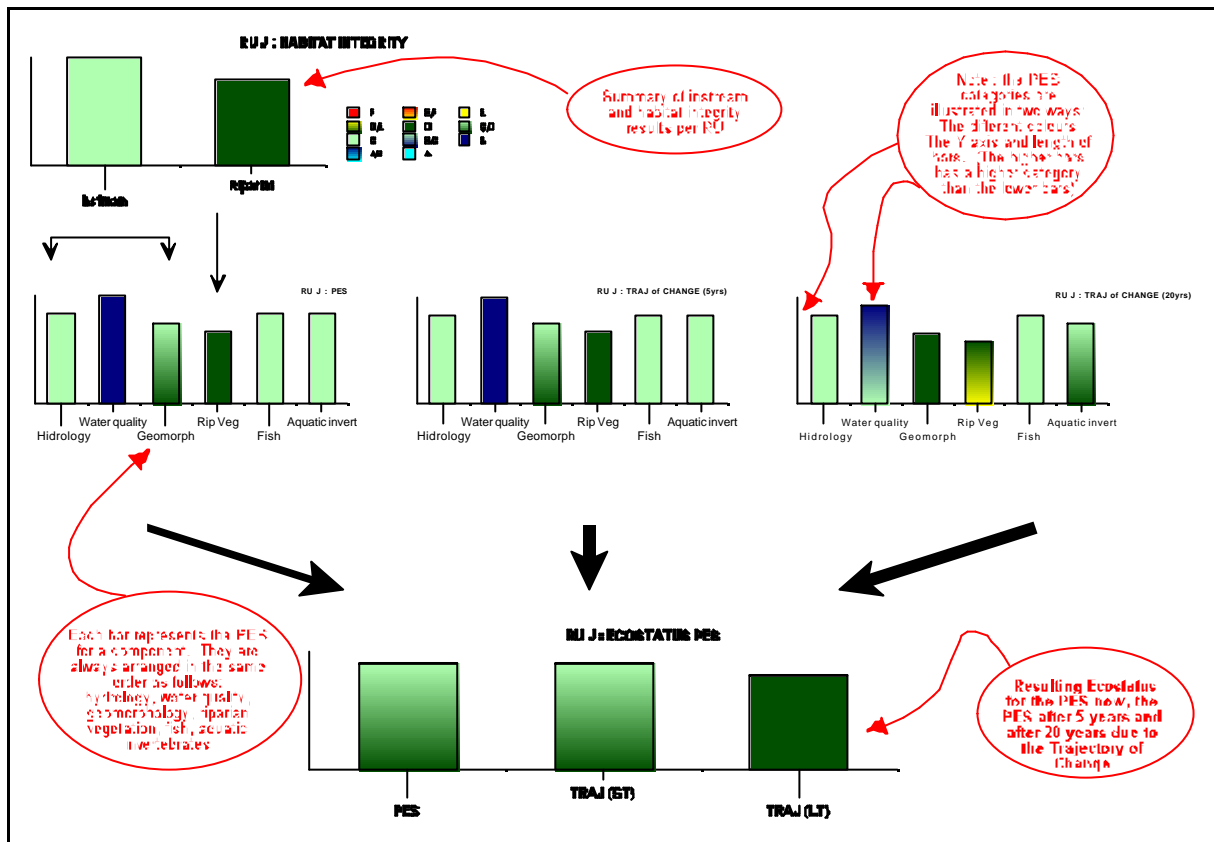
5.2 INFORMATION GENERATED DURING THE SPECIALIST MEETING

To facilitate the report writing as well as to document information accurately, all the above information is documented within the draft chapters per RU. (See the following chapters 6 to 26). These chapters are then presented at the specialist meeting by means of a data projector so that specialists can check the integration, summaries, assumptions and analysis undertaken by the IFR coordinator, as well as check the interpretation and document of new information generated at the specialist meeting. The following is undertaken:

- The summary of reference conditions and the confidence evaluations are checked by the specialist.
- The summary and integration of the PES (Figure 5.2) are checked by the specialists
- The trajectory of change information as summarised in the table (Figure 5.3) is checked by the specialists.
- PES categories and resulting trajectory of change categories have been used (prior to the specialist meeting) to generate the PES graph (see example and explanation of figure (Figure 5.5)). The graph is provided to specialists without the Ecostatus (see Chapter

3 Ecstatus) information. The specialists discuss and generate the Ecstatus¹ information, the graph is completed accordingly and the rationale used for the decision of the Ecstatus is documented in the report.

Fig 5.5 Example and explanation of the PES graph



- The EIS model (RDM, 1999) is run and specialists provide all the information to fill in the spread sheets. The results of the spreadsheets are summarised (see section 6.3), and confidence evaluated provided (a general impression of the overall confidence when assessing the confidence evaluations provided per determinant in the spreadsheet).
- The Socio/cultural importance information as documented in the specialist appendix is used to complete the socio-cultural table (see Appendix G) and the same information as for the EIS is provided in the document.
- Aim: Considering the results of the importance, the aim (i.e. maintenance or improvement) is decided on, by the specialists and the rationale for the decision provided in the document.
- Attainable ERC: The attainable ERC has to be determined by the specialists. The information provided regarding the actions required and the degree of difficulty as illustrated in Figure 5.4 is used in the decision-making process. All the results generated are summarised in a table (see fig below) and considering the aim, as well as the degree of difficulty which needs to be overcome to address the aim is provided. The table is illustrated in Figure 5.6. The ERC according to the aim as well as considering attainability is provided for each component. The Ecstatus ERC is also determined and the rationale documented.

¹ The "Ecstatus" is the term used for the integration of the component categories into one category - the Ecstatus. When dealing with the PES value, the Ecstatus category is either referred to as "the PES" or the Ecstatus PES. When dealing with the ERC value, the Ecstatus category is either referred to as "the ERC" or the Ecstatus ERC.

Fig 5.6 Example showing the ERC required to achieve the aim and the attainable ERC considering the degree of difficulty

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B/C	B	B/C
Geomorphology	D Y D/E	D	D/E
Riparian vegetation	E Y E/F	D	E
Fish	B Y C	B	C
Aquatic invertebrates	C Y C	C	C
Ecstatus	D Y D/E	D	D/E

- All the category results are then summarised in a figure (Figure 5.7) which provides all the information in a sequential order to determine the final outcome, i.e. the recommended ERC that should be achieved in the long term.

Fig 5.7 Example of the result summary figure

RU H : SUNDAYS CONFLUENCE TO BUFFALO CONFLUENCE

COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B	-	B	B/C	EIS M O D E R A T E	B	B/C
GEOMORPH	D	-	D	D/E		D	D/E
RIPARIAN VEGETATION	E	-	E	E/F		D	E
FISH	B	-	B	C	SI M O D E R A T E	B	C
AQUATIC INVERTS	C	0	C	C		C	C
ECOSTATUS	D	-	D	D/E		D	D/E

* ATTAINABLE CATEGORY

- All the confidence evaluations provided for the results of the specific RU are then summarised in a table.

6. RU A : THUKELA RIVER SEGMENT 1 - 4 (Rugged Glen to Woodstock Dam)



6.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 178.61 mcm

Geomorphology

Moderately steep stream dominated by bedrock or boulder. Reach types include plain-bed, pool-rapid or pool riffle. Confined or semi-confined valley floor with limited floodplain development.

Riparian vegetation

Significantly woody vegetated riparian zone dominated by typically alluvial species such as *Combretum erythrophyllum* (riparian zone) and *Salix mucronata* (marginal zone). *Phragmites* in isolated patches and on river fringes.

Fish

Five fish species would have been present in the pristine condition: *Anguilla mossambica*, *Barbus natalensis*, *Labeo rubromaculatus*, and *Amphilius natalensis*. Ample habitat (clean water, except during floods, a moderately steep gradient, abundant riffles and rapids) would have been present for the flow-dependent *Amphilius natalensis*.

Aquatic invertebrates

The highest density of organisms in riffles in the Thukela was found in the upper river. The highest density in marginal vegetation was in the upper river and foothill sand bed zones, with low numbers in the middle reaches. Stable populations dominated by mayflies occur in the more torrential zones in the upper reaches in summer and winter. Simuliids occur in high numbers in midwinter in the Oliviershoek region, and in the upper region of this reach, *Oligoneuropsis lawrenci*, which need abundant and cool water at swift velocities, occur. The distribution of the tricorythid *Neurocaenis discolor* appears to be governed by current velocity (derived from Oliff 1960).

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	3	4	3	4	5	5

6.2 PES

The majority of impacts in this RU are close to Woodstock Dam, while upstream of that a large proportion of the catchment is less impacted.

6.2.1 PES, causes and sources

Table 6.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C					
Habitat change.	Sediment aggradation.	Bank instability and overgrazing due to catchment land-use.	NFL	Land-use management (create riparian buffer zone).	3
Change in morphology.	Change in flow and sediment dynamics.	In-channel structures (bridges, weirs, dam).	NFL	-	
RIPARIAN VEGETATION PES: C/D					
Reduced vegetation cover.	Sedimentation and disturbance.	Trampling, bank erosion and grazing from informal agriculture.	NFL	Improved farming techniques.	4
Loss of marginal zone.	Bank undercutting.	Backup of Woodstock Dam.	FL	Management of Woodstock Dam levels.	
FISH PES: B					
Reduced abundance of fish.	Habitat decline.	Alien fish species invasion and competition from alien species from the introduction of catfish and carp into Woodstock and Kilburn Dams.	NFL	Eradicate and/or prevent escape of alien fish from Kilburn Dam.	4
	Habitat reduction due to reduced water levels (water abstraction).	Clifford Chambers weir.	FL	Minimise abstraction in spawning season - December/February.	
AQUATIC INVERTEBRATES PES: A/B					
No known effect but possible loss of diversity.	Sedimentation/siltation.	Overgrazing due to agriculture.	NFL	Improved farming practices.	3

6.2.2 Trajectory of change

Table 6.2 Trajectory of change, RU A

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence
Geomorphology	Negative	C	C	C/D	3
	Continuing sediment accumulation will result in increased sediment storage in the channel, with concomitant loss of habitat area and diversity. The assumption is that the present flow is in equilibrium with the channel morphology and that there is therefore no capacity to transport increased sediment load.				
Riparian vegetation	Negative	C/D	C/D	D	4
	Continued grazing and trampling will result in further degradation of the riparian zone in the long term.				
Fish	Stable	B	B	B	4
	No additional alien species have access to this unit. Indigenous fish species have equilibrated with the presence of alien species and with habitat changes.				
Aquatic invertebrates	Negative	A/B	A/B	B	2
	Conditions are likely to be worsening in the lower reaches of this unit because of deteriorating geomorphology and deteriorating habitat.				

6.2.3 Summary and resulting Ecstatus

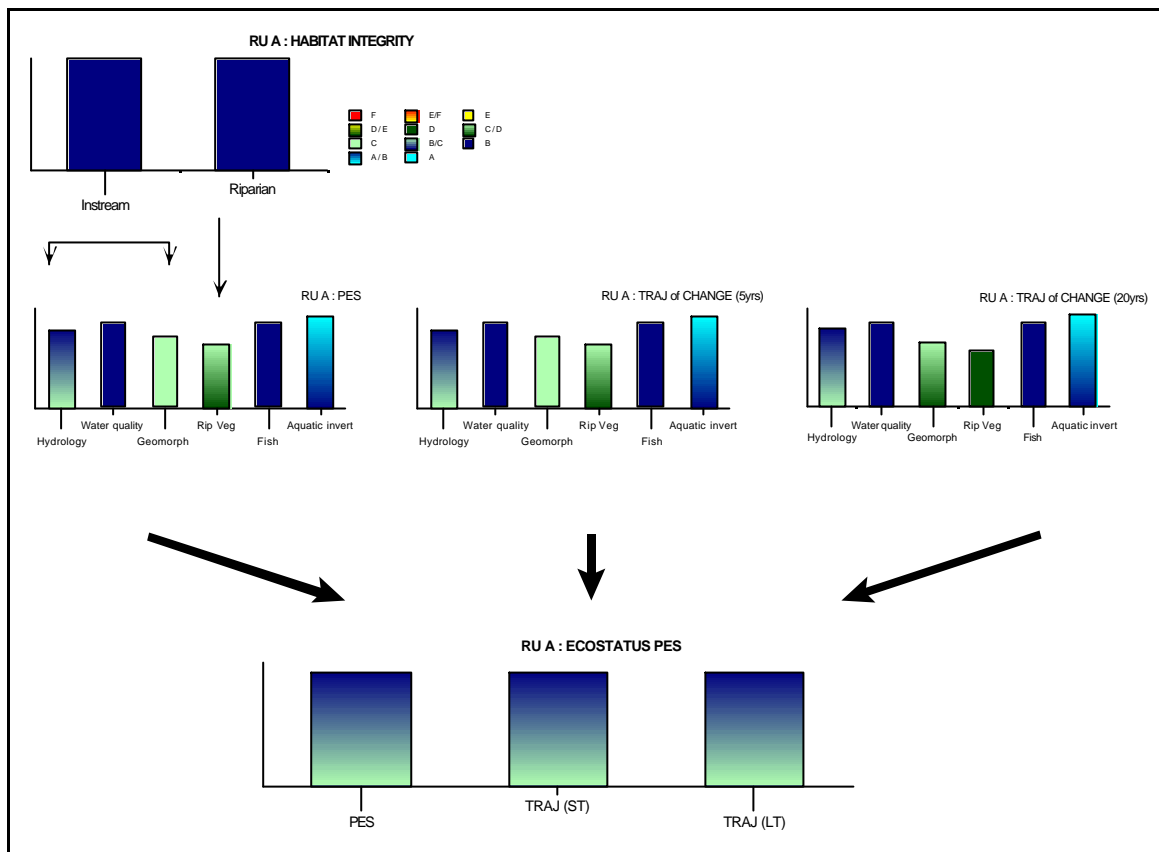
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES B/C.

Water quality: PES B.

The information on PES for the different components is summarised in Figure 6.1.

Fig 6.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The geomorphology (PES C) is considered the key driver in this unit. The instream biota reflects higher PES categories (B for fish and A/B for invertebrates) which indicates that they consist of organisms largely resistant to these changes. As the biota were evaluated with a higher confidence, the Ecostatus (B/C) therefore reflects the state of the geomorphology, with a half a category increase to cater for the higher confidence instream biota PES. Further rationale for the Ecostatus category is that the Habitat Integrity for instream habitat in this RU is a B category, and for riparian vegetation is a B. This already represents an integration of some of the component categories and a B/C category was therefore deemed appropriate.

6.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Unique, flow dependent fauna, high invertebrate diversity.

SI rating: High
 Confidence: Medium to high
 Determinants: People dependent on a healthy flowing river and riparian plants, sacred place, sense of place.

6.4 AIM

The EIS is **moderate**, the social importance is **high** and the PES is a B/C. Normally the aim would be to maintain PES and minimise the risk of degradation unless there are overriding reasons to improve conditions.

In terms of the ecological importance of this RU, the present state is considered acceptable. The only concern is the riparian vegetation which is on a negative trajectory, and for which there is a high social demand. Thus, the overall aim would be to **maintain** present state. This would require remedial action directed towards the riparian vegetation, or at least intervention to halt the present degradation.

6.5 ATTAINABLE ERC

The sources and actions required to address the aim are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this is also included.

Critical Sources	Action	Degree of difficulty
<p><i>Non-flow related</i></p> <ul style="list-style-type: none"> Catchment related activities specifically related to informal agriculture, specifically stock grazing and browsing (leading to sedimentation). 	<ul style="list-style-type: none"> Land-use management (agricultural). 	<ul style="list-style-type: none"> Very difficult.

Table 6.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B	B	B
Geomorphology	C Y C/D	C	C/D
Riparian vegetation	C/D Y D	C/D	D
Fish	B Y B	B	B
Aquatic invertebrates	A/B Y B	A/B	B
Ecostatus	B/C Y B/C	B/C	B/C

Rationale for the attainable ERC

The aim is to maintain the PES. ***However, to enable maintenance of the PES, the negative trajectory of change in geomorphology and riparian vegetation will have to be addressed and some improvement is required.*** To enable maintenance of the PES, the non-flow-related critical sources related to landuse activities, specifically stock grazing and browsing and the resulting sedimentation would have to be addressed. Aquatic invertebrates also have a negative trajectory which is linked to the geomorphology and riparian vegetation. If these are addressed, the negative trajectory for the invertebrates will also be addressed. As fish has no negative

trajectory, nothing additional is required to maintain the PES. In order to maintain the invertebrates in an A/B, water quality will have to remain a B. The negative trajectory of change in water quality is due to deteriorating nutrient conditions which must be halted.

Addressing the negative trajectory of change is evaluated as 'very difficult'. In the short term the ERC might not be achieved (i.e. a C category). The ERC might therefore only be achieved in the long term.

Reserve scenarios (quantity) which will be supplied for this resource unit are: B, B/C and C/D categories.

6.6 SUMMARY OF RESULTS

The results are illustrated in Figure 6.2.

Fig 6.2 Summary of results

RU A : RUGGED GLEN TO WOODSTOCK DAM (segm 1 - 4)

COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B	-	B	B	EIS M O D E R A T E	B	B
GEOMORPH	C	-	C	C/D		C	C/D
RIPARIAN VEGETATION	C/D	-	C/D	D		C/D	D
FISH	B	0	B	B	S I G N I F I C A N T	B	B
AQUATIC INVERTS	A/B	-	A/B	B		A/B	B
ECOSTATUS	B/C		B/C	B/C		B/C	B/C

* ATTAINABLE CATEGORY

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	4	3	4	5	5
PES	4	3	4	4	3
Trajectory of change	4	3	4	4	2
EIS	3				
SI	2-3				

The evaluation ranges from medium-low to high with most of the components in the medium high range

7. RU B : THUKELA RIVER SEGMENT 5- 9 (Driel Barrage to Spioenkop Dam)



7.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 706.39 mcm

Geomorphology

Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow floodplain of sand, gravel or cobble often present.

Riparian vegetation

Mainly grassland with woody shrubs and small trees in protected patches on steep river bends. Appearance of narrow woody stands only on flatter reaches, dominated by *Salix mucronata* and *Combretum erythrophyllum*.

Fish

In the pristine condition, the same five species as occurred originally in RU A would have occurred in this RU: *Anguilla mossambica*, *Barbus natalensis*, *Labeo rubromaculatus*, and *Amphilius natalensis*.

Aquatic invertebrates

In the foothill sandbed zone, *Neoperla*, *Pseudocloeon maculosum*, *Baetis harrisoni*, *Caenis* sp., and *Euthraulius elegans*, various other mayflies, *Cheumatopsyche zuluensis*, *Simulium* sp. and chironomids were common in the stones. At Bergville, although torrential, the habitat was more stable, producing high winter populations and very low summer conditions (derived from Oliff 1960).

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	5	3	4	3	5	5

7.2 PES

7.2.1 PES, causes and sources

Table 7.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: D					
Habitat change	Sediment aggradation.	Bank instability due to Driel barrage and Woodstock Dam.	FL	Adequate flow to mobilise sediments.	4
		Bank instability, overgrazing and gulying from agriculture (mostly formal).	NFL	Land-use management which includes riparian vegetation management.	
Change in morphology	Change in flow and sediment dynamics.	Driel and Woodstock Dams, weirs, and bridges.	NFL	Provide the Reserve.	
RIPARIAN VEGETATION PES: E					
Reduced vegetation cover.	Trampling and grazing.	Agriculture.	NFL	Controlled cattle ranching.	4
	Reduced flows.	Flow regulation from Driel Barrage.	FL	Operation of Driel Barrage.	
Loss of marginal zone.	Sedimentation from bank erosion.	Agriculture (formal).	NFL	Improved land-use management.	
Shift in species composition.	Exotic species encroachment.	Poor catchment management.	NFL	Alien species control programme.	
FISH PES: D					
Reduced abundance and diversity of fish.	Alien species invasion (competition).	Stocking of Spioenkop Dam with alien species.	NFL	Eradicate alien species.	3
	Habitat destruction due to eutrophication.	Bergville abattoir outfall.	NFL	Sewage treatment process.	
	Habitat destruction, irregular and unseasonal fluctuations in flow.	Woodstock and Driel Dams.	FL	Minimise abstraction in spawning season - December/February.	
AQUATIC INVERTEBRATES PES: D					
Marginal changes in invertebrate composition. Loss of mayflies (except baetids). Loss of biomass.	Habitat problems due to irregular and unseasonal fluctuations in flows.	Woodstock Dam and Driel Barrage.	FL	Dam operating rules to supply the Reserve.	4

7.2.2 Trajectory of change

Table 7.2 Trajectory of change, RU B

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D/E	4
	Long-term trajectory is negative as sediment accumulates within the active channel. This will result in increased sediment storage in the channel, and a concomitant loss of habitat area and diversity. This assumes that the two dams have a large attenuation effect.				
Riparian vegetation	Negative	E	E	E/F	4
	Further degradation of the system is likely, due to further erosion of the riparian zone, sediment accumulation, encroachment of macrophytes and alien species.				
Fish	Stable	D	D	D	3
	Species present are in equilibrium with habitat changes.				
Aquatic invertebrates	Stable	D	D	D	4
	Species present are in equilibrium with habitat changes.				

7.2.3 Summary and resulting Ecstatus

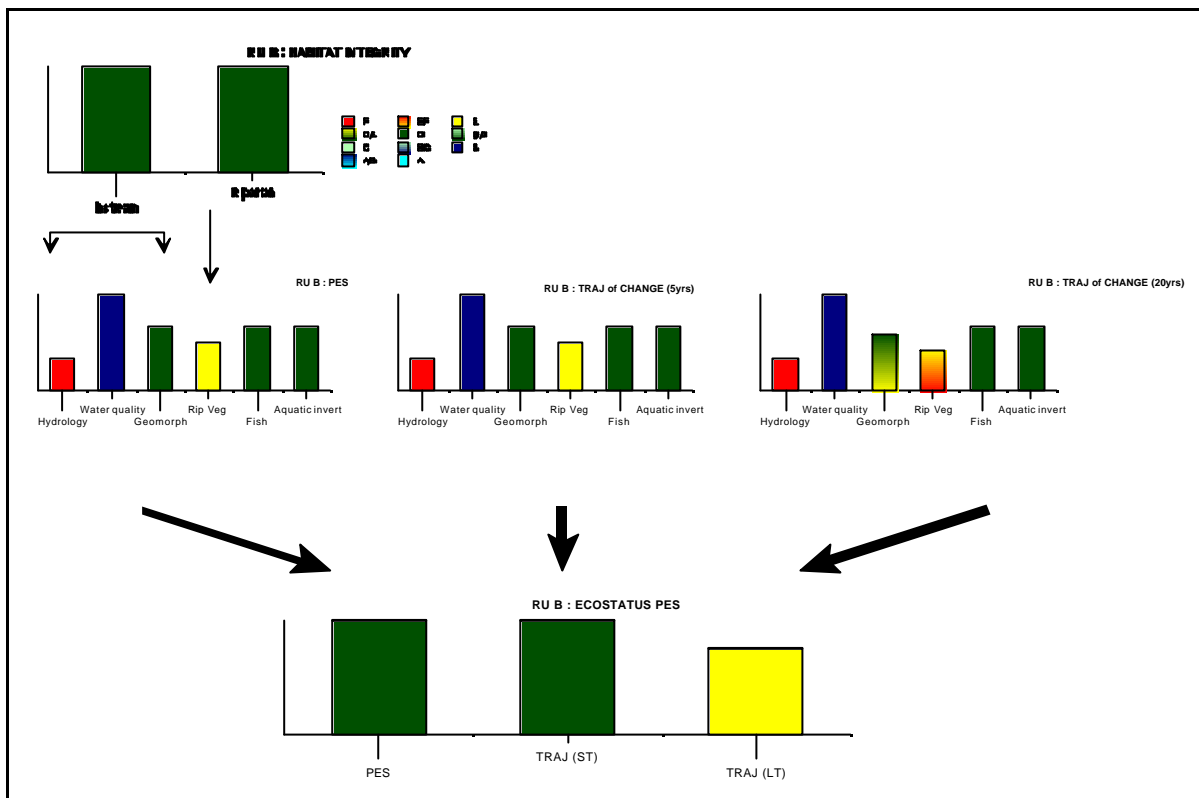
The other drivers to be considered when providing the Ecstatus are:

Hydrology : PES F (*The flow regime is critically modified as a result of the operating rules of Driel Barrage*).
Present MAR as % of virgin MAR: 20.5%.

Water quality : PES B.

The information on PES for the different components is summarised in Figure 7.1.

Fig 7.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The drivers in this RU are hydrology (F) geomorphology (D). The outlier is water quality (PES B), which is in an acceptable condition. The biota (Fish, Aquatic invertebrates (D)) are responding to the hydrology and geomorphology, although there may be sediment and temperature effects for which there are no data. The habitat integrity (D) also supports an Ecostatus of D.

7.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Diverse fauna with unique and flow-sensitive species.

SI rating: Low
 Confidence: Medium

7.4 AIM

The EIS is *moderate*, the social importance is *low*, and the PES is a D. Normally the aim would be to maintain PES and to minimise the risk of degradation unless there are overriding reasons to improve conditions. In this instance, there is no particular motivation to improve the ecological state. The aim is thus to *maintain the PES*.(i.e. an ERC of D)

7.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The actions required to address these, as well as the degree of difficulty associated with this are also included.

Critical sources	Action	Degree of difficulty
<p><i>Non-flow related</i></p> <ul style="list-style-type: none"> Land-use practices (sedimentation due to bank instability). Alien vegetation. Alien fish species introductions. 	<ul style="list-style-type: none"> Land-use management. Alien vegetation control programme. Alien fish control programme. 	<ul style="list-style-type: none"> Very difficult. Reasonable. Very difficult.
<p><i>Flow related</i></p> <ul style="list-style-type: none"> Woodstock/Driel Dam (regulated flow and irregular high flow releases; bank slaking). 	<ul style="list-style-type: none"> Supply the Reserve. 	<ul style="list-style-type: none"> Reasonable.

Table 7.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B	B	B
Geomorphology	D Y D/E	D	D/E
Riparian vegetation	E Y E/F	D	E/F
Fish	D Y D	D	D
Aquatic invertebrates	D Y D	D	D
Ecstatus	D Y E	D	D

Rationale for the attainable ERC

The aim is to maintain the PES of D and to address the negative trajectory of change that will, in the long term, result in unacceptable conditions (PES E). Addressing the land-use issues is mostly considered 'very difficult'. However, alien vegetation control programmes have proved to be successful and if such a programme were put in place, this would go a long way towards addressing the negative vegetation and geomorphology trajectories. Addressing the flow related problems and operating the upstream dams to supply the Reserve is seen as reasonable, and this in addition to the alien vegetation control programme should enable the maintenance of the river in a D category. To ensure that the objectives are achieved with releasing the Reserve, the other catchment problems would also need be addressed. Neither fish nor aquatic invertebrates have a negative trajectory, so to maintain the PES for the biota, no additional actions are required. Water quality should however be maintained in its PES to support the aquatic biota.

7.6 SUMMARY OF RESULTS

The results are illustrated in Figure 7.2.

RU B : DRIEL BARRAGE TO SPIOENKOP DAM (segm 5 - 9)

COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B	0	B	B	HIGH MODERATE LOW	B	B
GEOMORPH	D	-	D	D/E		D	D/E
RIPARIAN VEGETATION	E	-	E	E/F		D	E/F
FISH	D	0	D	D		D	D
AQUATIC INVERTS	D	0	D	D		D	D
ECOSTATUS	D	-	D	E		D	D

* ATTAINABLE CATEGORY

Fig 7.2 Summary of results

A summary of the confidence evaluation is provided below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	3	5	5
PES	4	4	4	3	4
Trajectory of change	4	4	4	3	4
EIS	3				
SI	2				

The confidence ranges from medium-low to high. Most of the components are in the medium-high range.

7.7 IFR 1

IFR 1 is situated in this RU. The PES of the RU also reflects the PES of the IFR site and therefore the resulting ERC.

Reserve scenarios will be set for a D and a C ERC.

8. RU C: THUKELA RIVER SEGMENT 10-16 (Spienkop Dam to Little Thukela confluence)



8.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 797.92 mcm

Geomorphology

Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Floodplain often present.

Riparian vegetation

Significantly woody vegetated riparian zone dominated by typically alluvial species such as *Combretum erythrophyllum* (riparian zone) and *Salix mucronata* (marginal zone). *Phragmites* in isolated patches and on river fringes.

Fish

The species are the following: *Anguilla mossambica*, *Barbus natalensis*, *Labeo rubromaculatus*, and *Amphilius natalensis*.

Aquatic invertebrates

In the 'stones' biotope, common species in the Foothill Sandbed Zone were *Neoperla*, *Pseudocloeon maculosum*, *Baetis harrisoni*, *Caenis* sp., *Euthraulius elegans*, various other mayflies, *Cheumatopsyche zuluensis*, *Simulium* sp., and Chironomidae. Tricorythid mayflies were not common (information derived from Oliff 1960).

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	5	3	4	3	5	4

8.2 PES

8.2.1 PES, causes and sources

Table 8.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: D					
Habitat change. Change in morphology.	Scouring due to sediment hungry flows.	Spioenkop Dam.	FL	Operate Spioenkop Dam to provide the Reserve.	4
	Aggradation due to insufficient transport capacity.	Spioenkop Dam.	FL	Operate Spioenkop Dam to provide the Reserve.	
	Sediment accumulation.	Tributary inputs.	NFL	Catchment land-use management.	
	Vegetation encroachment.	Tributary inputs, farm land.	NFL	Catchment land-use management.	
RIPARIAN VEGETATION PES: C					
Reduced vegetation cover. Shift in species composition. Change in vegetation distribution.	Trampling and grazing.	Agriculture.	NFL	Improved farming practices.	3
	Alien species encroachment.	Catchment activities.	NFL	Alien vegetation control programme.	
	Reed encroachment from sedimentation and return flows.	Catchment activities and agriculture.	NFL	Catchment land-use management.	
FISH PES: C					
Reduced abundance of fish	Habitat alteration due to alien species invasion.	Stocking of Spioenkop Dam; escapees from Spioenkop.	NFL	Control or eradication and prevention of re-stocking.	3
	Habitat decline due to siltation and upstream abstraction.	Spioenkop Dam and Thukela Vaal Dam Scheme.	FL	Operate to supply the Reserve.	
AQUATIC INVERTEBRATES PES: B/C					
Loss of uncommon species and reduced abundances.	Regulation of river flow.	Spioenkop Dam.	FL	Operate the dam to supply the Reserve.	4
	Water quality changes.	Spioenkop Dam.	FL	Unless multi-level outlets can be installed, very little that can be done.	

8.2.2 Trajectory of change

Table 8.2 Trajectory of change, RU C

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D/E	4
	The trajectory is negative as sediment accumulates within the active channel as is evidenced by the aerial photographic record. This section of the river appears to be aggrading. Large sediment inputs from tributary bars do not move through the system but are stored as bars.				
Riparian vegetation	Negative	C (B/C in gorge areas)	C	C/D	3
	It is expected that the further encroachment of the river channel by reeds will occur with increased sediment accumulation. Alien vegetation is likely to become more significant, to the detriment of indigenous species in the riparian zone.				
Fish	Stable	C	C	C	3
	No <i>Amphilius</i> has been collected in this RU for several years.				
Aquatic invertebrates	Stable	B/C	B/C	B/C	3
	Reed encroachment is unlikely to affect present invertebrate habitat, (if anything provides additional habitat).				

8.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

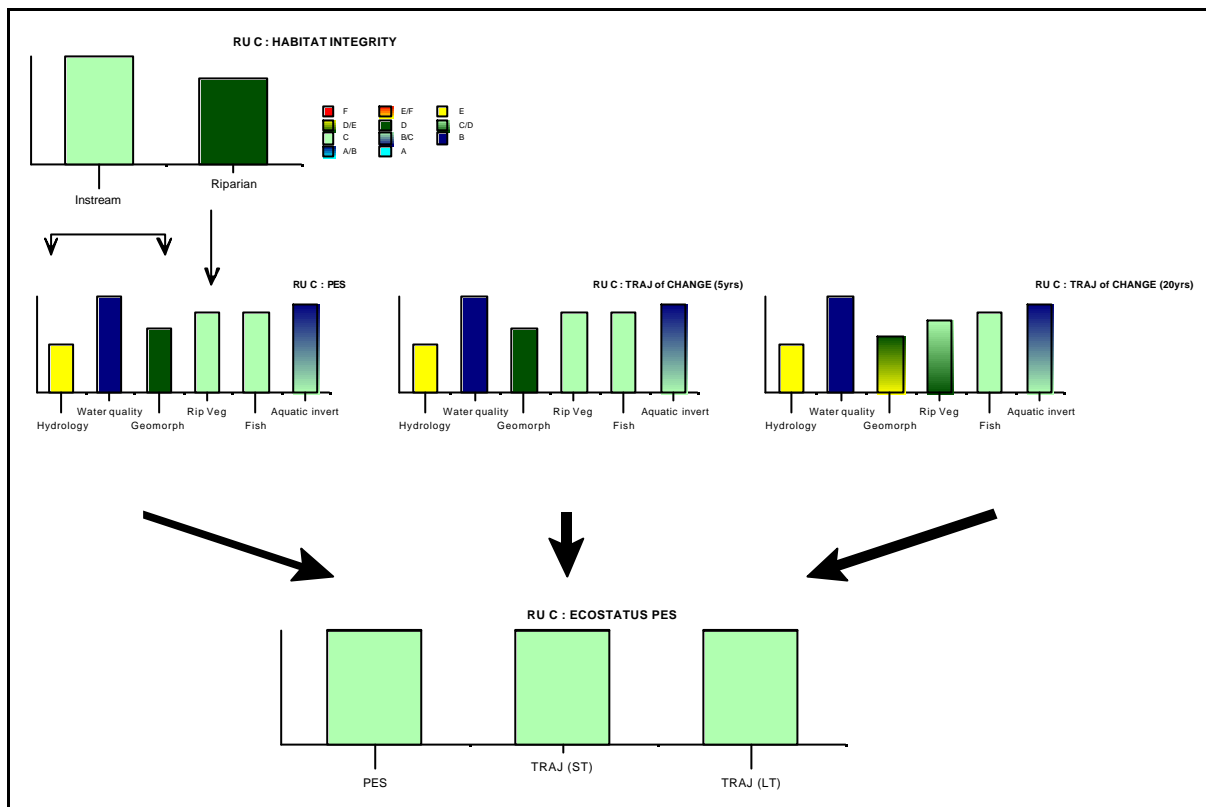
Hydrology: PES category E (critically modified).
(High flows and low flows are still present, but the medium sized flows are missing. If dams are not spilling, releases are made on demand from the farmers and average 1-2m³/s. There are ad hoc releases for canoe races and also, for example, when there are water quality problems).

Present MAR as % of virgin MAR: 27.8%.

Water quality: PES B, Short-term B, Long-term B.

The information on PES for the different components is summarised in Figure 8.1.

Fig 8.1 PES results and the resulting Ecostatus



Rationale for Ecostatus

This unit exhibits a critically modified hydrology (PES E). The geomorphological state, which provides the template for the rest of the parameters, is considered poor and degrading (PES D). Some of the changes in the system have however resulted in additional/different habitats than were present before, eg islands with reeds and marginal vegetation. This could be the reason for the biota being in a higher class than geomorphology (template). The water quality is good (PES B), although there are no measurements for the changes caused by dam releases. The Ecostatus in this case reflects the biota which have reacted to the changed geomorphology.

8.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: Very high
 Determinants: Unique and flow-sensitive species and migration corridor.

SI rating: Moderate
 Confidence: Medium to high
 Determinants: Recreational use of the river.

8.4 AIM

The EIS is *moderate*, the social importance is *moderate* and the PES is a C category. The aim is to *maintain the PES of C*. This will require that the non-flow related issues related to the negative trajectories of riparian vegetation and geomorphology (alien encroachment, land-use, sedimentation) be addressed.

8.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated are also included.

Critical sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (aggradation, sedimentation, reed encroachment). Alien vegetation encroachment. 	<ul style="list-style-type: none"> Land-use management. Alien vegetation control program. 	<ul style="list-style-type: none"> Very difficult. Reasonable.
<i>Flow related</i> <ul style="list-style-type: none"> Flow regulation. 	<ul style="list-style-type: none"> Provide the Reserve. 	<ul style="list-style-type: none"> Reasonable.

Table 8.3 Ecological Reserve Category (ERC) for each component.

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B	B	B
Geomorphology	D Y D/E	D	D
Riparian vegetation	C Y C/D	C	C
Fish	C Y C	C	C
Aquatic invertebrates	B/C Y B/C	B/C	B/C
Ecostatus	C Y C	C	C

Rationale for the ERC

To maintain the PES it will be necessary to address land-use and to supply the Reserve, following a similar rationale to RU B. The negative trajectory of the riparian vegetation and geomorphology could be slowed by addressing these concerns. The geomorphology, although PES D and on a negative trajectory, is supplying adequate habitat at present conditions. Sediment inputs come largely from gulleys, and sediments may be mobilised/flushed by high flows and floods. The future of this RU seems to be dependent on the amount of sediment coming into the system. If this is high, reeds may stabilise and encroach, increasing flow resistance and decreasing the sediment transport capacity.

8.6 SUMMARY OF RESULTS

The results are illustrated in Figure 8.2 below.

Fig 8.2 Summary of results

RU C : SPIOENKOP DAM TO LITTLE THUKELA CONFLUENCE (segm 10 -1B)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B	0	B	B	EIS MODERATE SI MODERATE	B	B
GEOMORPH	D	-	D	D/E		D	D
RIPIARIAN VEGETATION	C	-	C	C/D		C	C
FISH	C	0	C	C		C	C
AQUATIC INVERTS	B/C	0	B/C	C/D		B/C	B/C
ECOSTATUS	C	-	C	C		C	C

* ATTAINABLE CATEGORY

A summary of the confidence evaluation is provided below:

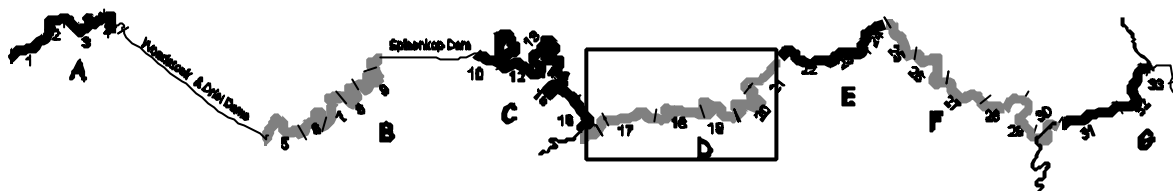
	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	3	5	4
PES	3	4	3	3	4
Trajectory of change	4	4	3	3	3
EIS	4				
SI	3				

The results vary from medium to high with most of the components in the medium and medium high range.

8.7 IFR SITE WITHIN THE RU

IFR 2 is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site. The Reserve scenarios that will be supplied will be a for C, B and D categories.

9. RU D : THUKELA RIVER SEGMENT 17 - 21 (Little Thukela confluence to end Lower Foothill Zone) (RU ends downstream of Hartshill Falls)



9.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 1126.25 mcm.

Geomorphology

Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Floodplain often present.

Riparian vegetation

Significantly woody vegetated zone dominated by typically alluvial species such as *Combretum erythrophyllum* (riparian zone) and *Salix mucronata* (marginal zone). *Phragmites* in isolated patches and on river fringes.

Fish

In the pristine condition the same five fish species which occurred originally in RU A,B and C (*Anguilla mossambica*, *Barbus natalensis*, *Labeo rubromaculatus*, and *Amphilius natalensis*) would have occurred in the Thukela River in reaches above Harts Hill falls below Colenso. The falls constituted an upstream migration barrier to those species which had entered the Thukela system in the late Tertiary, at which time uplift caused renewed erosion resulting in the formation of these falls. *Amphilius natalensis* would have been restricted to riffles in the rejuvenated section just above the falls.

Aquatic invertebrates

The more torrential zones in the upper reaches, at Hart's Hill and Middledrift, had stable invertebrate populations in summer and winter, dominated by mayflies. Species commonly found in the Foothill Sandbed Zone were *Neoperla*, *Pseudocloeon maculosum*, *Baetis harrisoni*, *Caenis* sp. and *Euthraulius elegans*, various other mayflies, *Cheumatopsyche zuluensis*, *Simulium* sp., and Chironomidae. Tricorythids were not common. Whereas the tricorythid *Neurocaenis discolor* was common in the Foothill Torrential Zone, it was uncommon in this Foothill Sandbed Zone. This distribution appears to have been governed by current velocity. (Derived from Oliff 1960).

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	2	4	3	4	5

9.2 PES

9.2.1 PES, causes and sources

Table 9.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C					
Channel morphology.	Sediment aggradation.	Bank instability and overgrazing due to catchment land-use.	NFL	Catchment land-use management.	4
	Sediment accumulation.	Instream structures (bridges).	NFL	-	
RIPARIAN VEGETATION PES: D					
Reduced vegetation cover. Shift in species composition. Change in vegetation distribution.	Trampling and grazing.	Agriculture.	NFL	Improved farming practices.	4
	Alien species encroachment.	Catchment activities.	NFL	Alien vegetation control programme.	
	Sedimentation and return flows.	Reed encroachment from Catchment activities and agriculture.	NFL	Catchment land-use management.	
FISH PES: B					
Reduced abundance of fish.	Alien species invasion and effects on habitat.	Stocking of Spioenkop Dam and escapees from the dam.	NFL	Eradication and prevention of re-stocking.	3
	Habitat decline due to siltation and abstraction.	Thukela Vaal Government Water Scheme.	FL	Minimise abstraction in spawning season - December/February.	
AQUATIC INVERTEBRATES PES: B/C					
Changes in species abundance and diversity.	Habitat alteration due to reed encroachment, sedimentation and regulation of river flow.	Land-use activities.	NFL	Catchment land-use management.	2
		Spioenkop Dam.	FL	Operation of the dam to provide the Reserve.	

9.2.2 Trajectory of change

Table 9.2 Trajectory of change, RU D

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C	C	C/D	4
	Negative as sediment accumulates within the active channel. This section of the river appears to be aggrading. Large sediment inputs from tributary bars do not move through the system but are stored as bars.				
Riparian vegetation	Negative	D	D	D/E	4
	In the long term the continued encroachment of reeds and exotics will result in a reduction in river category.				
Fish	Stable	B	B	B	4
	The instream habitat is not changing significantly.				
Aquatic invertebrates	Stable	B/C	B/C	B/C	2
	Likely changes to river habitat are unlikely to affect invertebrates.				

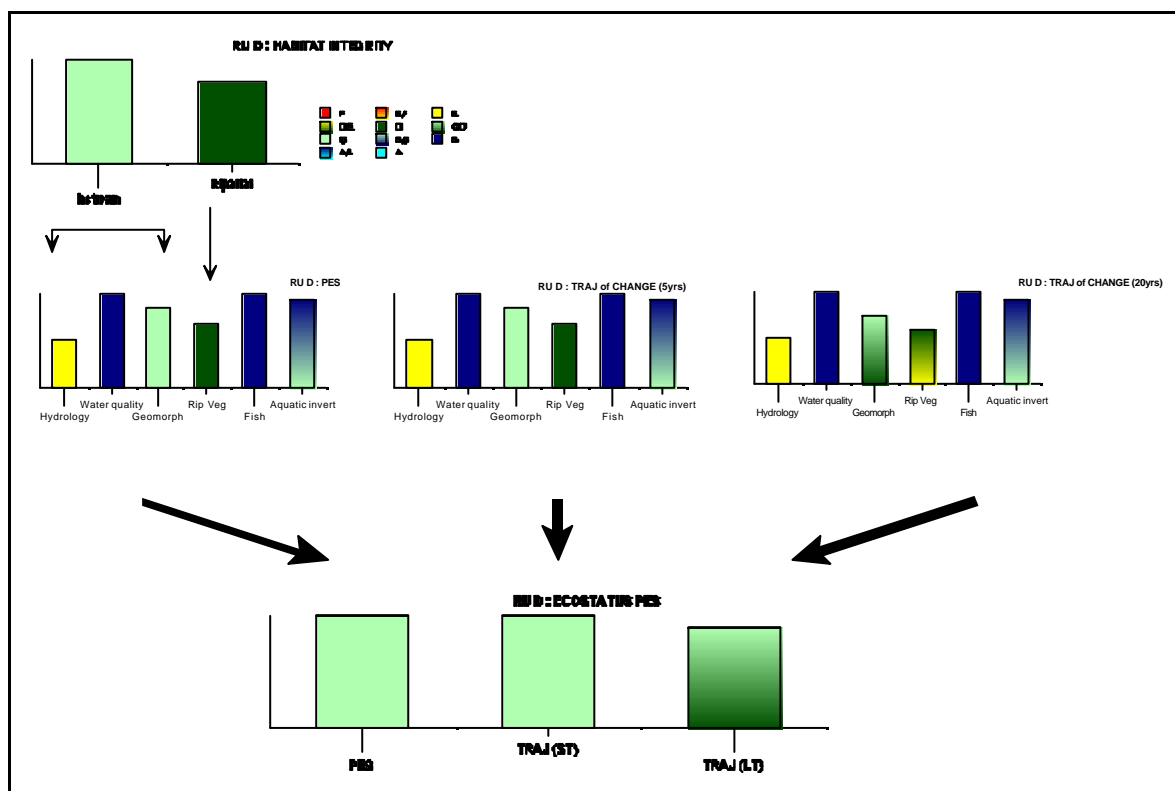
9.2.3 Summary and resulting Ecostatus

The other drivers to be considered when providing the Ecostatus are:

Hydrology: PES E.
 Water quality: PES B, Short term B, Long term B.

The information on PES for the different components is summarised in Figure 9.1.

Fig 9.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The outlier in the distribution of PES classes is the E category for hydrology which relates in particular to the impact on low flows. The level of hydrological change does not seem highly significant in relation to the other categories. The fish species, for example, are mostly pool-dwelling animals which are not hugely flow dependent. In terms of invertebrates, the flow sensitive organisms are assumed to be present on the basis of extrapolation from RU C as no data is available for this RU, and persistence of species is considered to be high. Confidence in fish data is therefore higher than for the invertebrates.

The geomorphology driver therefore plays a more significant role than the hydrology. The recommended Ecostatus of a C category follows the trend of the geomorphology driver. This is further correlated by the instream habitat integrity which is an integration of some of the components and is also in a C category.

9.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Presence of unique species and provision of refugia.

SI rating: Moderate
 Confidence: Medium
 Determinants: N/A

9.4 AIM

The EIS is **moderate**, the social importance is **moderate**, and the PES is a C category. Normally the aim would be to maintain PES and minimise the risk of degradation unless there are overriding reasons to improve conditions. In this case the **aim therefore is to maintain the PES**. Some improvement will be required to address the trajectory of change within the geomorphology and riparian vegetation

9.5 ATTAINABLE ERC

The critical sources are summarised below with the causes in brackets. The actions required to address these as well as the degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (alien vegetation, sedimentation, reed encroachment). 	<ul style="list-style-type: none"> Land-use management Exotic vegetation control programme. 	<ul style="list-style-type: none"> Very difficult. Reasonable.
<i>Flow related</i> <ul style="list-style-type: none"> Spioenkop Dam (regulation of river flow). 	<ul style="list-style-type: none"> Provide the Reserve. 	<ul style="list-style-type: none"> Reasonable.

Table 9.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B	B	B
Geomorphology	C Y C/D	C	C/D
Riparian vegetation	D Y D/E	D	D
Fish	B Y B	B	B
Aquatic invertebrates	B/C Y B/C	B/C	B/C
Ecostatus	C Y C/D	C	C

Rationale for the attainable ERC

The aim is to maintain the PES. In order to do so, the negative trajectory for the geomorphology and the riparian vegetation must be addressed. The sources are mostly related to landuse issues (non-flow related) which are **very difficult** to address. However, the vegetation negative trajectory could be addressed in some ways by implementing the alien vegetation control programme (evaluated as **reasonable**). Risk of other components degrading can also be minimised by implementing some components of the Reserve (evaluated as **reasonable**). The C ERC is therefore assessed as attainable.

9.6 SUMMARY OF RESULTS

The results are illustrated in Figure 9.2 below.

Fig 9.2 Summary of results

RU D : LITTLE THUKELA CONFLUENCE END LOWER FOOTHILL ZONE (segm 17 - 21)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	B	0	B	B	EIS M O D E R A T E S I M O D E R A T E	B	B
GEOMORPH	C	-	C	C/D		C	C/D
RIPARIAN VEGETATION	D	-	D	D/E		D	D
FISH	B	0	B	B		B	B
AQUATIC INVERTS	B/C	0	B/C	B/C		B/C	B/C
ECOSTATUS	C	-	C	C/D		C	C

* ATTAINABLE CATEGORY

A summary of the confidence evaluation is provided below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	2	4	3	4	5
PES	2	4	4	3	2
Trajectory of change	4	4	4	4	2
EIS	3				
SI	2				

The results vary from low-medium to high with most of the components in the medium-high range.

10. RU E: THUKELA RIVER SEGMENT 22 - 23 (Rejuvenated Bedrock Falls Zone to Klip River confluence)



10.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 1405.78 mcm

Geomorphology

Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.

Riparian vegetation

Gorge area relatively devoid of vegetation due to the influence of bedrock. Isolated patches of marginal vegetation expected in flatter areas. The gorge is at the initial processes of recovery following floods, and is in the same state it would be in under natural conditions following flooding.

Fish

Ten species probably occurred in the warmer waters of this RU. These included the five species which would have occurred in the upper RU's (*Anguilla mossambica*, *Barbus natalensis*, *Labeo rubromaculatus* and *Amphilius natalensis*), as well as *Anguilla marmorata*, *Barbus trimaculatus*, *Barbus viviparus*, *Labeo molybdinus* and *Tilapia sparrmanii*.

Aquatic invertebrates

Common invertebrates in the stones biotope were: *Elassonuria trimeniiana*, *Baetis* sp., *Centroptilum indusii*, *Euthraulius elegans*, *Afronurus* sp., *Hydropsyche* sp., *Cheumatopsyche* sp., Simuliidae and Chironomidae. The tricorythid *Neurocaenis discolor*, which does not occur in RU D, reappears.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	4	4	2	2

10.2 PES

10.2.1 PES, causes and sources

Table 10.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: B					
Change in morphology.	Sediment retention upstream of weir.	Weir.	NFL	-	3
	Change in flow regime from upstream.	Spioenkop Dam.			
RIPARIAN VEGETATION PES: B					
Reduced marginal zone.	Change in flow regime.	Spioenkop Dam.	FL	Operate to supply the Reserve.	2
FISH PES: B					
Slightly reduced abundance of fish.	Alien species presence impacting on habitat.	Escapees, stocking.	NFL	Eradicate alien species and prevent further stocking.	3
	Impoundment and abstraction.	Thukela Vaal Government Transfer Scheme, Ladysmith abstraction works.	FL	Minimise abstraction in spawning season - December/February.	
AQUATIC INVERTEBRATES PES: B/C					
Loss of uncommon species.	Regulation of river.	Spioenkop Dam.	F L	Operate to supply the Reserve.	2

10.2.2 Trajectory of change

Table 10.2 Trajectory of change, RU E

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	B	B	B	4
	Although this unit is in a state of recovery following the 1987 floods, it is recovering at a lower rate to what it would have under natural conditions, due to the presence of Spioenkop dam. Thus the trajectory is considered negative (within the category) relative to a natural recovery trajectory . The end-point on the recovery trajectory may be the same as under natural conditions. A change from present land-use (i.e. improvement) could result in reduced sedimentation.				
Riparian vegetation	Negative	B	B	B	4
	No changes are expected in the short-term. It is however recovering at a higher rate than natural, and the effects of this are to reduce resilience in the vegetation in the long term. The change is expected to be within category.				
Fish	Stable	B	B	B	2
	Flows have been modified as a result of impoundment by Spioenkop Dam and fish have adjusted to the effects of this change.				
Aquatic invertebrates	Stable	B/C	B/C	B/C	2
	Geomorphology and riparian changes are small enough not to affect the category.				

10.2.3 Summary and resulting Ecstatus

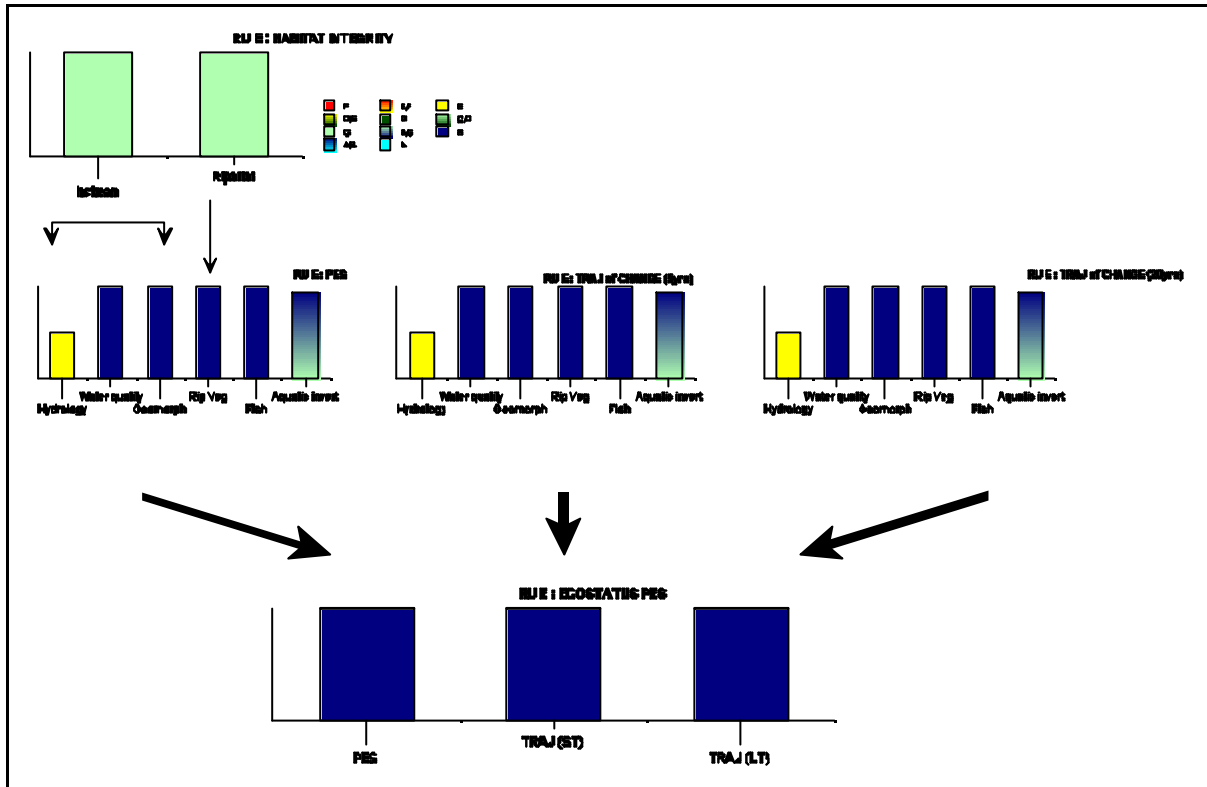
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES E.
Present MAR as % of virgin MAR: 50.22%.

Water quality : PES B, Short-term B, Long-term B.

The information on PES for the different components is summarised in Figure 10.1.

Fig 10.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

Hydrology (PES E) is the outlier in this resource unit, relative to water quality, geomorphology and riparian vegetation (all PES B). This is understandable for geomorphology and riparian vegetation as the impacts on geomorphology are all non-flow related and the PES category for hydrology refers to the impact on low flows which do not play a significant role in geomorphology. All components are considered stable or with a very slow negative trajectory within the category. The gorge characteristics of this section provide a protective buffer for all the components. In the fish community, *Amphilius* is the only flow dependent species, the rest of the fish community is fairly flow-independent. With respect to the invertebrates: habitat will be provided by the relatively stable geomorphology, and this is unlikely to be altered by changing hydrology. The Habitat Integrity (instream) is a lower category, i.e. C which reflects the altered hydrology.

The hydrology is not seen as the key driver and the Ecostatus of a B therefore reflect the other drivers.

10.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating:	Moderate
Confidence:	High
Determinants:	Presence of rare, endangered, unique and flow-dependent species.
SI rating:	High
Confidence:	Medium to High
Determinants:	Human dependence on river for water, riparian plants, fishing and recreation.

10.4 AIM

The EIS is *moderate*, the social importance is *high* and the PES is a B category. Normally the aim would be to maintain PES and minimise the risk of degradation unless there are overriding reasons to improve conditions. As the PES is already in a B category, the aim would be to ***maintain the PES***. There is no motivation to improve even though the social importance is high. The high social importance is associated with aesthetics, and not with resource utilisation. As there is also no negative trajectory, improvement is therefore not required.

10.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this, are also included.

Critical sources	Action	Degree of difficulty
<i>Flow related</i> <ul style="list-style-type: none"> Spioenkop Dam. 	<ul style="list-style-type: none"> Supply the Reserve. 	<ul style="list-style-type: none"> Reasonable (low flows). Difficult (high flows).

Table 10.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B	B	B
Geomorphology	B Y B	B	B
Riparian vegetation	B Y B	B	B
Fish	B Y B	B	B
Aquatic invertebrates	B/C Y B/C	B/C	B/C
Ecostatus	B Y B	B	B

Rationale for the attainable ERC

The aim is to maintain the PES. The aim is seen to be attainable as most of the components are in a B category and reasonably stable over the long term. Minimal actions are required to ensure that the ERC is achieved. The most important is the management of Spioenkop Dam and for low flows, this seemed to be **reasonable**.

The Reserve scenarios that will be supplied are a B and a C category.

10.6 SUMMARY OF RESULTS

The results are illustrated in Figure 10.2 below.

Fig 10.2

Summary of results

RUE : REJUVENATED BEDROCK FALLS TO KLIP RIVER CONFLUENCE (segm 22 - 24)

COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	B	+	B	B	EIS MODERATE SI HIGH	B	B
GEOMORPH	B	-	B	B		B	B
RIPARIAN VEGETATION	B	-	B	B		B	B
FISH	B	0	B	B		B	B
AQUATIC INVERTS	B/C	0	B/C	B/C		B/C	B/C
ECOSTATUS	B	0	B	B		B	B

*ATTAINABLE CATEGORY

A summary of the confidence evaluation is provided below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	4	2	2
PES	4	3	2	3	2
Trajectory of change	4	4	4	2	2
EIS	3				
SI	3				

The confidence evaluation ranges from medium-low to medium high.

11. RU F : THUKELA RIVER SEGMENT 25-30 (Klip River confluence to Bushmans River confluence)



11.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 1425.15 mcm

Geomorphology

Steepened section within the middle reaches of the river caused by uplift, often within or downstream of gorge, with characteristics similar to foothill zone river (gravel/cobble bed rivers with pool/riffle pool/rapid morphology), but of a higher order. A compound channel is often present with an active channel contained within a macro-channel, activated only during infrequent flood events. A limited floodplain may be present between the active and the macro-channel.

Riparian vegetation

Ranging from densely wooded riparian zone dominated by *Ficus sycamorus*, *Schotia brachypetala*, *Nuxia oppositifolia* and *Trichilia emetica* in low gradient areas, to a less densely wooded riparian zone in steep gradient gorges.

Fish

Eleven species probably occurred here in the pristine state: *Anguilla bengalensis*, *Anguilla marmorata*, *Anguilla mossambica*, *Barbus natalensis*, *Barbus trimaculatus*, *Barbus viviparus*, *Labeo molybdinus*, *Labeo rubromaculatus*, *Amphilius natalensis*, *Clarias gariepinus*, *Tilapia sparmanii* and *Awaous aeneofuscus*.

Aquatic invertebrates

Data from the 1950/60s indicate that the site showed a classic good quality torrential river fauna with several flow-dependent species. The greatest density of organisms in riffles occurred in the upper river, next to Nkasini (lower end of this Resource Unit) and Tugela Ferry. In the marginal vegetation biotope, the highest invertebrate densities occurred in the upper river and Foothill Sandbed Zones, with low numbers in the middle reaches (Nkasini and Middledrift). In the stones biotope, invertebrates commonly collected in the rejuvenated zone were *Elassoneuria trimeniana*, *Baetis* sp., *Centroptilum indusii*, *Euthraulius elegans*, *Afronurus* sp., *Neurocaenis discolor* (tricorythid), *Hydropsyche* sp., *Cheumatopsyche* sp., Simuliidae and Chironomidae. In the stones biotope, at Nkasini, Tugela Ferry, and Mandini, populations were similar to the above (high winter populations), but large numbers of *Simulium* sp. were dominant in winter (Derived from Oliff 1960).

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high confidence'.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	2	4	4	4	5

11.2 PES

11.2.1 PES, causes and sources

Table 11.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: B/C					
Change in river morphology.	Sediment aggradation and bank instability.	Catchment land-use, bridge and irrigation canal (has been under construction and reconstruction).	NFL	Land-use management.	4
RIPARIAN VEGETATION PES: C					
Degradation of riparian vegetation.	Grazing.	Agriculture (informal).	NFL	Land-use management.	4
FISH PES: B					
Slightly reduced abundance of fish.	Alien species presence (effects on habitat).	Stocking of the river with alien species.	NFL	Control or eradication, and prevention of further stocking.	3
	Habitat reduction due to flow abstraction.	Thukela Vaal Government Scheme; Ladysmith abstraction works.	FL	Minimise abstraction in spawning season - December/February.	
AQUATIC INVERTEBRATES PES: B/C					
Loss of species possible.	Effluent from the Klip River.	Industry and waste water works in Ladysmith.	NFL	Source Directed Measures.	4
	Regulation of river.	Spioenkop Dam.	FL	Operation of the dam to provide the Reserve.	
	Deteriorating water quality	Land-use activities.	NFL	Land-use management.	

11.2.2 Trajectory of change

Table 11.2 Trajectory of change, RU F

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Stable	B/C	B/C	B/C	4
	No significant change between aerial photographs from different periods.				
Riparian vegetation	Negative	C	C	C/D	2
	Pressure due to continued grazing pressure, trampling etc.				
Fish	Stable	B	B	B	4
	In terms of the whole RU, the resumed abstraction via the Thukela Vaal Government Scheme only occurs in the lower section.				
Aquatic invertebrates	Stable	B/C	B/C	B/C	4
	Due to the stable geomorphology the invertebrates are likely to remain the same.				

11.2.3 Summary and resulting Ecostatus

The other drivers to be considered when determining the Ecostatus are:

Hydrology:

PES E.

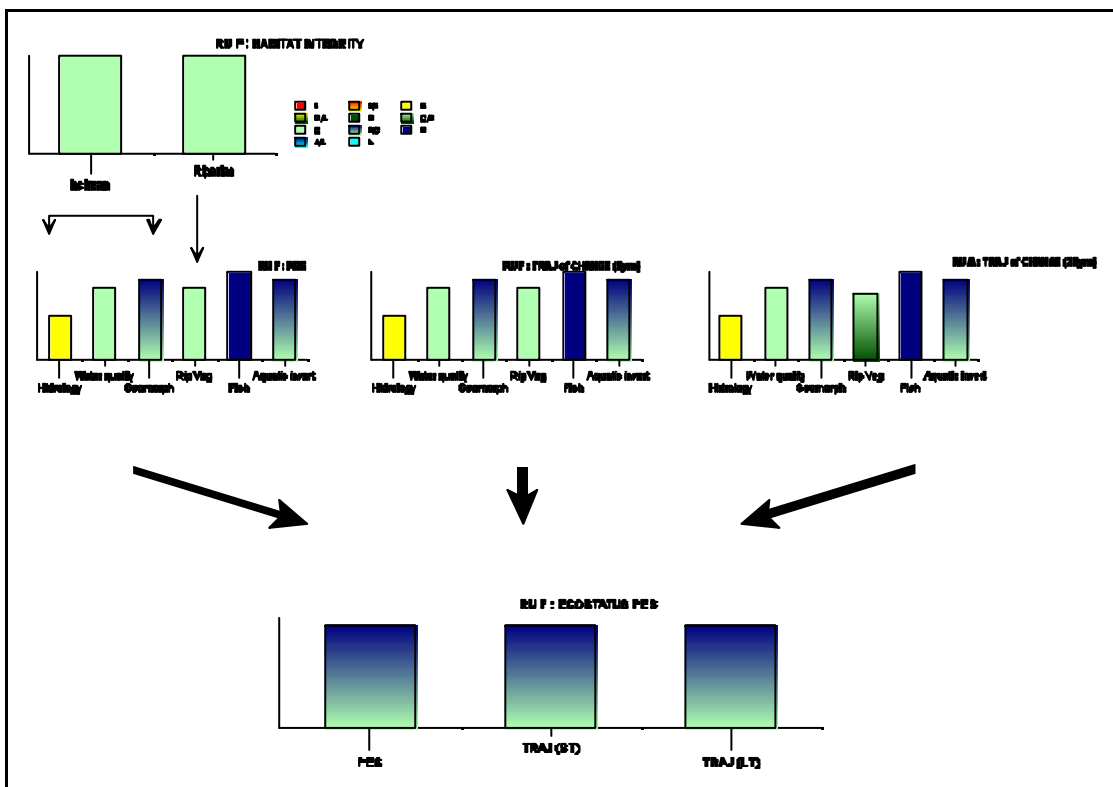
Present MAR as % of virgin MAR: 54.2%.

Water quality:

PES C (*This is on account of the organic content coming in from the Klip River, particularly during critical low flows.*)

The information on PES for the different components is summarised in Figure 11.1.

Fig 11.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

Hydrology is an outlier (PES E) and as all the biota is in a higher category, the hydrology is not seen as the main driver. The geomorphology driver (a B/C category) is probably more critical. The upper reaches of this section (which is still in the gorge proper) is deemed to be overall in a B category whereas the larger portion of the unit (which is more accessible and therefore more prone to disturbance) is in a B/C category. The Ecostatus representative for the RU is therefore set as B/C.

11.3 ECOLOGICAL AND SOCIAL-CULTURAL IMPORTANCE

The results of the Social-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: High
 Confidence: Very high
 Determinants: Unique, rare fish and invertebrate present. Fauna show high diversity and some are sensitive to flow and water quality related changes. High habitat diversity.

SI rating: High
 Confidence: High
 Determinants: High human dependence on the river for water, riparian vegetation, subsistence fishing and recreation. Sacred places, general aesthetics of river, sense of place and special features on the river. Potential of the area for ecotourism.

11.4 AIM

The EIS is **high**, the social importance is **high** and the PES is a B/C category. The aim is therefor to **improve** the river to an ERC of a B.

11.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes in brackets. The degree of difficulty associated with this is also included.

Critical sources	Action	Degree of difficulty
<p><i>Non-flow related</i></p> <ul style="list-style-type: none"> Land-use (including grazing). Deteriorating water quality (effluent from Klip River, urban runoff, heavy industrial effluent and waste water treatment works). 	<ul style="list-style-type: none"> Land-use management. Source Directed Controls.* 	<ul style="list-style-type: none"> Very difficult.
<p><i>Flow related</i></p> <ul style="list-style-type: none"> Spioenkop Dam (lag effect from regulated flows and unseasonal floods, upstream abstractions). 	<ul style="list-style-type: none"> Operate to release the Reserve. 	<ul style="list-style-type: none"> Reasonable.

* Although the implementation of Source Directed Controls (SDC) is not necessarily difficult, experience has shown that there is often a lack of willingness of implementation. The likelihood of SDCs being implemented is thus low and the degree of difficulty is thus expressed as very difficult.

Table 11.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	C Y C	B/C	C
Geomorphology	B/C Y B/C	B/C	B/C
Riparian vegetation	C Y C/D	C	C/D
Fish	B Y B	B	B
Aquatic invertebrates	B/C Y B/C	B	B/C
Ecotatus	B/C Y B/C	B	B/C

Rationale for the attainable ERC

The high social and ecological importance of this unit provides the motivation to improve from a B/C to a B. However, the degree of difficulty associated with all the non flow related aspects is very difficult, the improvement will probably only be attainable in the long term. Thus the short term ERC is a B/C, and if all the aforementioned issues can be addressed, the long-term ERC of a B will be achieved.

11.6 SUMMARY OF RESULTS

The results are illustrated in Figure 11.2.

Fig 11.2 Summary of results

RJ F : KLIP CONFLUENCE TO BUSHMANS CONFLUENCE (segm 25 - 30)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	C	0	C	C	HIGH	B/C	C
GEOMORPH	B/C	0	B/C	B/C		B/C	B/C
RIPARIAN VEGETATION	C	-	C	C/D		C	C/D
FISH	B	0	B	B	HIGH	B	B
AQUATIC INVERTS	B/C	0	B/C	B/C		B	B/C
ECOSTATUS	B/C	0	B/C	B/C		B	B/C

* ATTAINABLE CATEGORY

A Summary of the confidence is provided below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	2	4	4	4	5
PES	2	4	4	3	4
Trajectory of change	3	4	2	4	4
EIS	4				
SI	3				

The confidence ranges from medium-low to high with most of the components being in the medium high range.

11.7 IFR SITE WITHIN THE RU

IFR sites 4a and 4b are situated in this RU. The PES of the RU reflects the PES and therefore ERC of these IFR sites.

12. RU G: THUKELA RIVER SEGMENT 31 - 33 (Bushmans River to Sundays River confluence)



12.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR 1743.72 mcm

Geomorphology

This is a steepened section within the middle reaches of the river, caused by uplift, often within or downstream of gorge. It has characteristics similar to a foothill zone river (gravel/cobble bed rivers with pool/riffle, pool/rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel, activated only during infrequent flood events. A limited floodplain may be present between the active and the macro-channel.

Riparian vegetation

Ranging from densely wooded riparian zone dominated by *Ficus sycamorus*, *Schotia brachypetala*, *Nuxia oppositifolia*, *Trichilia emetica* in low gradient areas to a less densely wooded riparian zone in steep gradient gorges.

Fish

Twelve species should have occupied this reach in its pristine condition: *Anguilla bengalensis*, *Anguilla marmorata*, *Anguilla mossambica*, *Barbus natalensis*, *Barbus trimaculatus*, *Barbus viviparus*, *Labeo molybdinus*, *Labeo rubromaculatus*, *Amphilius natalensis*, *Clarias gariepinus*, *Tilapia sparrmanii*, and *Awaous aeneofuscus*. *Anguilla bengalensis* is the only addition to the list of those which would have occurred in RU F.

Aquatic invertebrates

Low numbers of invertebrates occurred in the marginal vegetation in this reach. Invertebrates common in this reach were *Elassoneuria trimeniana*, *Baetis* sp., *Centroptilum indusii*, *Euthraulius elegans*, *Afronurus peringueyi*, *Neurocaenis discolor* (tricorythid), hydropsychids, cheumatopsychids, simuliids and chironomids.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no' confidence and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	3	2	5	3	3	2

12.2 PES

12.2.1 PES, causes and sources

Table 12.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C/D					
Change in morphology.	Sediment aggradation and bank instability from alien vegetation.	Land-use.	NFL	Land-use management.	4
		Tributary inputs.	NFL	Land-use management.	
RIPARIAN VEGETATION PES: E					
Reduced vegetation cover.	Trampling and grazing.	Agriculture.	NFL	Land-use management.	4
Loss of marginal zone.	Sedimentation.	Bank erosion.			
Shift in species composition.	Encroachment of alien species.	Land-use.	NFL	Alien vegetation control programme.	
FISH PES: B					
Slight population decline.	Alien species presence.	Stocking of fish.	NFL	Eradication and prevention of further stocking.	1
WATER QUALITY PES: B/C					
Variability in invertebrate communities.	Loss of marginal habitats and sedimentation.	Land-use activities from Estcourt.	NFL	Land-use management, improvement of Source Directed Measures.	2

12.2.2 Trajectory of change

Table 11.2 Trajectory of change, RU G

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C/D	D	D	3
	Sediment aggradation, catchment land-use, bank instability, tributary inputs.				
Riparian vegetation	Negative	E	E	E/F	3
	Continuous impact of grazing, browsing, exotic vegetation and sedimentation.				
Fish	Stable	B	B	B	2
	-				
Aquatic invertebrates	Negative	B/C	B/C	C	2
	Driven by deteriorating geomorphology. River has a lower slope here, so settling out of sediments onto the river bed is likely (hence reducing habitats: e.g. marginal habitat lost due to sedimentation).				

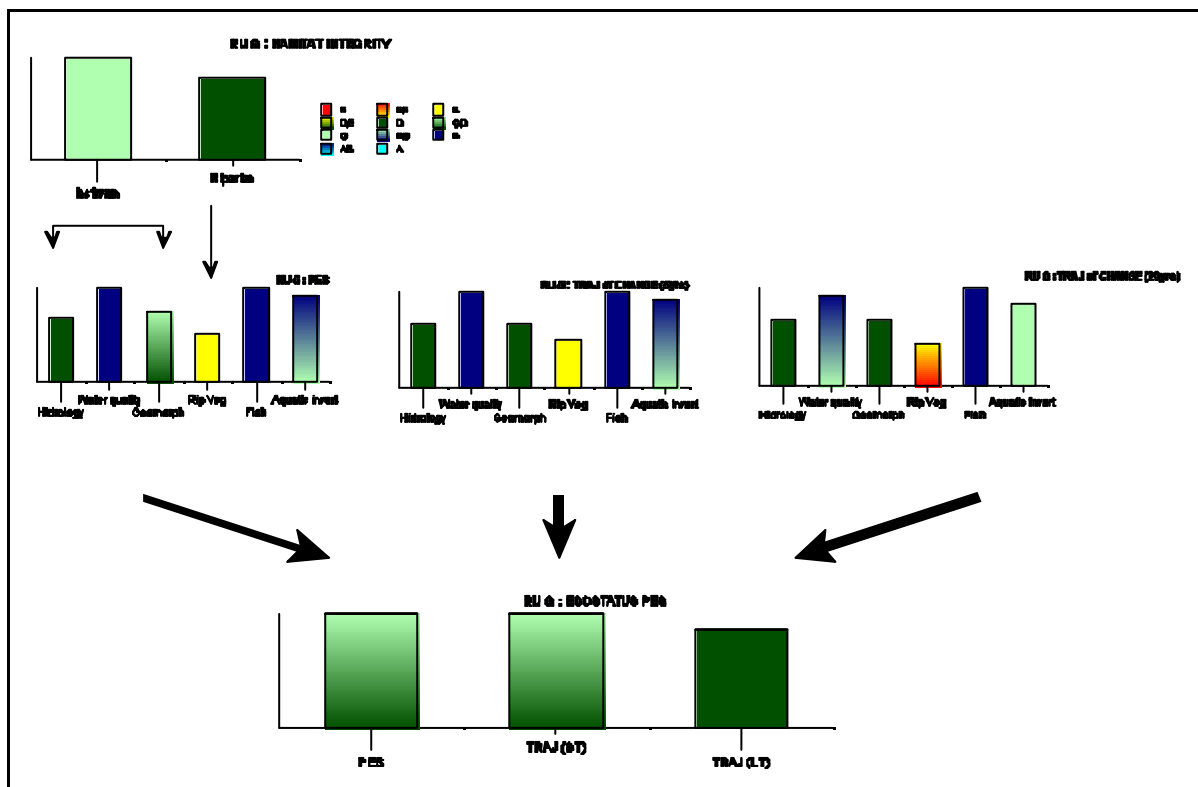
12.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES D.
 Water quality: PES B, Short-term B, Long term B/C.

The information on PES for the different components is summarised in Figure 12.1.

Fig 12.1 PES results and the resulting Ecstatus



Rationale for the Ecostatus

This unit is in a natural recovery cycle, and is a natural sediment sink. There is a discrepancy between the condition of the major drivers: the hydrology, geomorphology and riparian vegetation, and the water quality and instream fauna. Cattle are abundant in this section, and utilisation is more intensive than upstream. This results in severe degradation of the marginal zone, and sedimentation of instream habitats. For this reason, geomorphology is considered the major driver, and the negative trajectories of the instream invertebrates reflect the effect of the modifications in geomorphology over the long term. The Ecostatus is set at C/D, reflecting the condition of the geomorphology, and is expected to follow a similar negative trajectory over the long term, resulting in a D category.

12.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Social-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate to High (due to rare biota)
 Confidence: High
 Determinants: High species richness, presence of rare, unique and flow-sensitive species in the fauna.

SI rating: High
 Confidence: High
 Determinants: Human dependence on the river for water, as a building resource, for subsistence fishing, and as a recreational resource.

12.4 AIM

The EIS is **moderate** (but tending towards high due to rare biota), the social importance is **high**, and the PES is a C/D. The aim is to maintain the PES and minimise the risk of degradation. Improvement will be required to halt the negative trajectory of change and to maintain the category. Improvement for the sake of the high social importance is not required as all the goods and services can be provided adequately under the present conditions.

12.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes in brackets. The actions required to address these, as well as the degree of difficulty associated with this, are also included.

Critical sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> • Land-use (sedimentation and grazing). • Alien vegetation. 	<ul style="list-style-type: none"> • Land-use management. • Alien vegetation control program. 	<ul style="list-style-type: none"> • Very difficult. • Reasonable.

The action required to maintain the PES is classified as 'very difficult'. The negative trajectory of change will have to be addressed through some improvement. The individual components are addressed as follows:

Table 12.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B/C	B	B/C
Geomorphology	C/D Y D	C/D	D
Riparian vegetation	E Y E/F	D	D
Fish	B Y B	B	B
Aquatic invertebrates	B/C Y C	B/C	C
Ecostatus	C/D Y D	C/D	C/D

Rationale for the attainable ERC

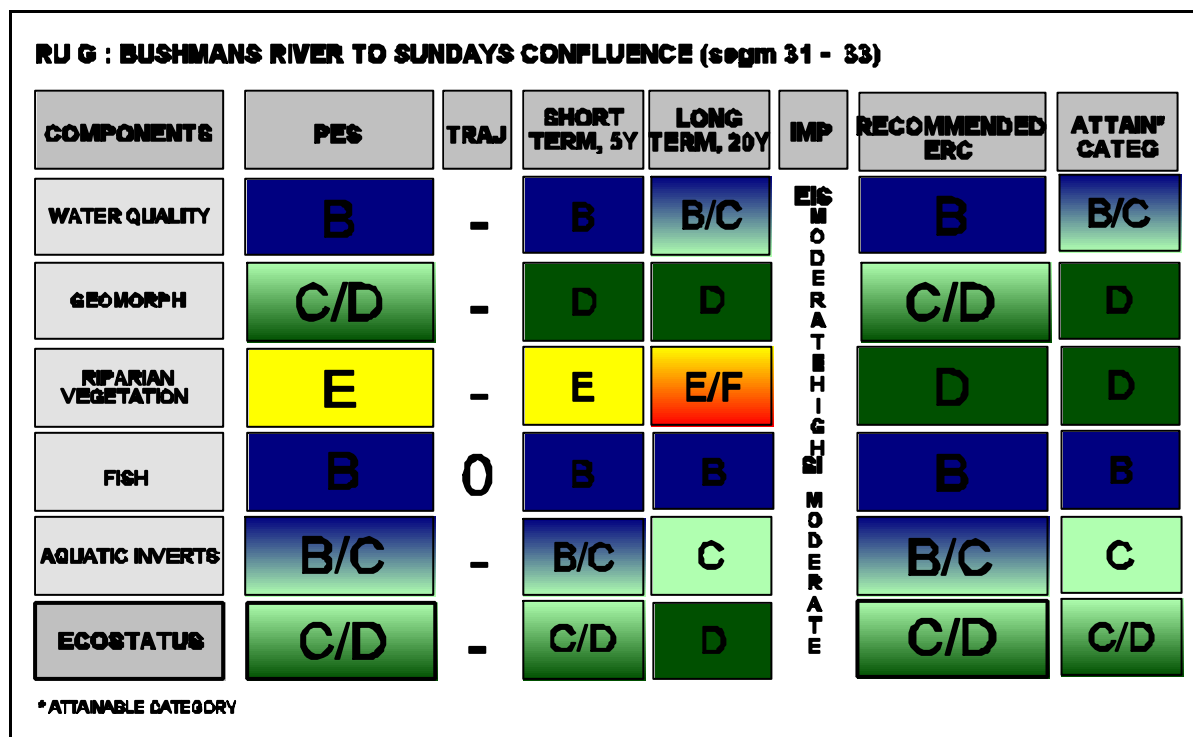
All the problems in the catchment is non flow related and to address them will be 'very difficult'. Addressing the negative trajectory of change to maintain the PES of some of the categories will be very difficult and can possibly only be addressed in the long term. An alien vegetation control programme is seen to be reasonable and this could address the problems with vegetation to some extent. The attainable ERC is C/D.

The IFR scenarios that will be addressed will be B/C, C/D and D.

12.6 SUMMARY OF RESULTS

The results are illustrated in Figure 12.2.

Fig 12.2 Summary of results



The confidence is summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	2	5	3	3	2
PES	2	4	4	1	2
Trajectory of change	3	3	3	2	2
EIS	4				
SI	3				

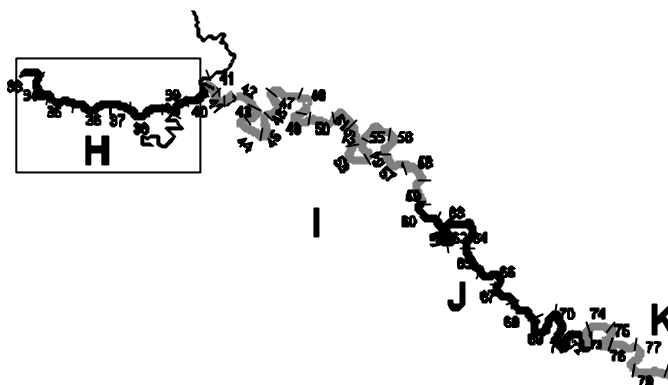
The confidence varies between low to high with most of the components reflecting a confidence rating of medium-low to medium-high.

13. RU H: THUKELA RIVER SEGMENT 34 - 40 (Sundays River Confluence to Buffalo Confluence)

13.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 2055.37 mcm



Geomorphology

Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge, characteristics similar to Foothill Zone river (gravel/cobble bed rivers with pool/riffle pool/rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel, activated only during infrequent flood events. A limited floodplain may be present between the active and the macro-channel.

Riparian vegetation

Ranging from densely wooded riparian zone dominated by *Ficus sycamorus*, *Schotia brachypetala*, *Nuxia oppositifolia*, *Trichilia emetica* in low gradient areas to a less densely wooded riparian zone in steep gradient gorges.

Fish

The same twelve species found in Unit G would have occupied this unit: *Anguilla bengalensis*, *Anguilla marmorata*, *Anguilla mossambica*, *Barbus natalensis*, *Barbus trimaculatus*, *Barbus viviparus*, *Labeo molybdinus*, *Labeo rubromaculatus*, *Amphilius natalensis*, *Clarias gariepinus*, *Tilapia sparrmanii*, and *Awaous aeneofuscus*.

Aquatic invertebrates

The greatest density of organisms in marginal vegetation occurred in the upper river, next to Nkasini and Thukela Ferry. The highest invertebrate densities in the stones biotope were in the upper river and Foothill Sandbed Zones, with low numbers in the middle reaches (Nkasini and Middledrift). Common taxa in the stones biotope in this reach were *Elassoneuria trimeniana*, *Baetis* sp., *Centroptilum indusii*, *Euthraulius elegans*, *Afronurus peringueyi*, *Neurocaenis disolor* (*tricorythid*), *Hydropsyche* and *Cheumatopsyche*, *Simulium* and Chironomidae. *Euthraulius elegans* dominated at all times. At Ngobevu, low flows in winter resulted in withdrawal of the water from the riparian zone, with stones in slow flowing water. At Nkasini, Thukela Ferry, large numbers of *Simulium* were dominant in stones in winter. Ngobevu was atypical as *Cheumatopsyche* were important in winter, though mayflies were dominant, as at other stations. Late winter, a growth of filamentous algae and diatoms occurs, providing food for invertebrates, especially in the Sand Bed Zones at Thukela Ferry (Conclusions derived from Oliff, 1960).

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting high confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	2	5	3	4	5

13.2 PES

13.2.1 PES, causes and sources

Table 13.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: D					
Habitat change.	Sediment aggradation due to bank instability and overgrazing.	Agriculture and land use.	NFL	Catchment land-use management.	4
Change in morphology.	Presence of in-channel structures.	In-channel structures (bridge, weir).	NFL	-	
RIPARIAN VEGETATION PES: E					
Reduced vegetation cover.	Trampling and grazing.	Agriculture.	NFL	Land-use management.	4
Loss of marginal zone.	Sedimentation.	Bank erosion.			
Shift in species composition.	Encroachment of alien species.	Land use.	NFL	Alien vegetation control programme.	
FISH PES: B					
Population decline.	Presence of alien species.	Spioenkop Dam.	NFL	-	2
Habitat decline.	Siltation.	Bad land management.	NFL	Erosion control.	2
AQUATIC INVERTEBRATES PES: C					
Decrease in species diversity.	Deterioration in water quality siltation/sedimentation.	Overgrazing of catchment and riparian zone; heavy rural developments due to population increases.	NFL	Catchment management and environmental education.	2

13.2.2 Trajectory of change

Table 13.2 Trajectory of change, RU H

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D/E	3
	Sediment accumulation and bank pressure (bank instability, overgrazing) from anthropogenic causes; structures (bridges and weirs) in channel.				
Riparian vegetation	Negative	E	E	E/F	3
	Continuing grazing pressure etc. (same as previous unit).				
Fish	Negative	B	B	C	4
	Continuing informal river bank agriculture and a bit of local abstraction.				
Aquatic invertebrates	Stable	C	C	C	2
	Geomorphological changes have already altered the condition of the habitats to a C, no significant further change anticipated.				

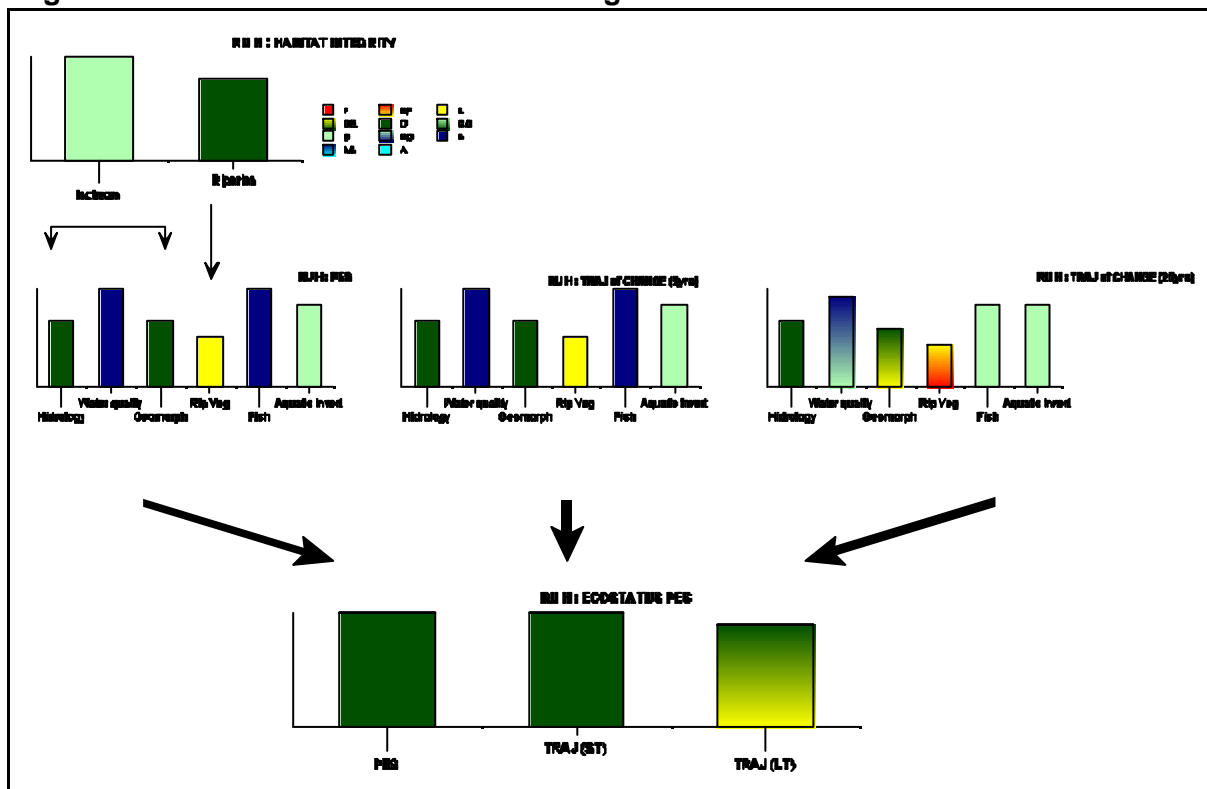
13.2.3 Summary and resulting Ecostatus

The other drivers to be considered when providing the Ecostatus are:

- Hydrology : PES D. Present MAR as % of virgin MAR: 63.91%.
- Water quality: PES B.

The information on PES for the different components are summarised in Figure 13.1 below.

Fig 13.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The situation is similar to RU G. The drivers again (apart from water quality) are in a worse condition than the instream components. Due to the degradation of the marginal zone, and sedimentation of instream habitats, geomorphology is considered the major driver in this unit.

13.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate (borderline High)
 Confidence: High
 Determinants: Presence of unique, flow sensitive species and a species rich biota.

SI rating: Moderate
 Confidence: Medium to High
 Determinants: Human dependence on river for water, building or medicinal purposes, fishing and recreation. Sacred places.

13.4 AIM

The EIS is **moderate** (borderline high), the social importance is **moderate**, and the PES is a D category. The aim would therefore be to **maintain** the PES as a D. This would require that the negative trajectories of water quality, geomorphology, and riparian vegetation are addressed. This effectively means addressing the land-use issues in the catchment.

13.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (siltation). 	<ul style="list-style-type: none"> Catchment land-use management. 	<ul style="list-style-type: none"> Very difficult.

The recommended ERCs for the various components are summarised below.

Table 13.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B/C	B	B/C
Geomorphology	D Y D/E	D	D/E
Riparian vegetation	E Y E/F	D	E
Fish	B Y C	B	C
Aquatic invertebrates	C Y C	C	C
Ecostatus	D Y D/E	D	D/E

Rationale for the attainable Ecostatus

All the actions required to address the problems to maintain the PES, i.e. to halt the negative trajectory of change are classified as “**very difficult**”. They are all non-flow related and all related to catchment land-use. The ERC can therefore probably only be achieved in the long-term.

13.6 SUMMARY OF RESULTS

The results are illustrated in Figure 13.2.

Fig 13.2 Summary of results

RU H : SUNDAYS CONFLUENCE TO BUFFALO CONFLUENCE (segm 34 -40)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	B	-	B	B/C	EIS M O D E R A T E	B	B/C
GEOMORPH	D	-	D	D/E		D	D/E
RIPARIAN VEGETATION	E	-	E	E/F		D	E
FISH	B	-	B	C	SI M O D E R A T E	B	C
AQUATIC INVERTS	C	0	C	C		C	C
ECOSTATUS	D	-	D	D/E		D	D/E

* ATTAINABLE CATEGORY

The confidence in the results are summarised below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	2	5	3	4	5
PES	4	4	4	4	2
Trajectory of change	3	3	3	4	2
EIS	3				
SI	2				

The confidence ranges from medium-low to high with most of the components falling within the medium-high range.

13.7 IFR SITE WITHIN THE RU

IFR Site 9 (Thukela Ferry) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

The IFR scenarios that will be addressed for this site are a D and a C.

14. RU I : THUKELA RIVER SEGMENT 41 - 59 (Buffalo River Confluence to Middledrift)

Sub-unit assessed: Gorge area from Buffalo Confluence to Jamieson's Drift, i.e. IFR 15.

14.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 3557.89 mcm

Geomorphology

Steepened section within the middle reaches of the river caused by uplift, often within or downstream of gorge. Characteristics similar to Foothill Zone River (gravel/cobble bed rivers with pool/riffle pool/rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel, activated only during infrequent flood events. A limited floodplain may be present between the active and the macro-channel.



Riparian vegetation

Ranging from densely wooded riparian zone dominated by *Ficus sycamorus*, *Schotia brachypetala*, *Nuxia oppositifolia*, *Trichilia emetica* in low gradient areas to a less densely wooded riparian zone in steep gradient gorges.

Fish

The same 12 species would have occurred in this unit in the pristine condition as occurred in Unit H: *Anguilla bengalensis*, *Anguilla marmorata*, *Anguilla mossambica*, *Barbus natalensis*, *Barbus trimaculatus*, *Barbus viviparus*, *Labeo molybdinus*, *Labeo rubromaculatus*, *Amphilius natalensis*, *Clarias gariepinus*, *Tilapia sparrmanii*, and *Awaous aeneofuscus*.

Aquatic invertebrates

The most abundant mayflies throughout the system were *Baetis harrisoni* and *Pseudocloeon glaucum*. *Afronurus peringueyi* and *Euthraulius elegans* were also abundant. *Centroptiloides bifasciata* was found at all sites, but in low numbers. These are all well known to be tolerant and successful under various conditions. The most diverse mayfly populations were found at Jamieson's Drift. Two species of hydroptilid caddis (*Hydroptila cruciata* and *Orthotrichia barnardi*) were common. *Simulium medusaeforme* was the most widespread species and was found all the way down to the Resource Unit J. *S. medusaeforme* is considered to be an adaptable species found under a wide range of flow conditions. It is common in the swift-flowing middle reaches of larger rivers where it dominates the simuliids numerically. Unique in the Thukela to this zone were three species of mayfly, *Pseudocloeon piscis*, *Crassabwa flave* and *Acanthiops tsitsa*, and three species of trichopteran, *Athripsodes corniculans*, *Dipseudopsis capensis* and *Oxyethira* sp. were recorded only from this zone. All three of these species should be found higher upstream and the two known species have a more widely recorded distribution

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	No data	4	3	4	4

14.2 PES

14.2.1 PES, causes and sources

Table 14.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: D					
Habitat change.	Sediment aggradation.	Bank instability and overgrazing due to agriculture and land-use.	NFL	Land-use management.	2
Change in morphology.	Presence of in-channel structures.	In channel structures (bridge, weir).	NFL	-	
RIPARIAN VEGETATION PES: C (Gorge RU li), E (Downstream of gorge RU lii)					
i: Change in species composition.	Alien species.	Land-use.	NFL	Land-use management Alien vegetation control programme	4
ii: Reduced vegetation cover, shift in species composition, marginal zone decrease.	Sedimentation, encroachment of alien species.	Agriculture (over-grazing), alien vegetation etc.	NFL	Land-use management Alien vegetation control programme	
FISH PES: C					
Absence of <i>Amphilius</i> . Reduced abundance of indigenous species.	Habitat degradation.	Siltation.	NFL	Land-use management.	3
AQUATIC INVERTEBRATES PES: B					
Changes in species composition.	Turbidity.	Overgrazing in the riparian zone due to informal agriculture.	NFL	Land-use management.	4

14.2.2 Trajectory of change

Table 14.2 Trajectory of change, RU I

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D/E	3
	Sediment accumulation and bank pressure (bank instability, overgrazing) from anthropogenic causes; structures (bridges and weirs) in channel.				
Riparian vegetation (ii) Gorge	Stable	C	C	C	4
	Little further change anticipated in the gorge section.				
Riparian vegetation (iii)	Negative	E	E	E/F	4
	Accumulation of reeds.				
Fish	Stable	C	C	C	3
	Very little further impact by local population and land-use on riverine habitat. In equilibrium with modified state.				
Aquatic invertebrates	Stable	B	B	B	3
	The most important habitats are unlikely to change.				

14.2.3 Summary and resulting Ecstatus

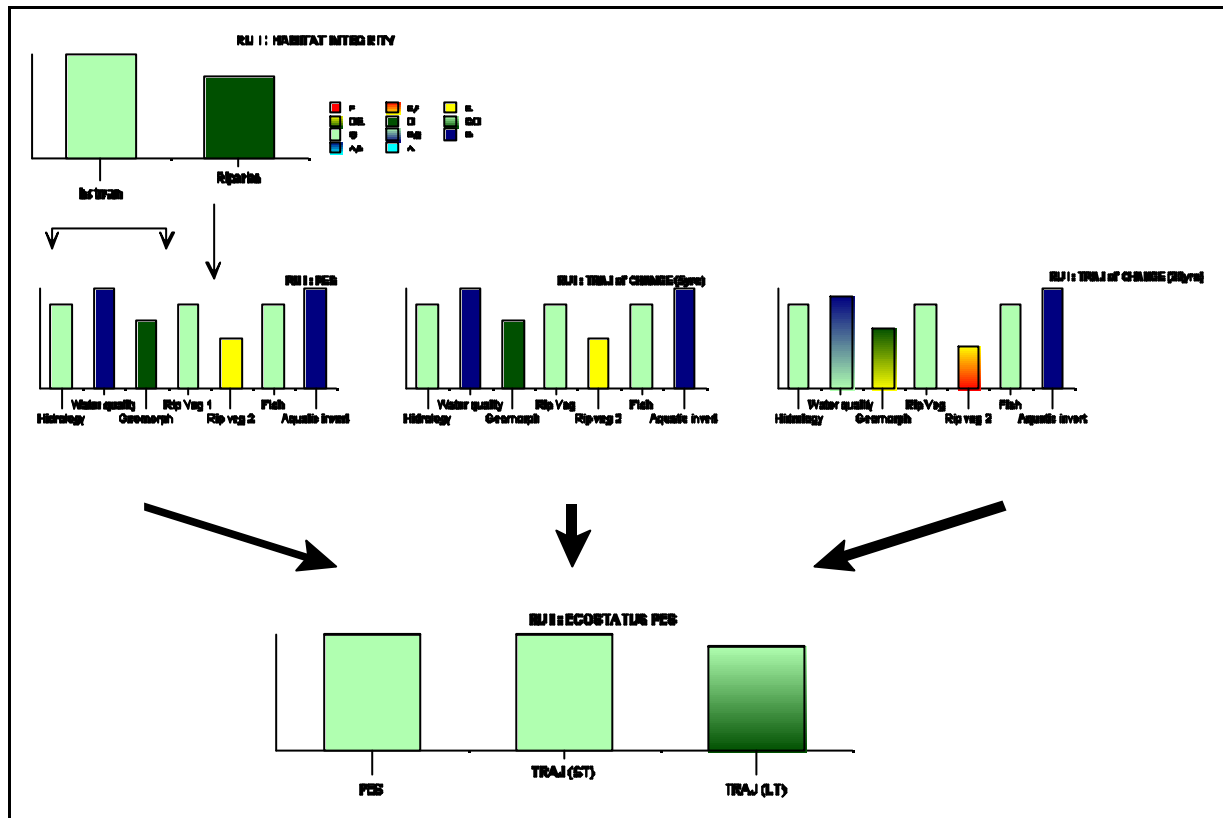
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES C.
Present MAR as % of virgin MAR:72.5%.

Water quality: PES B.

The information on PES for the different components are summarised in Figure 14.1.

Fig 14.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The gorge section is more protected and therefore will be in a better state overall than the downstream area. The geomorphology is the driver in the worst conditions (category D). Hydrology is a C and waterquality a B. The Instream Habitat Integrity that integrates most of these components is in a C category and it was decided that this is also relevant for the Ecostatus. This Ecostatus also reflects in the riparian vegetation within the gorge, but not the section outside the gorge.

14.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and a Ecological Importance and Sensitivity (EIS) re attached as Appendix G.

EIS rating: High
 Confidence: High
 Determinants: Species diversity, presence of unique and flow-sensitive biota. Biota use this section as a migration corridor.

SI rating: High
 Confidence: Medium to High
 Determinants: Human dependence on the river for water, as a resource and for recreational purposes. Sacred places on the river in this section.

14.4 AIM

The EIS is **high**, the social importance is **high** and the PES is a C category. Downstream of the gorge, problems with the riparian vegetation need to be addressed in order to supply the social requirements and to maintain the C category. Importance in this stretch resides in the invertebrate

biota which is in a good condition (B category) and should be maintained in a B category. Overall improvement of the Ecstatus if therefore not required to maintain the aquatic invertebrates in a B category. The aim therefore is to **maintain** the PES.

14.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (siltation and turbidity). 	<ul style="list-style-type: none"> Catchment land-use management. 	<ul style="list-style-type: none"> Very difficult.

The recommended ERCs for the various components are summarised below.

Table 14.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B/C	B	B/C
Geomorphology	D YD/E	D	D/E
Riparian vegetation (li)	C Y C	C	C
Riparian vegetation (lii)	E Y E/F	D	E
Fish	C Y C	C	C
Aquatic invertebrates	B Y B	B	B
Ecstatus	C Y C/D	C	C/D

Rationale for the attainable ERC

The aim is to **maintain** present conditions, both in order to maintain the resource because of its high social and ecological importance, and as the invertebrate biota is ecologically important. The riparian vegetation downstream of the gorge needs to be addressed to halt its negative trajectory, and because it is considered important as a resource for local people. As the degree of difficulty to address these problems are evaluated as “very difficult”, the ERC of C will only be achieved in the long term.

14.6 SUMMARY OF RESULTS

The results are illustrated in Figure 14.2.

Fig 14.2 Summary of results

RU I : BUFFALO CONFLUENCE TO MIDDLEDRIFT (segm 41 - 59)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B	-	B	B/C	EIS HIGH	B	B/C
GEOMORPH	D	-	D	D/E		D	D/E
RIPARIAN VEGETATION (1)	C	0	C	C		C	C
RIPARIAN VEGETATION (2)	E	-	E	E/F	SI HIGH	D	E
FISH	C	0	C	C		C	C
AQUATIC INVERTS	B	0	B	B		B	B
ECOSTATUS	C	-	C	C/D		C	C/D

* ATTAINABLE CATEGORY

The confidence in the results are provided below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	No data	4	3	4	4
PES	2	2	4	3	4
Trajectory of change	2	3	4	3	3
EIS	3				
SI	2				

The confidence range from medium-low to medium-high with most of the results being in the medium and medium-high range.

14.7 IFR SITE WITHIN THE RU

IFR 15 (Jamieson's Drift) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site. The Reserve scenarios for this site will be supplied for a C, a B and a D category.

15. RU J: THUKELA RIVER SEGMENT 60 - 72 (Middledrift to end of Rejuvenated Foothills Zone)

15.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 3718.05 mcm

Geomorphology

Steepened section within the middle reaches of the river caused by uplift, often within or downstream of a gorge, with characteristics similar to a Foothill Zone river (gravel/cobble bed rivers with pool/riffle pool/rapid morphology), but of a higher order. A compound channel is often present with an active channel contained within a macro-channel, activated only during infrequent flood events. A limited floodplain may be present between the active and the macro-channel.

Riparian vegetation

This ranges from a densely wooded riparian zone dominated by *Ficus sycamorus*, *Schotia brachypetala*, *Nuxia oppositifolia*, and *Trichilia emetica* in low gradient areas to a less densely wooded riparian zone in the steep gradient gorges.

Fish

In its pristine condition, RU J supported 12 species, all of these being the same as those in Units H and I. The presence of *Amphilius natalensis* in the pristine condition may be questionable on the grounds of lack of suitable riffle habitat, except in the upper reaches of the unit, and at low altitude. Its fairly recent presence below here in Unit K, however, suggests that this species once occurred throughout the length of the main Thukela River.

Aquatic invertebrates

The most abundant mayflies throughout the system were *Baetis harrisoni* and *Pseudocloeon glaucum*. *Afronurus peringueyi* and *Euthraulius elegans* were also abundant. *Centroptiloides bifasciata* was found at all sites, but in low numbers. These are all well known to be tolerant and successful under various conditions. Two species of hydroptilid caddis (*Hydroptila cruciata* and *Orthotrichia barnardi*) were common. *Simulium medusaeforme* was the most widespread species. *S. medusaeforme* is considered to be an adaptable species found under a wide range of flow conditions. It is common in the swift-flowing middle reaches of larger rivers where it dominates the simuliids numerically. Unique in the Thukela to this zone of the river were three species of mayfly, *Pseudocloeon piscis*, *Crassabwa flave* and *Acanthiops tsitsa*, and three species of trichopteran, *Athripsodes corniculans*, *Dipseudopsis capensis* and *Oxyethira sp.*

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'very high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	No data	5	4	4	1

15.2 PES

15.2.1 PES, causes and sources

Table 15.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C/D					
Habitat change.	Sediment aggradation due to bank instability and overgrazing.	Agriculture and land-use.	NFL	Land-use management.	5
Change in morphology.		In-channel structures (bridge, weir).	NFL	-	
RIPARIAN VEGETATION PES: D					
Shift in species composition. Riparian vegetation degradation.	Reed encroachment due to sedimentation. Grazing.	Agricultural practices.	NFL	Land-use management.-	3
FISH PES: C					
Decreased abundance.	Habitat degradation.	Flow reduction and siltation.	FL	Operate the upstream dams to provide the Reserve.	4
AQUATIC INVERTEBRATES PES: C					
Loss of some species; changes in species composition.	Excessive turbidity due to overgrazing in the riparian zone.	Informal agriculture.	NFL	Land-use management.	2

15.2.2 Trajectory of change

Table 15.2 Trajectory of change, RU J

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C/D	C/D	D	4
	River flows through a densely populated area, catchment condition poor, in-channel structures, removal of indigenous vegetation, local sediment sources.				
Riparian vegetation	Negative	D	D	D/E	3
	Continued grazing pressure and accumulation of weeds.				
Fish	Stable	C	C	C	3
	Very little impact by rural population on riverine environment, and minimal impact of abstraction by Thukela/Mhlatuze water transfer schemes.				
Aquatic invertebrates	Negative	C	C	C/D	2
	Long-term loss of rock biotope due to increased sedimentation.				

15.2.3 Summary and resulting Ecstatus

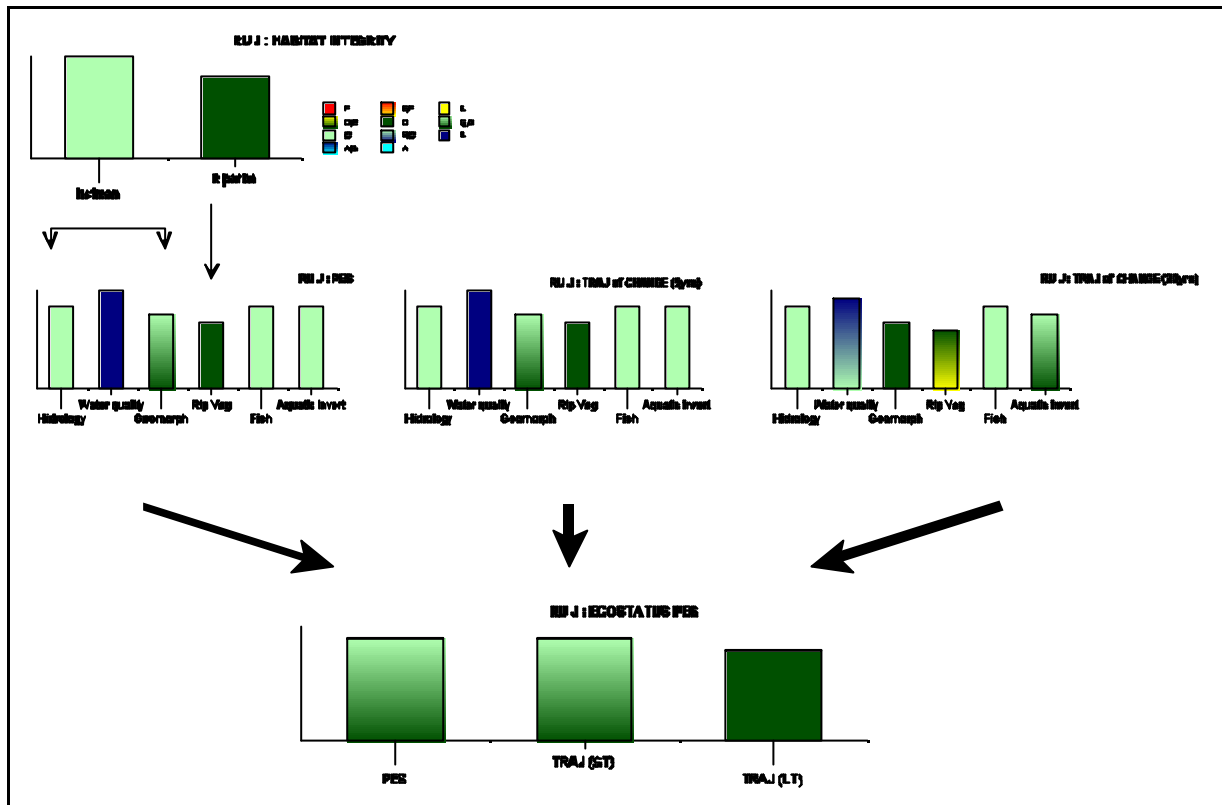
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES C.
(Mandini offtake/abstraction has been included in J in the modelling).
 Present MAR as % of virgin MAR: 73%.

Water quality: PES B.

The information on PES for the different components is summarised in Figure 15.1.

Fig 15.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

Geomorphology (C/D) and hydrology (C) are the dominant drivers for the instream components (fish - C, aquatic invertebrates - C). The geomorphological category (C/D) reflects the overall river condition and the Ecostatus is set at a C/D.

15.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Presence of unique species, importance as a fish migration route.

SI rating: High
 Confidence: Medium to High
 Determinants: Human dependence on river for water, fishing, building and other resources and recreation. Places of cultural or spiritual importance.

15.4 AIM

The EIS is **moderate**, the social importance is **moderate**, and the PES is a C/D category. The aim is to **maintain** the category and to minimise the risk of degradation by addressing the negative trajectories of change, particularly in the geomorphology.

15.5 ATTAINABLE ERC

The causes, sources and degree of difficulty to maintain the PES in a C/D are summarised below. The actions required to address these are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (siltation and turbidity). 	<ul style="list-style-type: none"> Catchment land-use management. 	<ul style="list-style-type: none"> Very difficult.

The recommended ERCs for the various components are summarised below.

Table 15.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B Y B/C	B	B/C
Geomorphology	C/D Y D	C/D	D
Riparian vegetation	D Y D/E	D	D/E
Fish	C Y C	C	C
Aquatic invertebrates	C Y C/D	C	C/D
Ecostatus	C/D Y D	C/D	D

Rationale for the attainable ERC

The major problems in this unit are with the geomorphology and riparian vegetation. These are non-flow related and are considered **very difficult** to address. Some improvement will be required to address the negative trajectory of change. Due to the difficulty associated with addressing the non-flow related aspects, the ERC of a C/D category will probably only be achieved in the long term.

15.6 SUMMARY OF RESULTS

The results are illustrated in Figure 15.2 below.

Fig 15.2 Summary of results

RU J : MIDDLEDRIFT TO END OF REJUVENATED FOOTHILLS ZONE (segm 60 - 72)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B	-	B	B/C	EIS M O D E R A T E	B	B/C
GEOMORPH	C/D	-	C/D	D		C/D	D
RIPARIAN VEGETATION	D	-	D	D/E		D	D/E
FISH	C	0	C	C	SI M O D E R A T E	C	C
AQUATIC INVERTS	C	-	C	C/D		C	C/D
ECOSTATUS	C/D	-	C/D	D		C/D	D

* ATTAINABLE CATEGORY

A summary of the confidence evaluation is provided below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	No data	5	4	4	1
PES	2	5	3	4	2
Trajectory of change	2	4	3	3	2
EIS	3				
SI	2				

The confidence ranges from low to very high with most of the components within the medium-low, medium and medium-high range.

15.7 IFR SITE WITHIN THE RU

IFR 16 (Mandini) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

The IFR Scenarios will be a C, D and a C/D category.

16. RU L: LITTLE THUKELA SEGMENT 1 - 4 (Wonder Valley base to Ecoregion break for Eastern Uplands B)

16.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 166.08 mcm

Geomorphology

Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow floodplain of sand, gravel or cobble often present.

Riparian vegetation

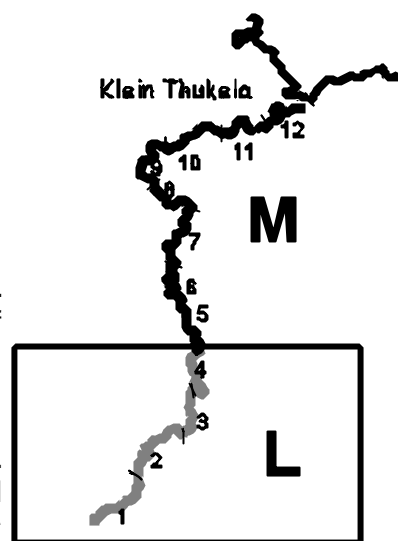
Mainly grasslands comprising mixed grasses and forbs. Narrow stands of woody trees and shrubs on steep banks and protected areas comprising *Leucosidea sericea*, *Diospyros lycioides*, *Acacia sieberana* and *A. karroo*. In flatter parts of the river, complete grass cover with occasional woody species in protected areas.

Fish

In its pristine condition, the upper Little Thukela would have supported four fish species, *Anguilla mossambica*, *Barbus anoplus*, *B. natalensis* and *Amphilius natalensis*.

Aquatic invertebrates

A typical mountain stream with good diversity and abundance of invertebrate organisms.



Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	3	3	3	4	5	2

16.2 PES

16.2.1 PES, causes and sources

Table 16.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C					
Habitat change.	Sediment aggradation (mixed sizes).	Bank instability and overgrazing due to agriculture and land use.	NFL	Land-use management.	4
Change in morphology.	Presence of in-channel structures.	In-channel structures (bridge, weir).	NFL	-	
RIPARIAN VEGETATION PES: D/E (but C/D in the upper parts)					
Loss and degradation of riparian zone.	Sedimentation (grazing, trampling, bank erosion).	Informal agriculture.	NFL	Land-use management.	4
FISH PES: B					
Absence of <i>Amphilius</i> . Reduced abundance.	Habitat degradation (siltation). Alien species (trout).	Upstream abstraction. Introduction of alien species.	FL	Manage abstractions. Eradicate aliens.	4
AQUATIC INVERTEBRATES PES: A/B					
Slight change in community structure.	Change in habitats due to sedimentation.	Upstream land-use.	NFL	Land-use management; environmental awareness.	2

16.2.2 Trajectory of change

Table 16.2 Trajectory of change, RU L

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C	C	C/D	4
	Sediment accumulates in the active channel, resulting in increased sediment storage. In the long term, the mixed bed could change to an alluvial bed.				
Riparian vegetation	Negative	D/E	D/E	E	3
	Further impact of grazing, bank trampling, subsistence farming and associated accumulations of sediment is likely to result in the encroachment of reeds.				
Fish	Stable	B	B	B	3
	No change anticipated based on current drivers.				
Aquatic invertebrates	Stable	A/B	A/B	A/B	2
	No change anticipated based on current drivers.				

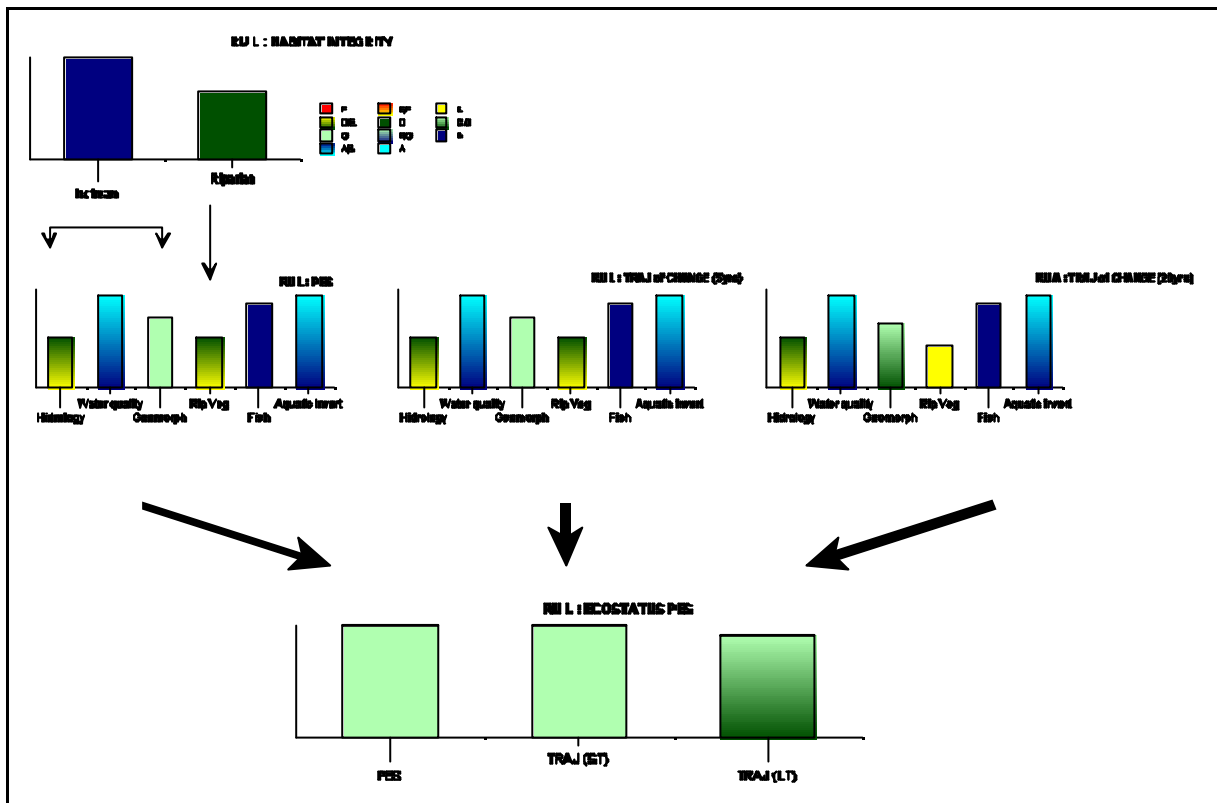
16.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES D/E.
 Water quality: PES A/B.

The information on PES for the different components are summarised in Figure 16.1 below.

Fig 16.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The water quality and instream components are in a higher category than the other drivers. This indicates that the instream components are reacting more to the water quality driver. The change in geomorphology and riparian vegetation are non-flow related. Land-use and grazing/trampling have resulted in degradation of the riparian zone, with concomitant sedimentation. It was felt that the geomorphology is the more representative driver and therefore representative of the Ecostatus category).

16.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: High species richness, flow-sensitive species present, diverse habitat types.

SI rating: Moderate
 Confidence: High
 Determinants: Human dependence on river for water, resources and fishing. Sacred or important cultural places, and sense of place.

16.4 AIM

The EIS is **moderate**, the social importance is **moderate** and the PES is a C category. The aim is therefore to **maintain** the PES and to minimise the risk of degradation. It will be necessary to address the problems with geomorphology and riparian vegetation in order to halt the negative trajectory of change.

16.5 ATTAINABLE ERC

The sources and actions required to address these problems are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Agriculture and land use (sediment aggradation). 	<ul style="list-style-type: none"> Catchment land-use management. 	<ul style="list-style-type: none"> Very difficult.

The attainable ERC is assigned in order to *maintain* the PES. To enable maintenance of the PES, the negative trajectories of change will have to be addressed and some improvement is required. The individual components are addressed as follows:

Table 16.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	A/B Y A/B	A/B	A/B
Geomorphology	C Y C/D	C	C/D
Riparian vegetation	D/E Y E	D	E
Fish	B Y B	B	B
Aquatic invertebrates	A/B Y A/B	A/B	A/B
Ecostatus	C Y C/D	C	C/D

Rationale for the attainable ERC

All the actions required to achieve the aim is set as very difficult. Improvement in both geomorphology and riparian vegetation is required to address the negative trajectory. Acknowledging the difficulty of addressing these problems, the ERC will probably only be achieved in the long tem

The Reserve scenarios that will be addressed are a C, B and D category.

16.6 SUMMARY OF RESULTS

The results are illustrated in Figure 16.2 below.

Fig 16.2 Summary of results

RU L : WONDER VALLEY BASE TO EASTERN UPLANDS							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	A/B	0	A/B	A/B	EIS MODERATE	A/B	A/B
GEOMORPH	C	-	C	C/D		C	C/D
RIPARIAN VEGETATION	D/E	-	D/E	E	SI MODERATE	D	E
FISH	B	0	B	B		B	B
AQUATIC INVERTS	A/B	0	A/B	A/B		A/B	A/B
ECOSTATUS	C	-	C	C/D	C	C/D	

* ATTAINABLE CATEGORY

The confidence in the results are summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	3	4	5	2
PES	3	4	4	4	2
Trajectory of change	3	4	3	3	2
EIS	3				
SI	3				

The confidence ranges from medium-low to high with most of the components are in the medium range.

17. RU M: LITTLE THUKELA SEGMENT 5 - 12 (Eastern Uplands A to Thukela Confluence)

17.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 301.21 mcm

Geomorphology

Lower gradient mixed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than riffles or rapids. A floodplain often is present.

Riparian vegetation

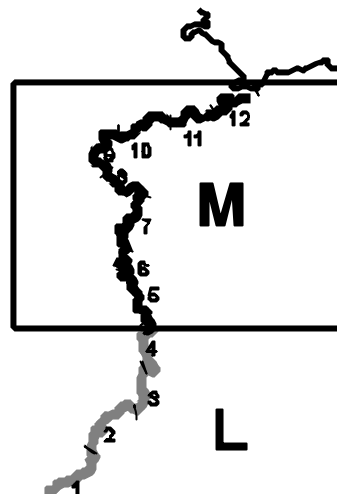
Mainly grassland comprising mixed grass and forbs. Narrow patches of woody vegetation on steep banks, river bends and other areas protected from floods, fire and natural grazing. Patches of reed in lower gradient areas.

Fish

In the lower Little Thukela, besides the four species found in Unit L, *Labeo rubromaculatus* would have occurred here in the pristine condition.

Aquatic invertebrates

This Resource Unit had not been surveyed in the past, so data from the similar reach in the Thukela (Resource Unit C) has been used as a reference. This river has a diversity of habitats including good riffle habitat. Accordingly it should offer a diversity of invertebrate species, including several flow dependent species as listed in Table 3.24. Interestingly the oligoneurid mayfly species to be expected is the warmer water *Elassoneuria*.



Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting high confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	3	4	4	2

17.2 PES

17.2.1 PES, causes and sources

Table 17.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C/D					
Habitat change. Change in morphology.	Sediment aggradation.	Land use.	NFL	Catchment land-use management.	3
	In-channel structures.	Weirs, causeway.	NFL	-	
RIPARIAN VEGETATION PES: D/E					
Reduced riparian zone. Shift in species composition. Reduced cover / distribution.	Farming lands to rivers edge.	Commercial agriculture.	NFL	Create riparian buffer zone.	3
	Exotic species encroachment.	Poor land-use management.	NFL	Exotic control programme.	
	Reed encroachment.	Sedimentation and runoff.	NFL	Catchment land-use management.	
FISH PES: C					
Reduced abundance and fish health.	Eutrophication.	Sewage, agricultural fertilizer .	NFL	Sewage treatment, farm runoff control.	3
	Change in flow regime (stops flowing in parts and for periods).	Abstraction for commercial farming.	FL	Regulating / restricting abstractions.	
	Alien fish invasion.	Stocking of alien fish.	NFL	Eradication and prevention of further stocking.	
AQUATIC INVERTEBRATES PES: B/C					
Loss of some species and excessive diatom growth.	Change in flow regime (stops flowing in parts and for periods).	Abstraction for commercial farming.	FL	Regulating/restricting abstractions.	2
	Deteriorating water quality.	Catchment land-use activities especially farming.	NFL	Catchment land-use management.	

17.2.2 Trajectory of change

Table 17.2 Trajectory of change, RU M

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C/D	D	D	3
	Trajectory is negative as sediment accumulates within the active channel. This will result in increased sediment storage in the channel.				
Riparian vegetation	Negative	D/E	D/E	E	4
	The continued encroachment of the channel by reeds colonising accumulating sediments, along with existing agricultural practices.				
Fish	Stable	C	C	C	2
	The fish are likely to remain in equilibrium with current conditions. Although fish health is affected by present water quality, it is unlikely to be further affected.				
Aquatic invertebrates	Negative	B/C	B/C	C	2
	Sediment accumulation will probably further impact on habitat diversity and availability.				

17.2.3 Summary and resulting Ecstatus

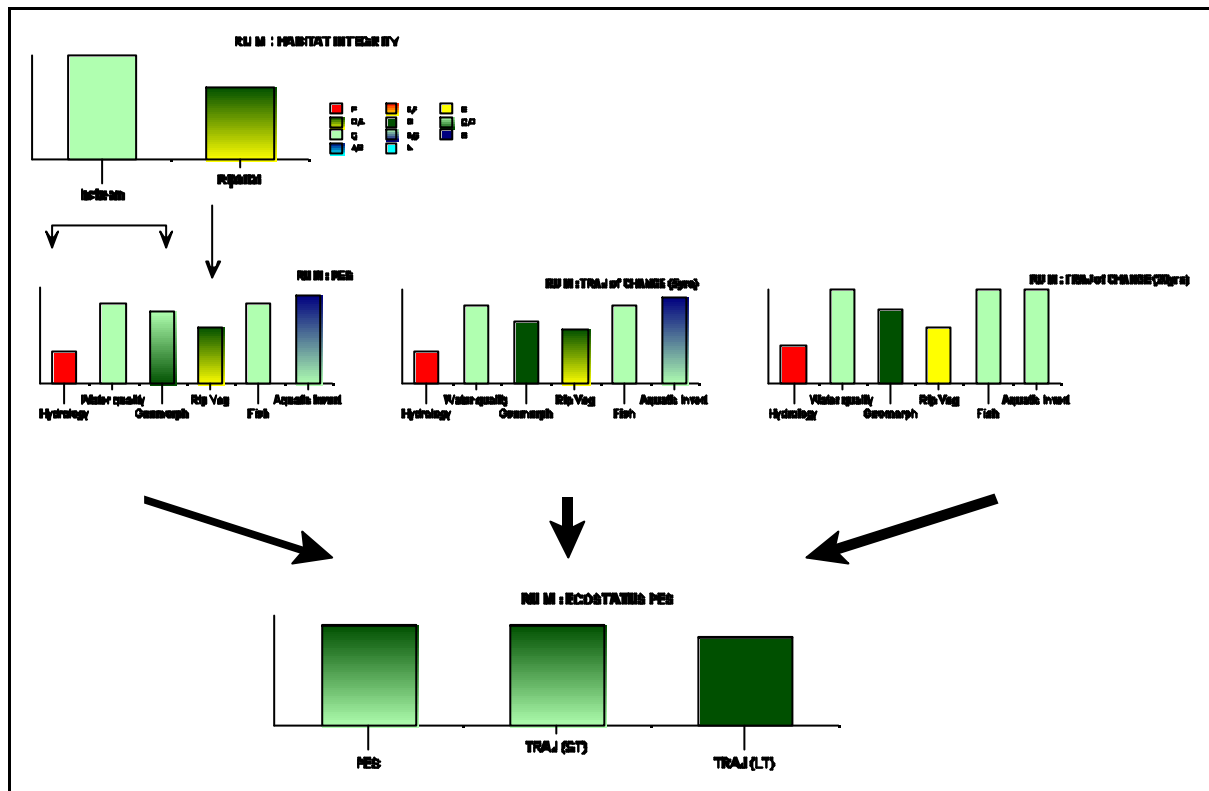
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES F.
 Present MAR as % of virgin MAR: 88.9%
(Approximately 20% of the time when there was previously flow, this river will now not flow - this is heavily weighted in the calculation of PES).

Water quality: PES C.
(Although water quality data indicated a B here, there was no data for pesticide use, but evidence exists of pesticide use in and around Winterton).

The information on PES for the different components are summarised in Figure 17.1 below.

Fig 17.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The major drivers in this RU are hydrology (though there is some uncertainty about the extent of no-flow situations), geomorphology and water quality. The former two are on a negative trajectory of change. The riparian vegetation reflects the PES and negative trajectory of the geomorphology. The aquatic invertebrates category is an outlier (C/B category) and this is probably due to the presence of resilient species that are not reacting to the no flow conditions and other problems in the system. The hydrology does not seem to be a major driver as the F category is not reflected in any of the other categories and the category of the geomorphology is therefore seen as more representative of the RU.

17.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Presence of unique and flow-sensitive biota, diversity of habitat types and importance as a migration route.

SI rating: Moderate
 Confidence: High
 Determinants: This RU has a local appeal.

17.4 AIM

The EIS is **moderate**, the social importance is **moderate** and the PES is a C/D category. The aim is to **maintain** the PES as a C/D and to minimise the risk of further degradation by addressing the negative trajectory of change.

17.5 ATTAINABLE ERC

The critical sources and actions required are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Flow- related</i> <ul style="list-style-type: none"> Commercial agriculture. 	<ul style="list-style-type: none"> Restricting/regulating abstractions Improve farming practices and control use of pesticides. 	<ul style="list-style-type: none"> Difficult.
<i>Non-flow related</i> <ul style="list-style-type: none"> Agriculture and land use (sediment aggradation). 	<ul style="list-style-type: none"> Catchment land-use management. Improve farming practices and control use of pesticides. 	<ul style="list-style-type: none"> Very difficult.

The recommended ERCs for the various components are summarised below.

Table 17.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	C Y C	C	C
Geomorphology	C/D Y D	C/D	D
Riparian vegetation	D/E Y E	D	D/E
Fish	C Y C	C	C
Aquatic invertebrates	B/C Y C	B/C	C
Ecostatus	C/D Y D	C/D	D

Rationale for attainable ERC

In order to maintain the present ecological state of C/D and to halt further degradation, it will be necessary to address the non-flow related issues such as farming practices. At low flows, the issue of altering the river from perennial to seasonal (due to abstractions) must also be addressed to ensure that the objectives are met. As all the actions required are evaluated to be difficult to very difficult; it is therefore likely that the ERC of a C/D will only be achieved in the long term.

17.6 SUMMARY OF RESULTS

The results are illustrated in Figure 17.2.

Fig 17.2 Summary of results

RU M : EASTERN UPLANDS TO THUKELA CONFLUENCE (segment 5 - 9)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	C	0	C	C	EIS MODERATE	C	C
GEOMORPH	C/D	-	D	D		C/D	D
RIPARIAN VEGETATION	D/E	-	D/E	E		D	D/E
FISH	C	0	C	C	SI MODERATE	C	C
AQUATIC INVERTS	B/C	-	B/C	C		B/C	C
ECOSTATUS	C/D	-	C/D	D		C/D	D

* ATTAINABLE CATEGORY

The confidence in all the factors are summarised below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	3	4	4	2
PES	4	3	3	3	2
Trajectory of change	4	3	4	2	2
EIS	3				
SI	3				

The confidence range from medium-low to medium-high with most of the components being in the medium and medium-high range

17.7 IFR SITE WITHIN THE RU

IFR 3 (Little Thukela) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

The IFR scenarios that will be addressed during the study for this RU/IFR site will be a B/C, C/D and D category.

17. RU M: LITTLE THUKELA SEGMENT 5 - 12 (Eastern Uplands A to Thukela Confluence)

17.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 301.21 mcm

Geomorphology

Lower gradient mixed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than riffles or rapids. A floodplain often is present.

Riparian vegetation

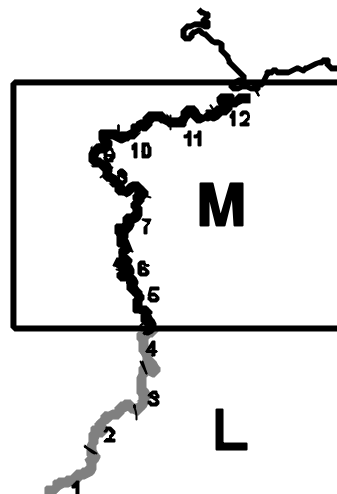
Mainly grassland comprising mixed grass and forbs. Narrow patches of woody vegetation on steep banks, river bends and other areas protected from floods, fire and natural grazing. Patches of reed in lower gradient areas.

Fish

In the lower Little Thukela, besides the four species found in Unit L, *Labeo rubromaculatus* would have occurred here in the pristine condition.

Aquatic invertebrates

This Resource Unit had not been surveyed in the past, so data from the similar reach in the Thukela (Resource Unit C) has been used as a reference. This river has a diversity of habitats including good riffle habitat. Accordingly it should offer a diversity of invertebrate species, including several flow dependent species as listed in Table 3.24. Interestingly the oligoneurid mayfly species to be expected is the warmer water *Elassoneuria*.



Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting high confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	3	4	4	2

17.2 PES

17.2.1 PES, causes and sources

Table 17.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C/D					
Habitat change. Change in morphology.	Sediment aggradation.	Land use.	NFL	Catchment land-use management.	3
	In-channel structures.	Weirs, causeway.	NFL	-	
RIPARIAN VEGETATION PES: D/E					
Reduced riparian zone. Shift in species composition. Reduced cover / distribution.	Farming lands to rivers edge.	Commercial agriculture.	NFL	Create riparian buffer zone.	3
	Exotic species encroachment.	Poor land-use management.	NFL	Exotic control programme.	
	Reed encroachment.	Sedimentation and runoff.	NFL	Catchment land-use management.	
FISH PES: C					
Reduced abundance and fish health.	Eutrophication.	Sewage, agricultural fertilizer .	NFL	Sewage treatment, farm runoff control.	3
	Change in flow regime (stops flowing in parts and for periods).	Abstraction for commercial farming.	FL	Regulating / restricting abstractions.	
	Alien fish invasion.	Stocking of alien fish.	NFL	Eradication and prevention of further stocking.	
AQUATIC INVERTEBRATES PES: B/C					
Loss of some species and excessive diatom growth.	Change in flow regime (stops flowing in parts and for periods).	Abstraction for commercial farming.	FL	Regulating/restricting abstractions.	2
	Deteriorating water quality.	Catchment land-use activities especially farming.	NFL	Catchment land-use management.	

17.2.2 Trajectory of change

Table 17.2 Trajectory of change, RU M

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C/D	D	D	3
	Trajectory is negative as sediment accumulates within the active channel. This will result in increased sediment storage in the channel.				
Riparian vegetation	Negative	D/E	D/E	E	4
	The continued encroachment of the channel by reeds colonising accumulating sediments, along with existing agricultural practices.				
Fish	Stable	C	C	C	2
	The fish are likely to remain in equilibrium with current conditions. Although fish health is affected by present water quality, it is unlikely to be further affected.				
Aquatic invertebrates	Negative	B/C	B/C	C	2
	Sediment accumulation will probably further impact on habitat diversity and availability.				

17.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology:

PES F.

Present MAR as % of virgin MAR: 88.9%

(Approximately 20% of the time when there was previously flow, this river will now not flow - this is heavily weighted in the calculation of PES).

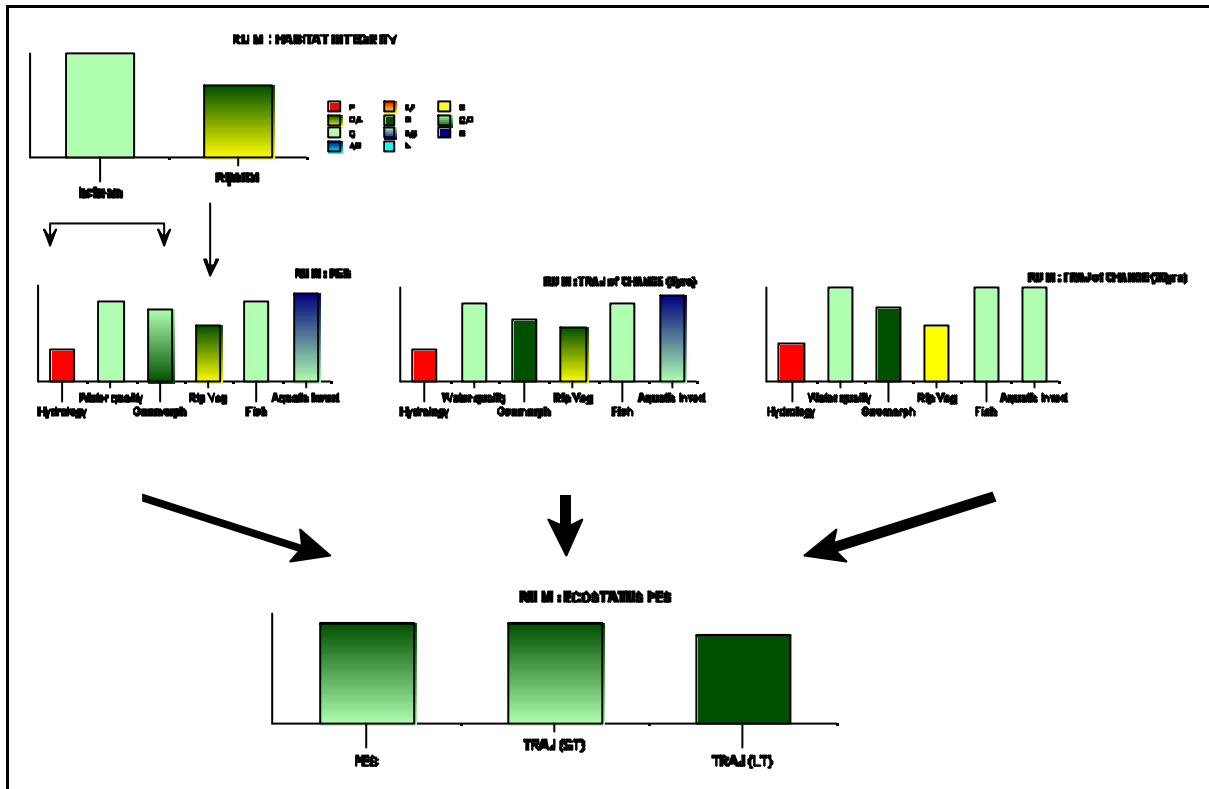
Water quality:

PES C.

(Although water quality data indicated a B here, there was no data for pesticide use, but evidence exists of pesticide use in and around Winterton).

The information on PES for the different components are summarised in Figure 17.1 below.

Fig 17.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The major drivers in this RU are hydrology (though there is some uncertainty about the extent of no-flow situations), geomorphology and water quality. The former two are on a negative trajectory of change. The riparian vegetation reflects the PES and negative trajectory of the geomorphology. The aquatic invertebrates category is an outlier (C/B category) and this is probably due to the presence of resilient species that are not reacting to the no flow conditions and other problems in the system. The hydrology does not seem to be a major driver as the F category is not reflected in any of the other categories and the category of the geomorphology is therefore seen as more representative of the RU.

17.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Presence of unique and flow-sensitive biota, diversity of habitat types and importance as a migration route.

SI rating: Moderate
 Confidence: High
 Determinants: This RU has a local appeal.

17.4 AIM

The EIS is **moderate**, the social importance is **moderate** and the PES is a C/D category. The aim is to **maintain** the PES as a C/D and to minimise the risk of further degradation by addressing the negative trajectory of change.

17.5 ATTAINABLE ERC

The critical sources and actions required are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Flow- related</i> <ul style="list-style-type: none"> Commercial agriculture. 	<ul style="list-style-type: none"> Restricting/regulating abstractions Improve farming practices and control use of pesticides. 	<ul style="list-style-type: none"> Difficult.
<i>Non-flow related</i> <ul style="list-style-type: none"> Agriculture and land use (sediment aggradation). 	<ul style="list-style-type: none"> Catchment land-use management. Improve farming practices and control use of pesticides. 	<ul style="list-style-type: none"> Very difficult.

The recommended ERCs for the various components are summarised below.

Table 17.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	C Y C	C	C
Geomorphology	C/D Y D	C/D	D
Riparian vegetation	D/E Y E	D	D/E
Fish	C Y C	C	C
Aquatic invertebrates	B/C Y C	B/C	C
Ecostatus	C/D Y D	C/D	D

Rationale for attainable ERC

In order to maintain the present ecological state of C/D and to halt further degradation, it will be necessary to address the non-flow related issues such as farming practices. At low flows, the issue of altering the river from perennial to seasonal (due to abstractions) must also be addressed to ensure that the objectives are met. As all the actions required are evaluated to be difficult to very difficult; it is therefore likely that the ERC of a C/D will only be achieved in the long term.

17.6 SUMMARY OF RESULTS

The results are illustrated in Figure 17.2.

Fig 17.2 Summary of results

RU M : EASTERN UPLANDS TO THUKELA CONFLUENCE (segment 5 - 9)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	C	0	C	C	EIS MODERATE	C	C
GEOMORPH	C/D	-	D	D		C/D	D
RIPARIAN VEGETATION	D/E	-	D/E	E		D	D/E
FISH	C	0	C	C	SI MODERATE	C	C
AQUATIC INVERTS	B/C	-	B/C	C		B/C	C
ECOSTATUS	C/D	-	C/D	D		C/D	D

* ATTAINABLE CATEGORY

The confidence in all the factors are summarised below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	3	4	4	2
PES	4	3	3	3	2
Trajectory of change	4	3	4	2	2
EIS	3				
SI	3				

The confidence range from medium-low to medium-high with most of the components being in the medium and medium-high range

17.7 IFR SITE WITHIN THE RU

IFR 3 (Little Thukela) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

The IFR scenarios that will be addressed during the study for this RU/IFR site will be a B/C, C/D and D category.

18. RU N: BUSHMANS RIVER SEGMENT 1 - 9 (Elands Park to Wagendrft Dam)

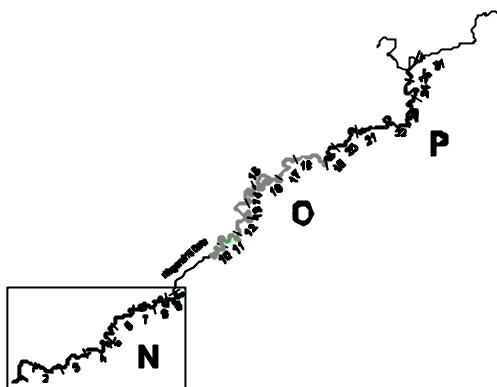
18.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 229.13 mcm

Geomorphology

Steepened section caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro channel activated only during infrequent flood events. A limited floodplain may be present between active and macro-channel.



Riparian vegetation

Mainly grasslands comprising mixed grasses and forbs. Indigenous woody trees and shrubs on steep banks and other areas protected from floods, fire and natural grazing.

Fish

Anguilla mossambica, *Barbus anoplus*, *B. natalensis* and *Amphilius natalensis* would have been present.

Aquatic invertebrates

This Resource Unit had not been surveyed in the past, so data from the similar reach in the Thukela (Resource Unit C) has been used as a reference. This river has a diversity of habitats including good riffle habitat. Accordingly it should offer a diversity of invertebrate species, including several flow dependent species as listed in Table 3.24. Interestingly the oligoneurid mayfly species to be expected is the warmer water *Elassoneuria*.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	5	3	3	4	5	2

18.2 PES

18.2.1 PES, causes and sources

Table 18.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C					
Change in morphology.	Sediment aggradation.	Instream structures (bridges, weirs, causeway).	NFL	-	3
RIPARIAN VEGETATION PES: C/D					
Reduced cover and distribution. Shift in species composition.	Vegetation removal/replacement.	Agriculture and vegetation utilisation.	NFL	Agricultural practices and sustainable utilisation.	4
	Exotic encroachment.	Catchment land-use management.	NFL	Alien vegetation control programme.	
FISH PES: B					
Absence of eels. Population decline.	Lack of migration.	Wagendrift Dam.	NFL	Construct eel-pass.	4
	Presence of trout.	Self perpetuating population.	NFL	Eradication and prevention of stocking.	
	Siltation.	Land-use activities.	NFL	Catchment management (erosion control).	
AQUATIC INVERTEBRATES PES: A/B					
Slight shift in population structure.	Sediment changes affecting biotopes.	Land-use activities.	NFL	Land-use management.	2

18.2.2 Trajectory of change

Table 18.2 Trajectory of change, RU N

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C	C	C	3
	Slow sediment accumulation, but will remain in a C category over 20 years.				
Riparian vegetation	Negative	C/D	C/D	D	4
	Gradual encroachment of reeds on accumulating sediments, further encroachment of exotic species and the impact of livestock.				
Fish	Stable	B	B	B	3
	Fish and habitat in equilibrium				
Aquatic invertebrates	Stable	A/B	A/B	A/B	2
	Changes in riparian vegetation are unlikely to affect the invertebrate community.				

18.2.3 Summary and resulting Ecstatus

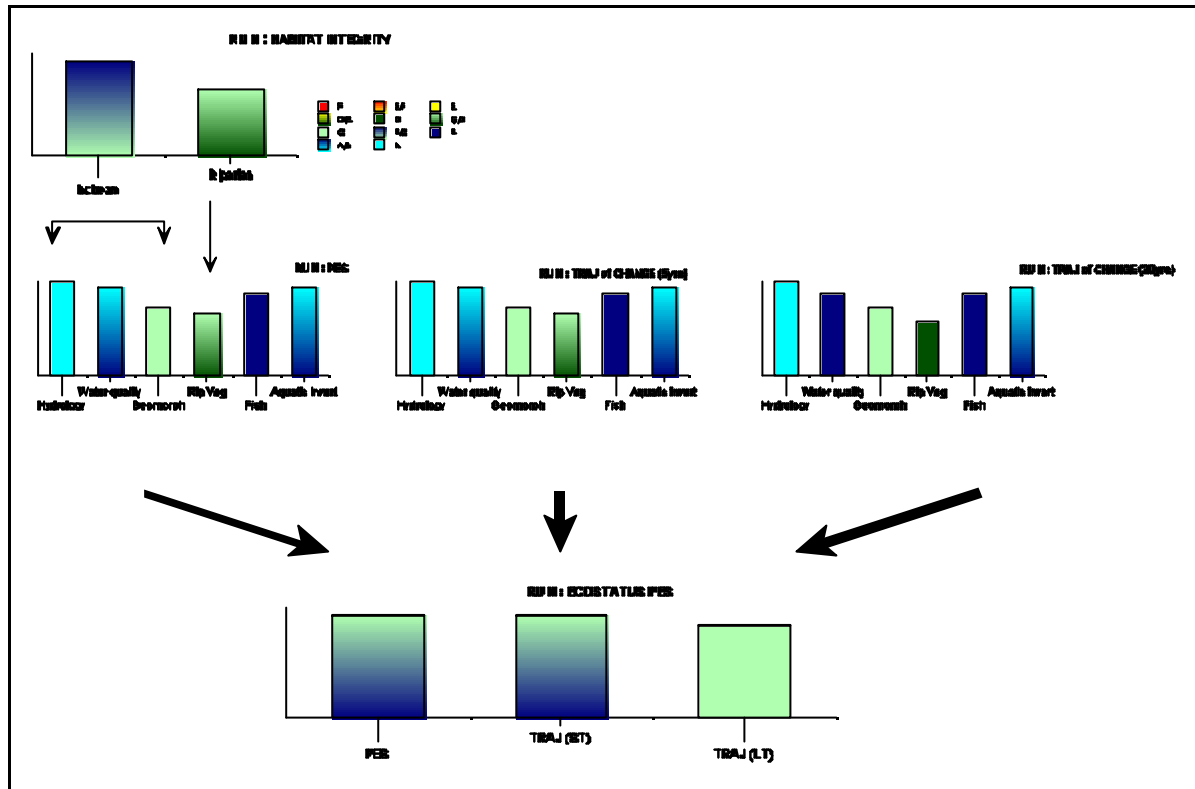
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES A.
Present MAR as % of virgin MAR: 97.3%.

Water quality: PES A/B (Stable).

The information on PES for the different components is summarised in Figure 18.1.

Fig 18.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The majority of drivers in this unit are in a good to moderate condition. The only driver contributing to in-stream degradation is geomorphology, however the changes in this parameter are slight (within the same category) over the long-term. Close to natural flows and good water quality provide good habitat for fish and invertebrates. The habitat integrity summarises these conditions in a B/C category and the Ecostatus follows this trend.

18.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and are Ecological Importance and Sensitivity (EIS) attached as Appendix G.

EIS rating: Moderate
 Confidence: Medium
 Determinants: Species/taxon richness and diversity of habitat types.

SI rating: Moderate
 Confidence: Medium
 Determinants: Human dependence on river for water, resources and fishing. Sacred or important places.

18.4 AIM

The EIS is **moderate**, the social importance is **moderate** and the PES is a B/C category. The aim would be to maintain PES and minimise the risk of degradation unless there are overriding reasons to improve conditions. The negative trajectory must be addressed which will only be possible if catchment land-use issues are attended to. Importantly, if black wattle were to be removed from the catchment, this would improve the riparian zone significantly and within a short period of time. This in turn will improve the vegetation class and may also improve the social opportunities for natural vegetation harvesting.

18.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<p><i>Non-flow related</i></p> <ul style="list-style-type: none"> Land use (vegetation removal and exotic encroachment, particularly Black Wattle). In-channel structures. 	<ul style="list-style-type: none"> Catchment land-use management. Alien eradication programme. 	<ul style="list-style-type: none"> Difficult. Reasonable.

The individual components are addressed as follows:

Table 18.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	A/B Y B	A/B	B
Geomorphology	C Y C	C	C
Riparian vegetation	C/D Y D	C/D	C/D
Fish	B Y B	B	B
Aquatic invertebrates	A/B Y A/B	A/B	A/B
Ecostatus	B/C Y C	B/C	B/C

Rationale for the attainable ERC

The aim is to maintain the PES of a B/C. Addressing the problems in the system varies from “very difficult” to “reasonable”. The “reasonable” evaluation of addressing alien vegetation should contribute to address the negative trajectory and the ERC is therefore attainable.

The Reserve scenarios which will be addressed are a B, C/D and a B/C category.

18.6 SUMMARY OF RESULTS

The results are illustrated in Figure 18.2.

Fig 18.2 Summary of results

RU N : ELANDS PARK TO WAGENDRIFT DAM							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	A/B	0	A/B	B	EIS MODERATE	A/B	B
GEOMORPH	C	-	C	C		C	C
RIPARIAN VEGETATION	C/D	-	C/D	D		C/D	C/D
FISH	B	0	B	B	SI MODERATE	B	B
AQUATIC INVERTS	A/B	0	A/B	A/B		A/B	A/B
ECOSTATUS	B/C	-	B/C	C		B/C	B/C

* ATTAINABLE CATEGORY

The confidence in the results are summarised below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	3	4	5	2
PES	3	3	4	4	2
Trajectory of change	3	3	4	3	2
EIS	2				
SI	2				

The confidence ranges from medium-low to high with most of the components in the medium range.

19. RU O: BUSHMANS RIVER SEGMENT 10 - 18 (Wagendrift Dam to Upper Foothills)

This unit ends at the most downstream border of the Weenen Nature Reserve, IFR 5

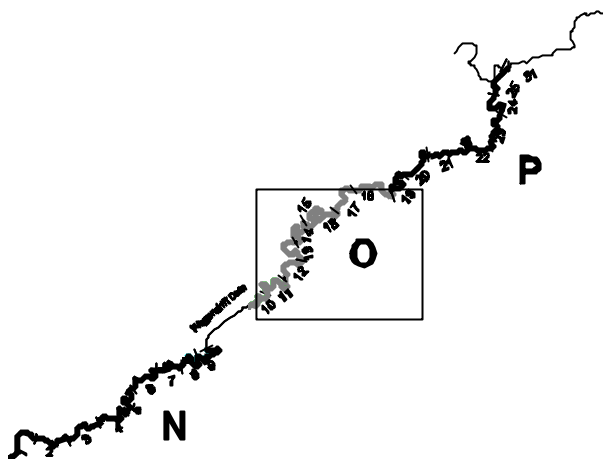
19.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 281.14 mcm

Geomorphology

Steepened section caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro channel, activated only during infrequent flood events. A limited flood plain may be present between active and macro-channel.



Riparian vegetation

Mainly grasslands comprising mixed grasses and forbs, particularly in the steeper areas. Distinct stands of indigenous woody trees and shrubs in the flatter areas dominated by *Combretum erythrophyllum*. Also isolated patches of perennial grasses on small islands and on river fringes.

Fish

Anguilla mossambica, *Anguilla bengalensis*, *Barbus anoplus* and *Barbus natalensis* would have been present.

Aquatic invertebrates

Oliff (1960b) allocated Resource Unit N and the upper part of RU O into his Foothill Sandbed zone. The data provided in Appendix F Table 3.27 is taken from a site just above Estcourt, in the lower extremity of this zone. For this reason the data is probably atypical of RU O. The lower part of the RU O would be more closely aligned to RU E or F on the Thukela. The data produced by Oliff was also limited, but did show the presence of a few flow dependent species, in particular *Afronurus*. Extrapolating from RU F, it is expected that *Prosistoma*, *Centroptiloides* and several species of Hydropsychidae would occur.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	5	3	4	3	4	2

19.2 PES

19.2.1 PES, causes and sources

Table 19.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: D					
Habitat change. Change in morphology.	Scouring and deposition.	Wagendrift Dam.	FL	Operate the Reserve.	4
	Sediment aggradation due to bank instability, overgrazing and gulying.	Agriculture.	NFL	Catchment land-use management.	
	Local changes in river morphology.	In-channel structures (bridges, weirs, causeways).	NFL	-	
RIPARIAN VEGETATION PES:D					
Shift in species composition. Loss of marginal zone. Change in distribution.	Exotic species encroachment.	Catchment land-use.	NFL	Alien eradication programme.	3
	Sedimentation from bank erosion. Reed encroachment due to flow regulation and sediment accumulation.	Catchment land-use.	NFL	Catchment land-use management.	
		Wagendrift Dam.	FL	Operation of Wagendrift Dam.	
FISH PES: C					
Reduced abundance of native species.	Alien species invasion.	Introduction of alien species and escapees from dam.	NFL	Eradication & prevention of further stocking.	4
	Habitat decline due to eutrophication (abundance of unknown aquatic macrophytes).	Industrial and farmland runoff.	NFL	Land-use management.	
AQUATIC INVERTEBRATES PES: D					
Fauna less diverse especially in the upper reaches.	Flow regulation.	Operation of Wagendrift Dam.	FL	Operate to provide the Reserve.	2
	Pollution causing water quality problems.	Catchment land-use activities, industry in Estcourt .	NFL	Land-use management and Source Directed Controls.	

19.2.2 Trajectory of change

Table 19.2 Trajectory of change, RU O

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D/E	4
	Sedimentation and sediment aggradation.				
Riparian vegetation	Negative	D	D	E	3
	The further encroachment of reeds, perennial grasses and exotic species.				
Fish	Negative	C	C/D	D	3
	Increasing agricultural and industrial pressure (Estcourt effluents) and impact of catfish.				
Aquatic invertebrates	Negative	D	D	D/E	3
	Based on deteriorating geomorphology, water quality and riparian vegetation.				

19.2.3 Summary and resulting Ecstatus

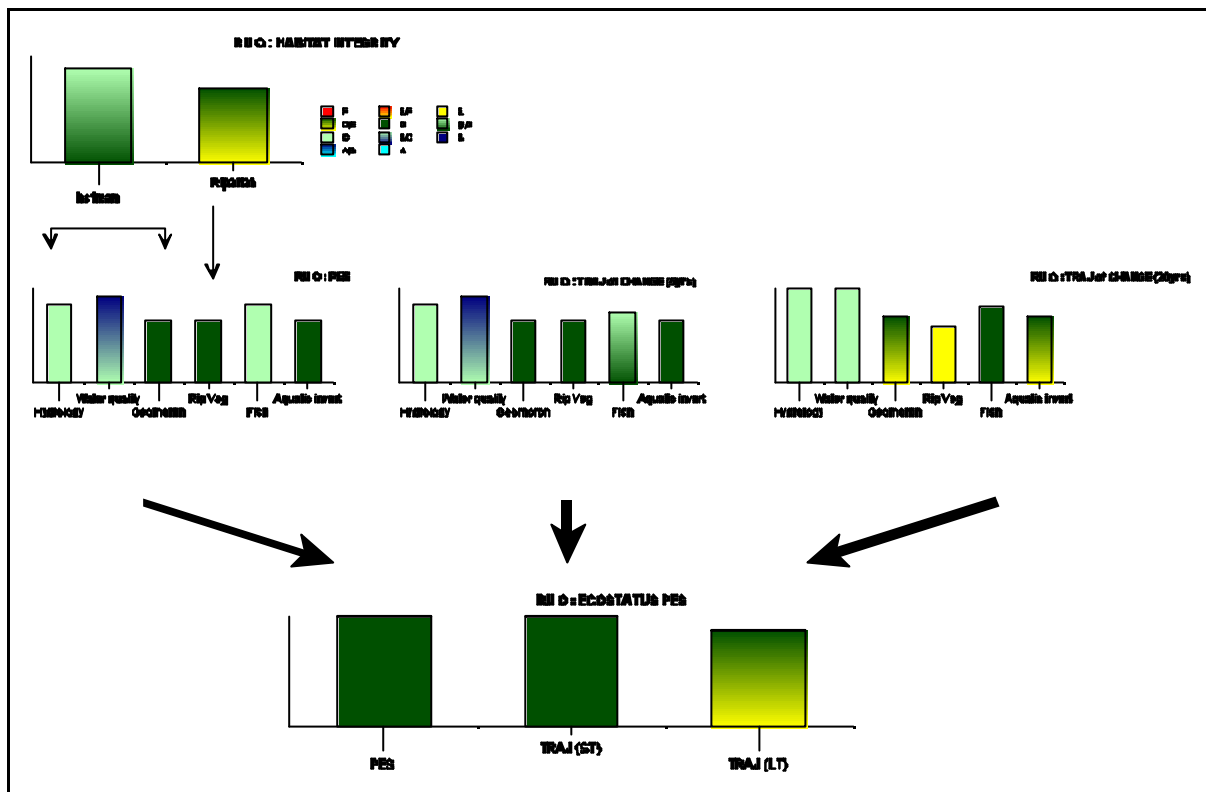
The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES C.
Present MAR as % of virgin MAR: 87.8%.

Water quality: PES B/C.

The information on PES for the different components is summarised in Figure 19.1.

Fig 19.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The habitat integrity which is a combination of most of the drivers is in a C/D (instream) category and a D/E (riparian) category. The Ecostatus was determined to be a D category following the habitat integrity trend as well as acknowledging the D categories for geomorphology, riparian vegetation and aquatic invertebrates.

19.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Flow-sensitive species, importance of migration route, high diversity of habitat types.

SI rating: Moderate
 Confidence: High
 Determinants: This RU has local appeal.

Note: There is a great deal of ecotourism development in this area and it is used extensively by water recreationists. The issue of recreational use and ecotourism use and potential of the river on a local scale not weighted in the social evaluation. This issue forms a component of the Management Class.

19.4 AIM

The EIS is **moderate**, the social importance is **moderate** and the PES is a D category. The aim is to **maintain** the PES of D, and to minimise the risk of degradation. This will require that catchment land-use and water quality issues are addressed. All the components illustrate a negative trajectory and improvement will be required to address this.

19.5 ATTAINABLE ERC

The sources and actions required to address these issues are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Critical sources	Action	Degree of difficulty
<p><i>Non-flow related</i></p> <ul style="list-style-type: none"> Land use (Sedimentation and aggradation, reed and alien encroachment). Industrial activity and limited agriculture (eutrophication). 	<ul style="list-style-type: none"> Catchment land-use management. Alien vegetation control programme. Source Directed Controls. 	<ul style="list-style-type: none"> Very difficult. Reasonable. Very difficult.
<p><i>Flow related</i></p> <ul style="list-style-type: none"> Wagendrift Dam (flow regulation). 	<ul style="list-style-type: none"> Operate to release the Reserve. 	<ul style="list-style-type: none"> Reasonable.

The individual components are addressed as follows:

Table 19.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B/C Y C	B/C ¹	C
Geomorphology	D Y D/E	D	D
Riparian vegetation	D Y E	D	D
Fish	C Y D	C	C
Aquatic invertebrates	D Y D/E	D	D
Ecstatus	D Y D/E	D²	D

¹ (red flag 1 in Figure 19.2)

It is important to note that water quality, which is driving a lot of the instream degradation, is classed as a B/C, however nutrients are classed as a D.

² (red flag 2 in Figure 19.2)

This relates to the water quality in this section, which is poor relative to the high recreational potential of the river. This is not immediately obvious in the Social Importance rating of 'Moderate'.

Rationale for the attainable ERC

The aim of the ERC is to maintain the PES of a D. To achieve this, the negative trajectory of geomorphology, riparian vegetation and instream components must be addressed. The high nutrient values which drive a number of instream degradational processes (nutrients are classed as a D in the water quality assessment) must also be addressed. The degree of difficulty to address the sources varies from "reasonable" to "very difficult". Taking into account that some of the actions required are "reasonable" it is felt that the ERC is attainable in the long and short term.

19.6 SUMMARY OF RESULTS

The results are illustrated in Figure 19.2.

Fig 19.2 Summary of results

RU 0 : WAGENDRIFT DAM TO UPPER FOOTHILLS (segm 10 - 18)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B/C	-	B/C	C	EIS M O D E R A T E	B/C	C
GEOMORPH	D	-	D	D/E		D	D
RIPARIAN VEGETATION	D	-	D	E		D	D
FISH	C	-	C/D	D	SI M O D E R A T E	C	C
AQUATIC INVERTS	D	-	D	D/E		D	D
ECOSTATUS	D	-	D	D/E		D	D

*ATTAINABLE CATEGORY

Flags - Refer to Table 19.3

The confidence in the results are summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	3	4	2
PES	3	4	3	4	2
Trajectory of change	3	4	3	3	3
EIS	3				
SI	3				

The confidence ranges from medium-low to medium-high with most of the components being in the medium range.

19.7 IFR SITE WITHIN THE RU

IFR 5 is situated in this unit. The results from the RU may not be reflected in the results for the IFR site. Sites are specifically chosen to provide as much ecological indicators as possible and therefore must be in as good conditions as possible. As such, the resource unit may be a different category than the site (often to worse). With the knowledge available for IFR 5, it was immediately obvious that the site is in a different condition than the RU. A site specific evaluation was therefore undertaken and the results are provided in Figure 19.3.

Fig 19.3 IFR 5 results

IFR 5							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B/C	-	B/C	B/C	EIS M O D E R A T E	B/C	B/C
GEOMORPH	B/C	-	B/C	C		B/C	C
RIPARIAN VEGETATION	B/C	-	B/C	C		B/C	B/C
FISH	C	-	C/D	D	S I M O D E R A T E	C	D
AQUATIC INVERTS	C	-	C	C/D		C	C/D
ECOSTATUS	B/C	-	B/C	C		B/C	C

* ATTAINABLE CATEGORY

The reason for the IFR5 PES being B/C for geomorphology (rather than D/E) is that it is in a gorge, and there is a certain amount of stability associated with this: it is also inaccessible, and it is in a nature reserve, so there are not the same local disturbances as in the rest of the RU. However, there is still sedimentation from the upstream sources.

Riparian vegetation for the IFR 5 is PES B/C (rather than a D) - the reason being that the site is situated in a nature reserve, it is inaccessible, grazing pressure has been extensively reduced, and exotics have been eradicated. The only reason it is not an A is that the perennial grasses are accumulating on the instream islands. Invertebrates would be a C category at this site due to improved water quality and good habitat diversity. There are however diatoms on the rocks at the site, so the negative trajectory for the invertebrates would be maintained. The PES for IFR 5 is a B/C, the trajectory is negative (long-term) and the ERC is a B/C.

The Reserve scenarios that must be addressed must cover the range applicable for the RU as well as for the IFR site. Results for Category B, C and D will be supplied as this would provide the complete range.

20. RU P : BUSHMANS RIVER SEGMENT 19-25 (Lower Foothills to Thukela Confluence)

The specific section addressed in this evaluation is the gorge which stretches from segment 22 to 25.

20.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 302.83 mcm

Geomorphology

Segment 23 - 24: Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral

development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.

Segment 24 - 25: Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge, characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel, activated only during infrequent flood events. A limited floodplain may be present between the active and macro-channel.

Riparian vegetation

Mainly grasslands comprising mixed grasses and forbs, particularly in the steeper areas. Distinct stands of indigenous woody trees and shrubs in the flatter areas dominated by *Combretum erythrophyllum*. Also isolated patches of perennial grasses on small islands and on river fringes. Limited vegetation is expected in the gorge area towards the Thukela confluence.

Fish

Below the Bushmans Falls: *Anguilla bengalensis*, *A. marmorata*, *A. mossambica*, *Barbus natalensis*, *B. trimaculatus*, *B. viviparus*, *Amphilius natalensis*, *Tilapia sparmanii*, *Labeo molybdinus*, *L. rubromaculatus*, *Clarias gariepinus* and *Awaous aeneofuscus*. Above the falls the last four species would not have occurred.

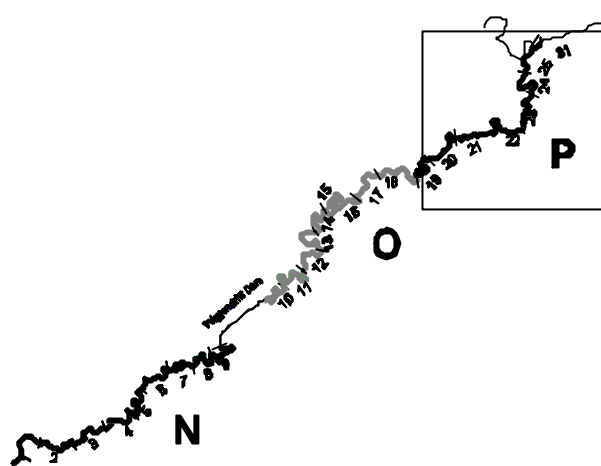
Aquatic invertebrates

This Resource Unit makes use of RU F on the Thukela to provide reference data. It falls within Oliff's (1960b) Rejuvenated Zone, and consequently will have typical torrential taxa such as *Afronurus*, *Prosopistoma*, *Centropiloides* and several species of *Hydropsychidae*.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	4	3	4	2



20.2 PES

20.2.1 PES, causes and sources

Table 20.1 PES, causes and sources (Specific to the Gorge)

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: B/C					
Habitat change. Change in morphology.	Sediment aggradation due to vegetation encroachment.	Agriculture.	NFL	Catchment land-use management.	3
	Sediment accumulation.	In-channel structures (causeway).	NFL	-	
RIPARIAN VEGETATION PES: B/C					
Shift in species composition. Loss of marginal zone. Change in distribution.	Sedimentation from bank erosion, sediment accumulation.	Land-use.	NFL	Catchment land-use management.	4
		Wagendrift Dam.	FL	Operation of Wagendrift Dam to supply the Reserve.	
FISH PES: B					
Reduced diversity, absence of <i>Amphilius</i> .	Alien species invasion above waterfall.	Introduction of alien species.	NFL	Eradication and prevention of further stocking.	3
	Habitat decline due to eutrophication and siltation.	Industrial and farmland runoff.	NFL	Catchment land-use management.	
AQUATIC INVERTEBRATES PES: B					
Fauna less diverse, especially in the upper reaches.	Flow alteration.	Operation of Wagendrift Dam, Irrigation return flows.	FL	Operate to provide the Reserve.	3
	Pollution causing water quality problems (excessive algae on stones).	Catchment activities, industry in Estcourt.	NFL	Catchment land-use management and Source Directed Controls.	

20.2.2 Trajectory of change

Table 20.2 Trajectory of change, RU P

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	B/C	B/C	B/C	4
	Gorge, limited localised sedimentation .				
Riparian vegetation	Stable	B/C	B/C	B/C	4
	No significant changes anticipated in vegetation in gorge.				
Fish	Stable	B	B	B	3
	Fish in equilibrium with habitat.				
Aquatic invertebrates	Stable	B	B	B	3
	Geomorphology and riparian vegetation stable, water quality close to stable.				

20.2.3 Summary and resulting Ecstatus

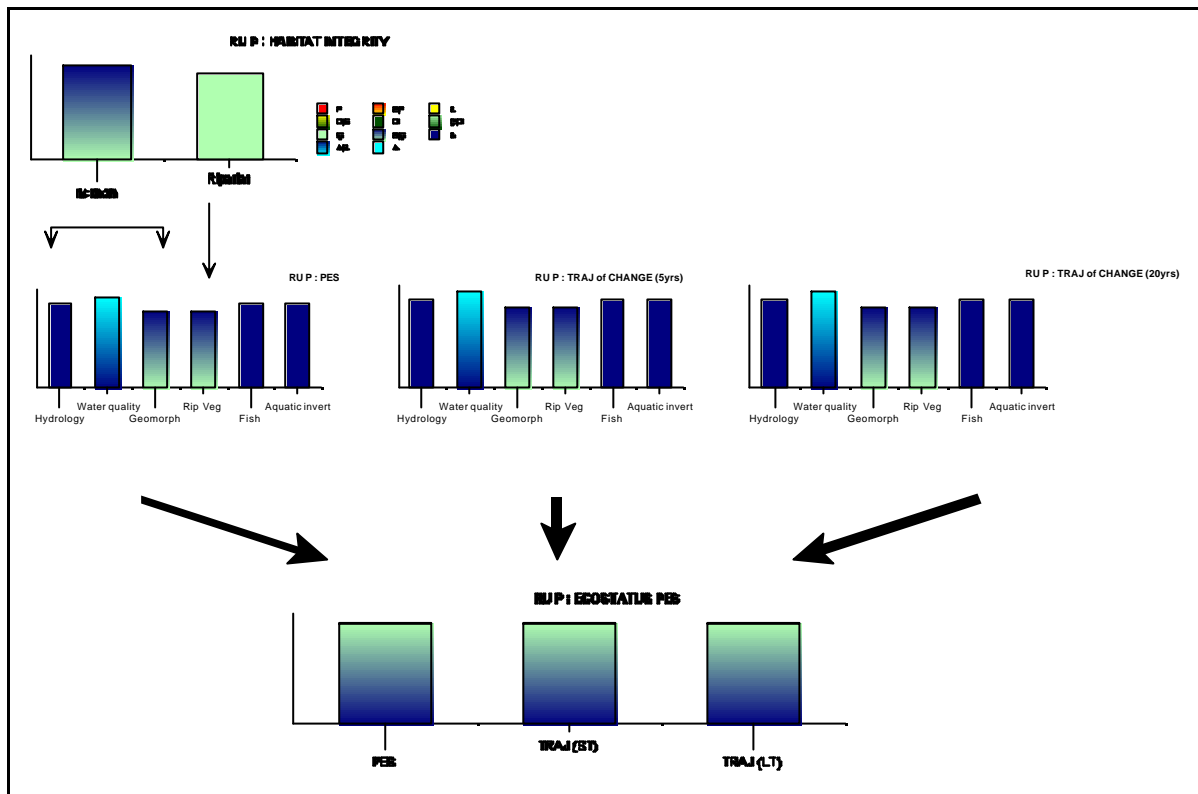
The other drivers to be considered when providing the Ecstatus are:

Hydrology : PES B.
(High flows and low flows are now practically natural but the middle-sized flows are partly modified (reduced)).
 Present MAR as % of virgin MAR: 83.1%.

Water quality : PES A/B.
(Negative trajectory in the long term to a B category, due to fertilizer use upstream of the gorge).

The information on PES for the different components is summarised in Figure 20.1.

Fig 20.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

The Ecostatus reflects the instream Habitat Integrity (B/C), and the drivers geomorphology (B/C) and riparian vegetation (B/C). Water quality and hydrology as the other drivers were in higher classes, but with lower confidence. The Ecostatus is therefore driven by geomorphology and correlates to the instream habitat integrity.

20.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: High (borderline)
 Confidence: Very High
 Determinants: Presence of rare, unique, flow sensitive species. High species richness.

SI rating: Moderate
 Confidence: Medium to High
 Determinants: Aesthetic value of the river, potential for ecotourism.

20.4 AIM

The EIS is (borderline) **high**, the social importance is **moderate** and the PES is a B/C category. The aim is to **maintain** the PES of a B/C. By aiming to maintain the gorge PES, it is expected that the required improvements in the rest of the RU will be addressed.

20.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Critical sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land use (agriculture and runoff). 	<ul style="list-style-type: none"> Catchment land-use management. Improve agricultural practices (to reduce eutrophication). 	<ul style="list-style-type: none"> Very difficult. Difficult.
<i>Flow related</i> <ul style="list-style-type: none"> Wagendrift Dam. 	<ul style="list-style-type: none"> Operate to release the Reserve. 	<ul style="list-style-type: none"> Reasonable.

The individual components are addressed as follows:

Table 20.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	A/B Y B	A/B	B
Geomorphology	B/C Y B/C	B/C	B/C
Riparian vegetation	B/C Y B/C	B/C	B/C
Fish	BY B	B	B
Aquatic invertebrates	B Y B	B	B
Ecostatus	B/C Y B/C	B/C	B/C

Rationale for the attainable ERC

This section of the RU has a high PES and all components are considered stable. Further improvement in this section requires actions which are described largely as 'very difficult'. The water quality issues in the unit will need to be addressed to halt the negative trajectory in this component, and to ensure maintenance of the Ecostatus. To address the riparian vegetation outside of the gorge, it will be necessary to tackle the non-flow related issues of alien vegetation control and to address land-use issues.

The Reserve scenarios that will be provided will be a B, a B/C and C/D.

20.6 SUMMARY OF RESULTS

The results are illustrated in Figure 20.2.

Fig 20.2 Summary of results

RU P : LOWER FOOTHILLS TO THUKELA CONFLUENCE (segm 19 - 25)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	A/B	-	A/B	B	EIS HIGH	B	A/B
GEOMORPH	B/C	-	B/C	B/C		B/C	B/C
RIPARIAN VEGETATION	B/C	0	B/C	B/C		B/C	B/C
FISH	B	0	B	B	SI MODERATE	B	B
AQUATIC INVERTS	B	0	B	B		B	B
ECOSTATUS	B/C	0	B/C	B/C		B/C	B/C

* ATTAINABLE CATEGORY

The confidence in the results are summarised below

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	3	4	2
PES	2	3	4	3	3
Trajectory of change	2	4	4	3	3
EIS	4				
SI	2				

The confidence ranges from medium low to medium high with most of the components being in medium range.

20.7 IFR SITE WITHIN THE RU

IFR 6 (Darkest Africa) is situated in this RU. The PES of the RU reflects the PES and therefore the ERC of the IFR site.

21. RU Q: SUNDAYS RIVER SEGMENT 1 - 4 (Newcastle/Ladysmith Road Bridge to end of Rejuvenated Bedrock Falls)

21.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 95.36 mcm

Geomorphology

Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.

Riparian vegetation

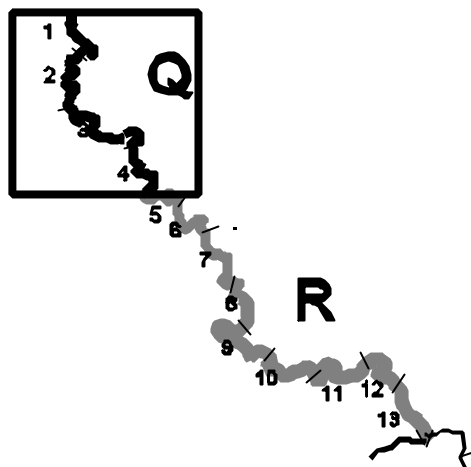
Largely grasslands with mixed grasses and forbs and occasional woody shrubs and trees in areas protected from fires, floods and natural grazing. Dominant species being typical alluvial species such as *Salix mucronata*, *Combretum erythrophyllum* and *Diospyrus lycioides*. Isolated patches of reeds expected in flatter areas.

Fish

Anguilla mossambica, *Barbus natalensis*, *Labeo rubromaculatus* and *Clarias gariepinus* would have been present.

Aquatic invertebrates

This unit could be expected to have a fauna typical of a fast-moving rocky stream. Several flow-dependent taxa could be expected here, including the species listed for RU P.



Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'very high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	?4	3	3	4	4	2

21.2 PES

21.2.1 PES, causes and sources

Table 21.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY		PES: C			
Habitat change. Change in morphology.	Apparent sediment aggradation (due to upstream bank erosion).	Land-use in upper catchment.	NFL	Catchment land-use management.	3
	Local changes in channel morphology.	In-channel structures (bridges, causeways).	NFL	-	
RIPARIAN VEGETATION		PES: C/D			
Reduced riparian zone. Shift in species composition. Change in distribution.	Farming lands to rivers edge Exotic species encroachment Reed encroachment.	Formal agriculture.	NFL	Create riparian zone (as a buffer).	3
		Land-use management.	NFL	Exotic eradication programme.	
		Sediment accumulation.	NFL	Catchment land-use management.	
FISH		PES: B*			
Reduced abundance.	Siltation.	Land-use management.	NFL	Catchment land-use management (erosion control).	4
AQUATIC INVERTEBRATES		PES: C			
Abundance low. Loss of some diversity.	Altered flow regime (no-flow periods).	Abstraction.	FL	Provide the Reserve.	2
	Water quality problems (fine sediments were also coating the habitats).	Coal mines; catchment pollution point sources.	NFL	Source-directed controls. Catchment land-use management.	

*PES B for fish: Only very hardy fish species present, not reacting to the siltation and habitat deterioration.

21.2.2 Trajectory of change

Table 21.2 Trajectory of change, RU Q

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C	C	C	3
	Continued sediment accumulation.				
Riparian vegetation	Negative	C/D	C/D	D	3
	Further encroachment of the river channel and marginal areas by reeds and exotic species.				
Fish	Stable	B	B	B	3
	No particularly sensitive spp, those present are in equilibrium with present habitat.				
Aquatic invertebrates	Stable	C	C	C	3
	The important habitats for the inverts will not be negatively affected by the sedimentation and the deterioration in riparian vegetation.				

21.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology :

PES category E.

(There is up to 25% zero flow in this reach at present day (modelled). (This means the river has been changed fundamentally at low flows). According to the DWAF data however, the monthly data does not have any zeroes in it, and this indicates a perennial river.)

Water quality :

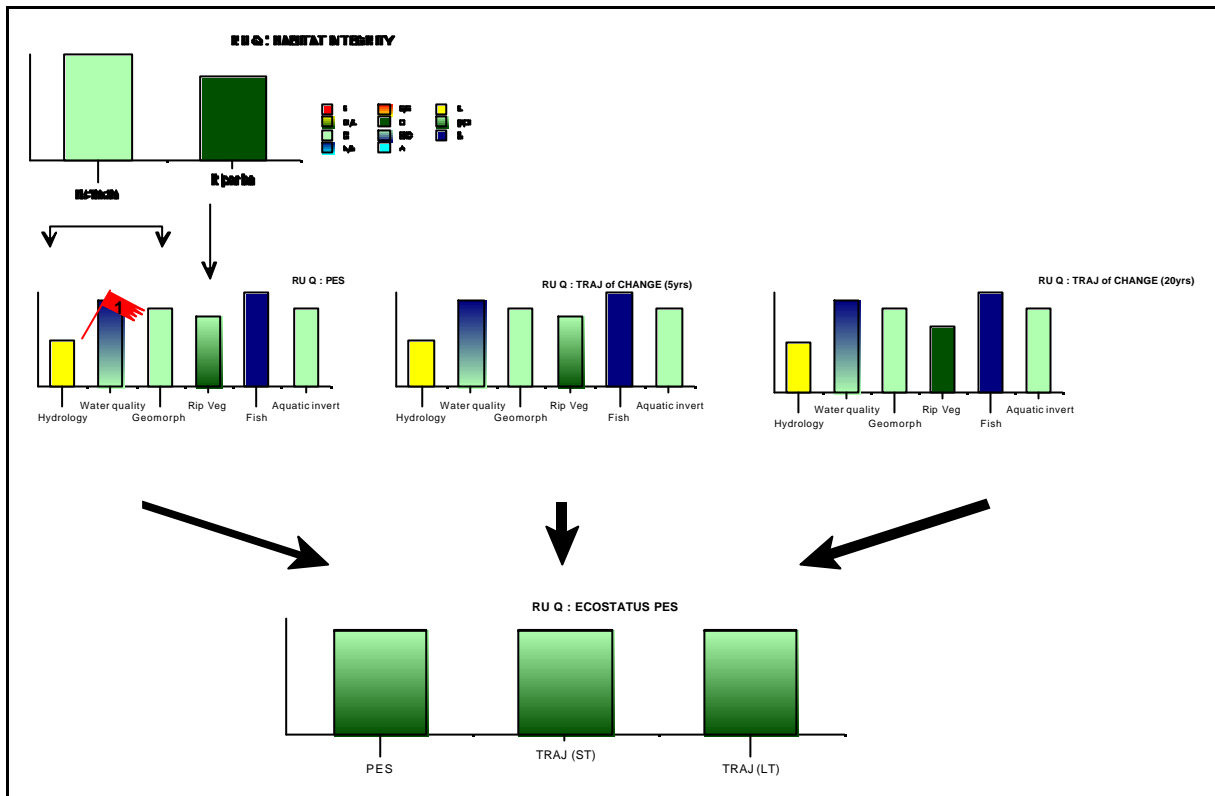
Present MAR as % of virgin MAR: 80.77%

Data suggests a B category.

(However the category is set at B/C and is judged to be stable over the long-term. The main water quality problem is high sulphates (due to mining). This is a large proportion of the TDS (and a toxic component). The nutrients are high and in a D class (FLAG 1, Figure 21.2). Note that the water quality problems are not caused by low flows but are exacerbated by low flows.

The information on PES for the different components are summarised in Figure 21.1.

Fig 21.1 PES results and the resulting



Rationale for the Ecostatus

Fish is in the highest category, i.e. a B. However, the fish occurring here are hardy species and therefore do not react to the drivers which are in lower categories. The hydrology driver is an outlier at an E category. As the other components have not reacted to this, it is assumed that the geomorphology is the more applicable driver (C category). However due to the lower riparian vegetation (which also acts as a driver in some cases) as well as the hydrology, the is set at a C/D.

21.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: Medium
 Determinants: Unique and flow-sensitive species present.

SI rating: Moderate (to low)
 Confidence: High
 Determinants: Human dependence on the river for water supply, plant resources and recreation. Sacred places or places of cultural importance present.

21.4 AIM

The EIS is **moderate**, the social importance is high and the PES is a C/D category. Normally the aim would be to **improve PES** based on the high social importance. Maintaining the PES with the required improvement to address the negative trajectory should improve those aspects relevant to the social importance. Some improvement will be required to address the negative trajectory of the geomorphology and the riparian vegetation.

21.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. The related causes are provided in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Flow related</i> <ul style="list-style-type: none"> Abstractions. 	<ul style="list-style-type: none"> Manage to ensure the Reserve. 	<ul style="list-style-type: none"> Difficult (no operating structure).
<i>Non-flow related</i> <ul style="list-style-type: none"> Agriculture (reed encroachment and sedimentation). Mining and catchment pollution problems (water quality). 	<ul style="list-style-type: none"> Catchment land-use management. Address point sources. Source Directed Controls. 	<ul style="list-style-type: none"> Very difficult. Difficult. Very difficult.

The individual components are addressed as follows:

Table 21.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B/C Y B/C	B/C	B/C
Geomorphology	C Y C	C	C
Riparian vegetation	C/D Y D	C/D	D
Fish	B Y B	B	B
Aquatic invertebrates	C Y C	C	C
	C/D Y C/D	C/D	C/D


Rationale for the attainable ERC

The geomorphology and riparian vegetation will deteriorate slightly over time, however these are non-flow related issues. To address these actions range from very difficult to difficult. As the geomorphology trajectory is extremely slow (within category), it is only the riparian vegetation that has a negative trajectory and the ERC is therefore attainable.

21.6 SUMMARY OF RESULTS

The results are illustrated in Figure 21.2.

Fig 21.2 Summary of results

RU Q : NEWCASTLE ROAD TO END OF REJUVENATED BEDROCK FALLS (segm 1 - 4)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B/C 	0	B/C	B/C	EIS H I G H	B/C	B/C
GEOMORPH	C	-	C	C		C	C
RIPARIAN VEGETATION	C/D	-	C/D	D		C/D	D
FISH	B	0	B	B	SI H I G H	B	B
AQUATIC INVERTS	C	0	C	C		C	C
ECOSTATUS	C/D	0	C/D	C/D		C/D	C/D

*ATTAINABLE CATEGORY

Flags: Refer to 21.2.3

The confidence in the results are summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	3	4	4	2
PES	3	3	3	4	2
Trajectory of change	3	3	3	3	3
EIS	3				
SI	3				

The confidence ranges from low-medium to medium-high with most of the components within the medium range.

21.7 IFR SITE WITHIN THE RU

IFR 7 is situated in this unit. The results from the RU may not reflect the results for the IFR site. Sites are specifically chosen to provide as much ecological indicators as possible and therefore must be in as good condition as possible. As such, the RU may be a different category than the site. With the knowledge available for IFR 7, it was immediately obvious that the site is in a different condition than the RU. A site specific evaluation was therefore undertaken and the results are provided in Figure 21.3.

Fig 21.3 IFR 7 results

IFR 7							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN* CATEG
WATER QUALITY	B/C	0	B/C	B/C	EIS MODERATE	B/C	B/C
GEOMORPH	B/C	-	B/C	C		B/C	B/C
RIPARIAN VEGETATION	B/C	?	?	?		B/C	B/C
FISH	B	0	B	B	EIS MODERATE	B	C
AQUATIC INVERTEB	C	0	C	C		C	C
ECOSTATUS	B/C	-	B/C	C		B/C	B/C

*ATTAINABLE CATEGORY

Water quality would be the same in both. At IFR 7, geomorphology would have a PES of B/C with a negative trajectory, with C in the long-term. Riparian vegetation at IFR7 has a PES of B/C with a stable trajectory, dependent on what happens in the catchment (present-day logging activities may affect the riparian zone). Fish at the site would remain at a PES of B. Invertebrates at the site would remain at a PES of C. The PES would be B/C with an ERC of B/C.

The Reserve scenarios that will be produced will be a C, B and D categories.

22. RU R: SUNDAYS RIVER SEGMENT 5-13 (Start of Rejuvenated Foothills to Thukela Confluence)

22.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 193.65 mcm

Geomorphology

Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro channel activated only during infrequent flood events. A limited flood plain may be present between the active and macro-channel.

Riparian vegetation

Densely vegetated stands of woody trees and shrubs characterised by *Combretum erythrophyllum*, *Schotia brachypetala*, *Acacia* sp. and *Ziziphus mucronata*. Isolated patches of reeds and perennial grasses in flatter areas.

Fish

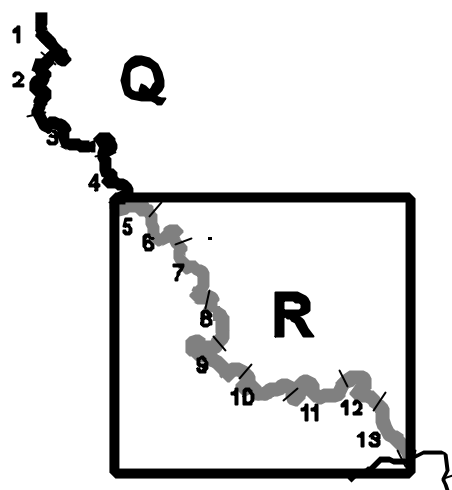
Same four species occur as do in the upper Sundays as well as *Anguilla bengalensis*, *A. marmorata*, *Barbus trimaculatus*, *B. viviparus*, and *Labeo molybdinus*.

Aquatic invertebrates

No monitoring data existed for this site or Resource Unit, so reference conditions have been extrapolated from a site on the Thukela, which lies in a similar ecoregion. This accounts for the low confidence. In its natural condition, this part of the river should be characterised by vigorous mayfly and caddisfly populations, with several flow sensitive families.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'high' confidence.



	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	4	3	4	2

22.2 PES

22.2.1 PES, causes and sources

Table 22.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY		PES: D			
Habitat change. Change in morphology.	Aggradation due to bank instability, sediment accumulation, vegetation encroachment.	Tributary inputs, catchment landuse, change in riparian zone.	NFL	Catchment land-use management.	4
		In-channel structures (dam, weirs, bridges, causeways).	NFL	-	
RIPARIAN VEGETATION		PES: E			
Reduced riparian zone. Reduced vegetation cover. Loss of marginal zone.	Sedimentation due to trampling, grazing and bank erosion.	Agriculture.	NFL	Catchment land-use management.	4
FISH		PES: C			
Reduced abundance and diversity, loss of <i>Amphilius</i> .	Change in flow regime (ceases to flow).	Abstractions.	FL	Manage the system to supply the Reserve.	2
	Siltation (habitat degradation).	Land use.	NFL	Catchment land-use management (erosion control).	
AQUATIC INVERTEBRATES		PES: B/C			
Possible decrease in diversity.	Water quality affected. Change in flow regime.	Catchment land-use activities. Abstractions.	NFL FL	Catchment land-use management. Manage the system to supply the Reserve.	2

22.2.2 Trajectory of change

Table 22.2 Trajectory of change, RU R

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D	D	D	3
	Continued effects of modifying determinants.				
Riparian vegetation	Negative	E	E	E/F	4
	Continued effects of modifying determinants				
Fish	Stable	C	C	C	3
	Fish species presence in equilibrium with modified conditions.				
Aquatic invertebrates	Stable	B/C	B/C	B/C	3
	Site dominated by cobble habitat. The changes in geomorphology and riparian vegetation are unlikely to affect this.				

22.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology :

PES F.

(It is assumed that the natural state was perennial. In the present state, there are substantial periods of no flow.)

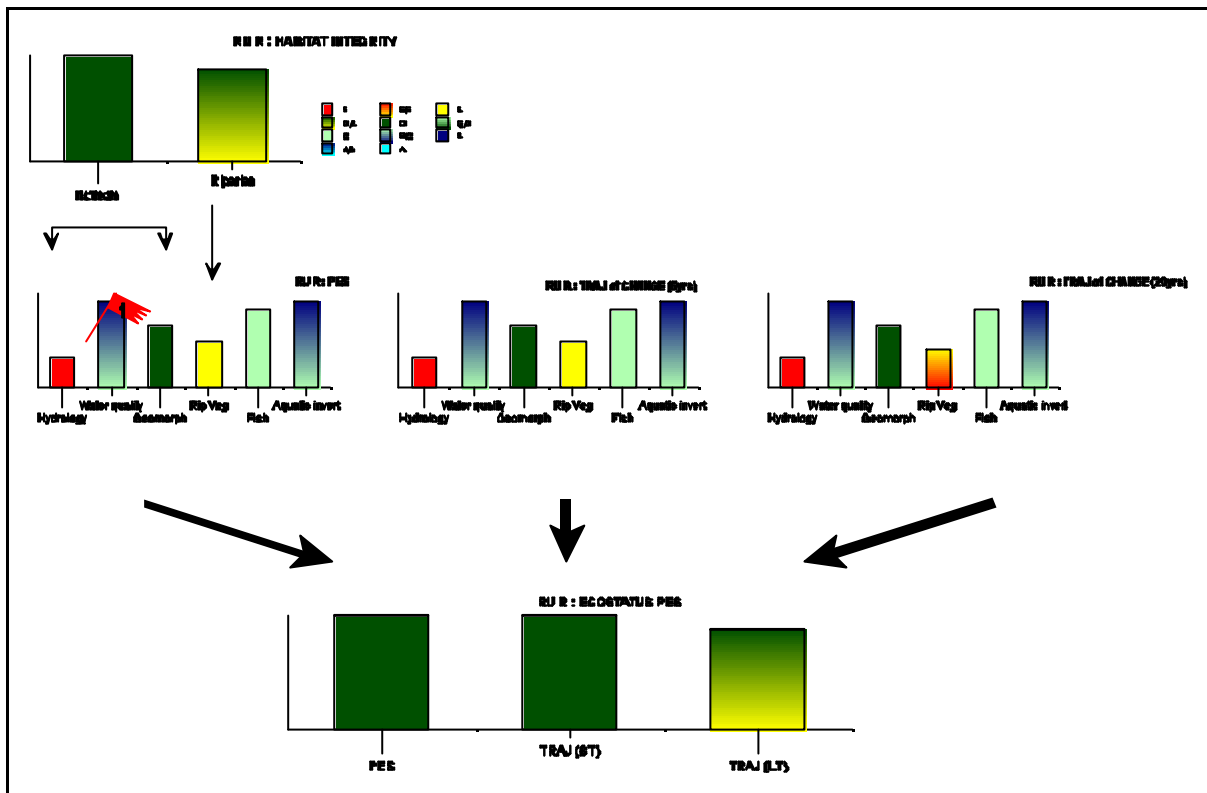
Present MAR as % of virgin MAR: 83.05%.

Water quality:

PES B/C.

(FLAG 1, Figure 22.1). The Wasbank tributary (carrying acid mine drainage from defunct coal mines) enters at the top of this unit (Segment 6/7), and present monitoring where B/C water was sampled is downstream of this. The large sulphate load and TDS from Wasbank is already ameliorated prior to the downstream monitoring site. Monitoring site data indicates a B/C. Water quality will be very flow dependent (dilutions). It is necessary to deal at source with the problems in the Wasbank).

Fig 22.1 PES results and the resulting



Rationale for the Ecstatus

The site and the reach are considered to be in poor condition overall, with resilient fish species present. The Habitat Integrity was categorised as D (instream) and D/E (riparian). The hydrology and geomorphology (drivers) and riparian vegetation are in poor to bad condition and assumed to be on negative trajectories. The water quality at the site is B/C but the impacts of the Wasbank is not necessarily measured. The invertebrates are in better condition than the other components, but this is due to the fact that good cobble habitat occurred at the IFR site where sampling took place. The representative of this site was therefore selected as a D which relates to the habitat integrity as well as the drivers other than water quality.

The information on PES for the different components is summarised in Figure 22.1.

22.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Diverse biota with unique and flow-sensitive taxa present; diverse habitats available.

SI rating: High (borderline)
 Confidence: Medium to High
 Determinants: Human use of the river for water, resources, fishing and recreation. Sacred or important cultural sites, sense of place.

22.4 AIM

The EIS is **moderate**, the social importance is **high** (borderline), and the PES is a D category.

The aim is to maintain the PES as a D and to improve the system based on the non-flow related issues to cater for both the resource utilisation (social importance) and to halt the negative trajectories. The riparian vegetation must be improved from an E to a D category.

22.5 ATTAINABLE ERC

The sources and actions required to address this aim are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with them, are also included.

Critical sources	Action	Degree of difficulty
<i>Flow related</i> <ul style="list-style-type: none"> Abstraction (no-flow conditions). 	<ul style="list-style-type: none"> Manage abstractions to provide the Reserve (part during low-flows). 	<ul style="list-style-type: none"> Difficult.
<i>Non-flow related</i> <ul style="list-style-type: none"> Agriculture (sedimentation). Coal mining in vicinity of Wasbank (water quality deterioration). 	<ul style="list-style-type: none"> Catchment land-use management. Source directed controls. 	<ul style="list-style-type: none"> Very difficult. Very difficult.

The individual components are addressed as follows:

Table 22.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B/C Y B/C	B/C	B/C
Geomorphology	D Y D	D	D
Riparian vegetation	E Y E/F	D	E
Fish	C Y C	C	C
Aquatic invertebrates	B/C Y B/C	B/C	B/C
ERC	D Y D/E	D	D


Rationale for the attainable ERC

The rationale for the D category is that it is necessary to overcome the negative trajectories, particularly in terms of riparian vegetation because that is important for social use, and for water quality. Both are considered “very difficult”. Although both in the short term and long term an attainable ERC of a D will be possible, a D with limited risk of falling in a lower category will only be achieved in the long term.

22.6 SUMMARY OF RESULTS

The results are illustrated in Figure 22.2.

Fig 22.2 Summary of results

RU R : START OF REJUVENATED FOOTHILLS TO THUKELA CONFLUENCE (segm 5 - 13)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	B/C 	0	B/C	B/C	EIS MODERATE SI HIGH	B/C	B/C
GEOMORPH	D	-	D	D		D	D
RPARIAN VEGETATION	E	-	E	E/F		D	E
FISH	C	0	C	C		C	C
AQUATIC INVERTS	B/C	0	B/C	B/C		B/C	B/C
ECOSTATUS	D	-	D	D/E		D	D
* ATTAINABLE CATEGORY							

Flag: refer to 22.2.3

The confidence in the results are provided below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	3	4	2
PES	2	4	4	2	2
Trajectory of change	3	3	4	3	3
EIS	3				
SI	4				

The confidence ranges from medium low to medium high with most of the components in the medium to medium-high range.

22.7 IFR SITE WITHIN THE RU

IFR 8 (Lower Sundays) is situated in this RU. The PES of the RU reflects the PES and therefore the ERC of the IFR site.

The Reserve scenarios that will be addressed for this site will be a D and a C category.

23. RU S: MOOI RIVER SEGMENT 1-25 (Little Mooi confluence to the Mooi River Falls)

23.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 193.65 mcm

Geomorphology

An upland low gradient channel, often associated with uplifted plateau areas such as occur beneath the eastern escarpment.

Riparian vegetation

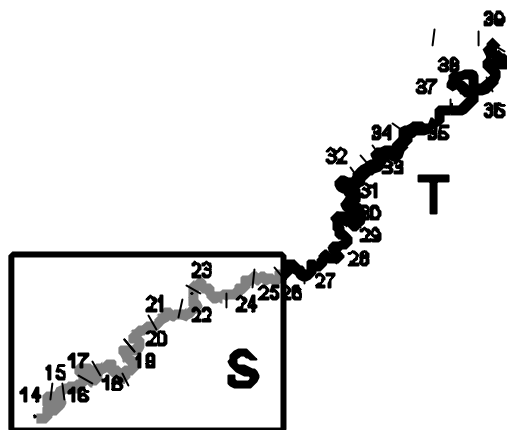
Mainly floodplain grassland, comprising mixed grasses and alluvial woody shrubs such as *Salix mucronata*, *Combretum erythrophyllum*, *Diospyros lycioides* and *Rhus gerrardii*. Woody species confined to a narrow strip on the rivers edge. Marginal areas (islands and river fringes) characterised by narrow areas of reeds and perennial grasses.

Fish

Anguilla mossambica, *Barbus anoplus*, *B. natalensis* and *Amphilius natalensis*.

Aquatic invertebrates

The biggest difference in the Mooi compared to other rivers in the basin was the richness of the Entomostraca and Chironomidae in the marginal vegetation, especially in the dry season. This occurred in the slow-moving Foothill Sandbed above the Mooi River town, resulting from the natural enrichment of the river in this area. De Moor (1995) recorded that some taxa were 'frequently recorded'. These included *Baetis harrisoni*, *Centroptiloides bifasciatum*, *Afroptilum excisum*, *Afronurus* sp., *Choroterpes elegans*, *Tricorythus discolor*, *Paragomphus* sp., *Zygonyx* sp., *Cheumatopsyche afra* type, *C. thomasseti* type, *Hydropsyche* sp., *Stenelmis*, Gyridinidae, *Simulium* and Chironomidae. Taxa characteristic of unimpacted rivers were recorded less frequently. These included *Neoperla spio*, Ephemerae, Caenidae, *Aeschna* sp., Naucoridae, *Macronema* sp., and Nymphulidae. Other absentees from the samples included mayflies *Prosopistoma* sp., *Elassoneuria* sp., caddisfly *Polymorphanisus bipunctatus* and Hydroptilidae.



Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'very high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	4	4	4	5

23.2 PES

23.2.1 PES, causes and sources

Table 23.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: C					
Change in morphology.	Sedimentation (due to bank instability caused by alien vegetation; agriculture).	Land-use. In-channel structures (bridges, weir, causeways).	NFL	Land-use management.	3
RIPARIAN VEGETATION PES: C/D					
Shift in species composition. Change in distribution. Reduced vegetation cover.	Exotic species encroachment.	Land-use.	NFL	Alien eradication programme.	3
	Reed encroachment. Trampling, grazing, bank erosion.	Agriculture. Return flows.	NFL	Catchment land-use management.	
FISH PES: C					
Absence of <i>Amphilius</i> . Population decline. Reduced diversity.	Alien species invasion.	Self-perpetuating alien populations.	NFL	Eradication and prevention of further population growth.	4
AQUATIC INVERTEBRATES PES: B/C					
Changes in species combinations and abundance.	Nutrient enrichment and pollution.	Piggeries, dairies and the town of Mooi River.	NFL	Catchment management programmes.	4
	Reduced flows.	Water abstraction at Mearns and by agriculture.	FL	Implementation of Reserve and IFR.	

23.2.2 Trajectory of change

Table 23.2 Trajectory of change, RU S

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Stable	C	C	C	3
	Photographic record indicates no change between 1984 and 1989. Sedimentation issue is marginal.				
Riparian vegetation	Negative	C/D	C/D	C/D	3
	No change in category. Exotic species, reed encroachment.				
Fish	Stable	C	C	C	3
	Fish species present are in equilibrium with the present habitat.				
Aquatic invertebrates	Stable	B/C	B/C	B/C	4
	Main drivers are sufficiently stable that there is unlikely to be a large change in invertebrates.				

23.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology:

PES E.

(According to the modeled results, the Mooi River in this section has changed from perennial to seasonal (only marginally).)
Present MAR as % of virgin MAR: 83.05%.

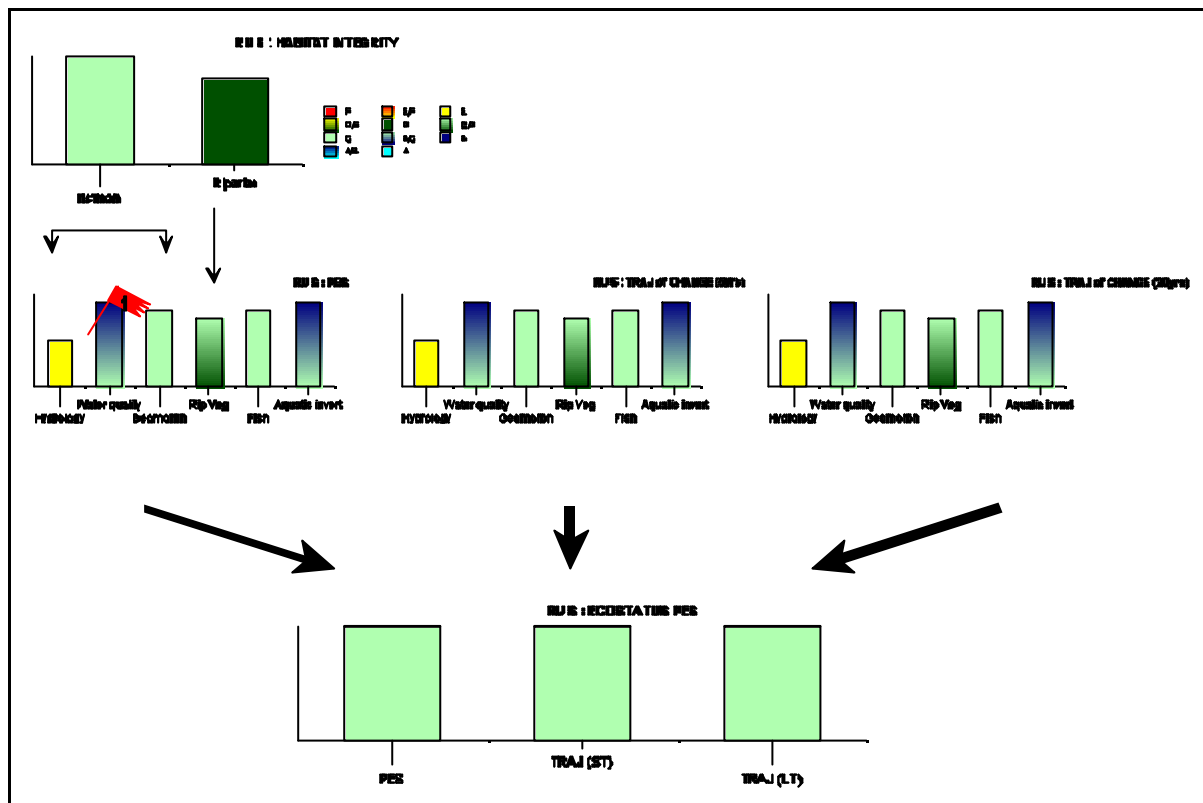
Water quality:

PES B/C.

(FLAG 1, Figure 23.1). (Based on expert judgement, this PES was adjusted downward to account for the impact of extensive nutrient enrichment. The monitoring point for this RU was downstream of Mooi River town and was not picking up the extensive nutrient enrichment known to exist due to fertilizer, pigs and dairy).

The information on PES for the different components are summarised in Figure 23.1.

Fig 23.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

Instream Habitat Integrity is a C. This already forms an integration of most of the drivers and other criteria. The outlier in this RU is hydrology. It seems that most of the components are not sensitive to the flow problems and the major driver is therefore geomorphology (which is a C category). Taking this and the instream Habitat Integrity into account, the Ecostatus is set as a C.

23.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Rare and endangered species with flow-sensitive taxa present, high species richness.

SI rating: Moderate (low)
 Confidence: Medium to High
 Determinants: General aesthetic value.

23.4 AIM

The EIS is **moderate**, the social importance is **low to moderate** and the PES is a C category. The aim is to maintain PES and to minimise the risk of degradation.

23.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Critical sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land use (exotic vegetation and reeds). Piggeries etc (water quality). 	<ul style="list-style-type: none"> Catchment management and alien vegetation control programme. Source directed controls. 	<ul style="list-style-type: none"> Very difficult. Reasonable. Reasonable.
<i>Flow related</i> <ul style="list-style-type: none"> Abstraction. 	<ul style="list-style-type: none"> Manage the abstractions. 	<ul style="list-style-type: none"> Difficult.

The individual components are addressed as follows:

Table 23.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	B/C Y B/C	B	B
Geomorphology	C Y C	C	C
Riparian vegetation	C/D Y C/D	C/D	C/D
Fish	C Y C	C	C
Aquatic invertebrates	B/C Y B/C	B/C	B/C
ERC	C Y C	C	C


Rationale for the attainable ERC

There is no significant trajectory of change in any of the components. The degree of difficulty associated the actions required to address the problems vary from reasonable to very difficult. If the 'reasonable' actions are undertaken, the ERC of a C should be attainable.

23.6 SUMMARY OF RESULTS

The results are illustrated in Figure 23.2.

Fig 23.2 Summary of results

RU 5 : LITTLE MOOI CONFLUENCE TO MOOI RIVER FALLS (segm 14 - 25)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	B/C 	0	B/C	B/C	HIGH MODERATE	B	B
GEOMORPH	C	-	C	C		C	C
RIPARIAN VEGETATION	C/D	-	C/D	C/D		C/D	C/D
FISH	C	0	C	C	SI MODERATE	C	C
AQUATIC INVERTS	B/C	0	B/C	B/C		B/C	B/C
ECOSTATUS	C	0	C	C		C	C

* ATTAINABLE CATEGORY

Flag: Refer to 23.2.3

The confidence in the results are summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	4	4	5
PES	4	3	3	4	4
Trajectory of change	4	3	3	3	4
EIS	4				
SI	2 - 3				

The results range from medium to high with most of the confidence in the medium-high range.

23.7 IFR SITE WITHIN THE RU

IFR 10 (Caravan Park) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

The Reserve scenarios that will be addressed are a B, C and D category.

24. RU T: MOOI RIVER SEGMENT 26-38 (Mooi River Falls to Thukela confluence)

This RU is assessed on the basis of segments 26-29 which is in better condition than the rest of the RU. The rest of the RU is extensively utilised for irrigation and then falls in a rural area with severe catchment degradation.

24.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 431.59 mcm

Geomorphology

Segment 20 - 24 and 27 - 38: Steepened section within middle reaches of the river caused by uplift often within or downstream of gorge, characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro channel activated only during infrequent flood events. A limited flood plain may be present between the active and macro-channel.

Segment 25 - 26: Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.

Riparian vegetation

Reasonable dense stands of woody riparian species downstream of the gorge characterised by *Combretum erythrophyllum* and *Salix mucronata*. Within the gorge relatively sparse riparian zone with few woody trees and shrubs except in flatter areas. Marginal zone in both areas occupied by narrow stands of reeds and perennial grasses.

Fish

The same twelve species as found in Unit G would have occupied this unit: *Anguilla bengalensis*, *Anguilla marmorata*, *Anguilla mossambica*, *Barbus natalensis*, *Barbus trimaculatus*, *Barbus viviparus*, *Labeo molybdinus*, *Labeo rubromaculatus*, *Amphilius natalensis*, *Clarias gariepinus*, *Tilapia sparrmanii*, and *Awaous aeneofuscus*.

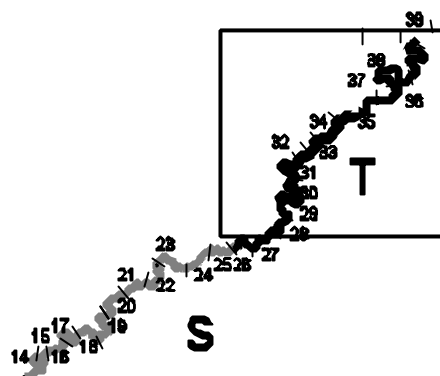
Aquatic invertebrates

Frequently recorded taxa included *Baetis harrisoni*, *B. glaucus*, *Centroptiloides bifasciatum*, *Afroptilum excisum*, *Afronurus sp.*, *Choroterpes elegans*, *Tricorythus discolor*, *Paragomphus sp.*, *Zygonyx sp.*, *Cheumatopsyche afra* type, *C. thomasseti* type, *Hydropsyche sp.*, *Stenelmis*, Gyridinidae, *Simulium* and Chironomidae. Taxa characteristic of unimpacted rivers were recorded less frequently. These included *Neoperla spio*, Ephemerae, Caenidae, *Aeschna sp.*, Naucoridae, *Macronema sp.*, and Nymphulidae.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'very high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	3	4	5	4



24.2 PES

24.2.1 PES, causes and sources

Table 24.1 PES, causes and sources (Segments 26-29, Gorge area)

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY		PES: C			
Habitat change. Change in morphology.	Aggradation.	Abstraction, tributary inputs, catchment landuse, roads, gullies, tracks	FL, NFL	Catchment management.	3
	-	In-channel structures (weir, causeway).	NFL	-	
RIPARIAN VEGETATION		PES: C			
Shift in species composition.	Encroachment of alien vegetation species.	Land-use management.	NFL	Exotic alien control programme.	4
FISH		PES: B			
Reduced abundance.	Change in flow regime.	Upstream abstraction.	FL	Regulate abstraction.	4
	Alien species invasion (small mouth bass).	Introduction of alien species.	NFL	Eradication and prevent stocking.	
AQUATIC INVERTEBRATES		PES: B			
Changes in species combinations and abundance, and some loss of diversity.	Reduced flows.	Abstraction for irrigation.	FL	Proper abstraction regulation to supply Reserve requirements.	4

24.2.2 Trajectory of change

Table 24.2 Trajectory of change, RU T

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	C	C	C	4
	Although there is aggradation, most of the material is moving through the system, and the geology is resilient.				
Riparian vegetation	Negative	C	C	C	3
	Further accumulation of exotic species.				
Fish	Stable	B	B	B	3
	The fish present have reached equilibrium with altered conditions.				
Aquatic invertebrates	Stable	B	B	B	4
	Important habitats are unlikely to change significantly.				

24.2.3 Summary and the resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology:

PES E.

(FLAG 2, Figure 24.1). (*Low flows have been removed and the river in this section ceases to flow for times*). Confidence is low as the hydrology is probably more representative of the lower section of the river than segment 26 to 29).

Present MAR as % of virgin MAR: 76.5%.

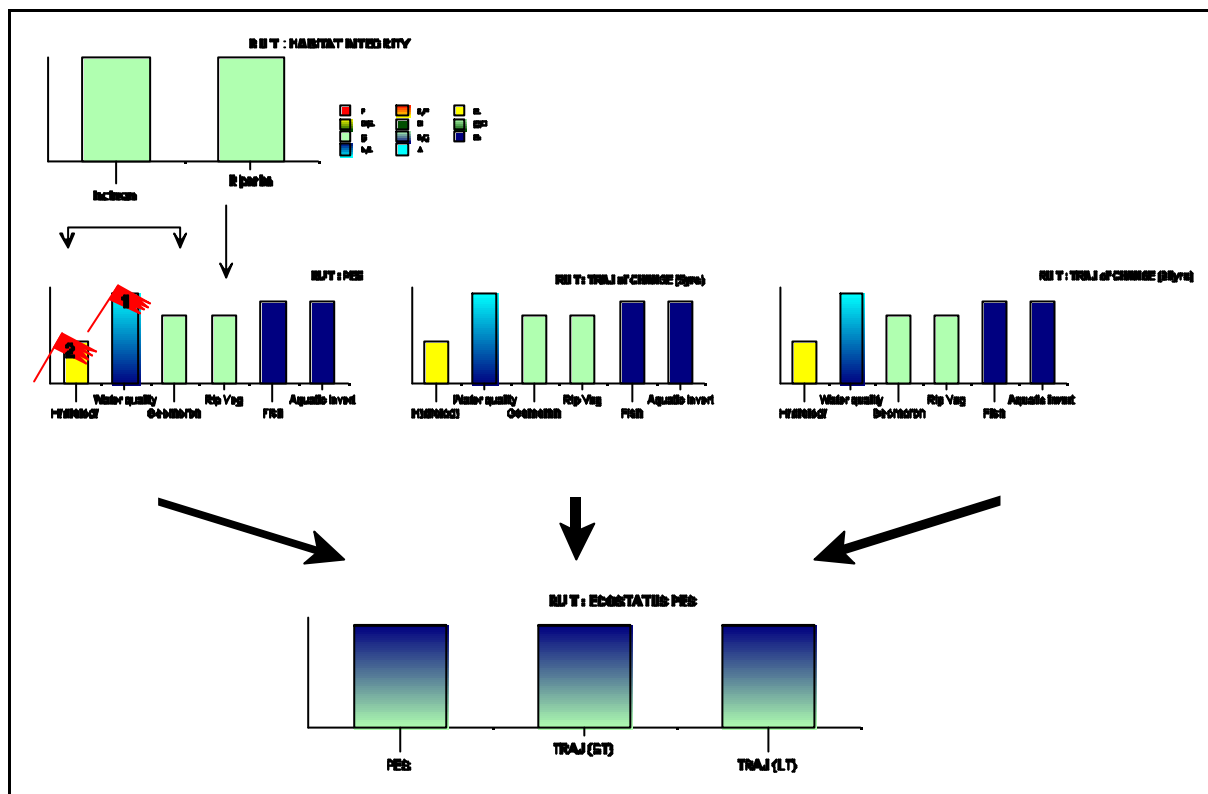
Water quality :

PES A/B

(FLAG 1, Figure 24.1). (*This was monitored at the end of the reach, well downstream of the gorge. There is likely to be a mismatch between the gorge water quality and this downstream sampling station's water quality. It has been decided to use the water quality from the upstream point above the gorge as being more representative*).

The information on PES for the different components is summarised in Figure 24.1.

Fig 24.1 PES results and the resulting Ecostatus



Rationale for the Ecotatus

It is suspected that the hydrology in this section is better than the conditions upstream of the RU and downstream in the RU. Water quality is in a good condition (A/B). Instream biota is also in a good condition. Habitat integrity is C for both instream and riparian. There are patches of vegetation (as at IFR 11) that are in better condition than reflected in the riparian vegetation PES of C. This section of river is more characteristic in general of a B/C river than a C. The Ecotatus is therefore set at a B/C.

24.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Unique and flow-sensitive taxa present. High diversity of habitats present.

SI rating: High
 Confidence: High
 Determinants: Human dependence on the river for water, fishing, resources, and recreation. Sense of place, and sacred or culturally important places on the river.

24.4 AIM

The EIS is **moderate**, the social importance for the entire resource unit is **high** and the PES is a B/C category. A traditional scattered population lives in this area, but population densities are high. The aim is to **maintain** the B/C in the gorge and thereby improve the river downstream of the gorge which is in a lower PES, thus addressing the social requirements (supply of resource requirements).

24.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> Land-use (aggradation and sedimentation). Agriculture (nutrient enrichment). 	<ul style="list-style-type: none"> Catchment land-use management. 	<ul style="list-style-type: none"> Very difficult.
<i>Flow related</i> <ul style="list-style-type: none"> Abstraction for irrigation. 	<ul style="list-style-type: none"> Implement the Reserve. 	<ul style="list-style-type: none"> Reasonable.

The individual components are addressed as follows:

Table 24.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	A/B Y A/B	A/B	A/B
Geomorphology	C Y C	C	C
Riparian vegetation	C Y C	C	C
Fish	B Y B	B	B
Aquatic invertebrates	B Y B	B	B
Ecostatus	B/C Y B/C	B/C	B/C

Rationale for the attainable Ecostatus

This assessment is based on Segments 26-29. The reason for this is that conditions are markedly different in the upstream and downstream sections of this RU, and it was decided to focus on the section in the best condition (upstream) on the basis that catering for this section would more than cater for the requirements of the downstream section. The hydrological assessment both upstream and downstream of the assessed segments indicates a loss of low-flows due to abstraction, however the assessment of the specialists was that the low flows would have recovered from upstream abstractions in this section and were only impacted further downstream. It is considered that the PES E for the hydrology in this section may be too low a category.


The recommendation for a B/C category is therefore based on the gorge (upstream) section where conditions are relatively unimpacted. Maintenance of the present B/C status will improve degraded conditions downstream where the social importance is high, and will provide for the social resource requirements downstream. Particularly important would be an improvement of downstream water quality and riparian habitat.

As there is very slow negative trajectory and as some of the actions required are evaluated as reasonable, the ERC of B/C is attainable.

The results are illustrated in Figure 24.2 below.

24.6 SUMMARY OF RESULTS

Fig 24.2 Summary of results

RU T : REJUVENATED FOOTHILLS TO THUKELA CONFLUENCE (segm 26 -38)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	A/B 	0	A/B	A/B	MODERATE	A/B	A/B
GEOMORPH	C	-	C	C		C	C
RIPARIAN VEGETATION	C	-	C	C		C	C
FISH	B	0	B	B	HIGH	B	B
AQUATIC INVERTS	B	0	B	B		B	B
ECOSTATUS	B/C	0	B/C	B/C		B/C	B/C

*ATTAINABLE CATEGORY

Flag: Refer to 24.2.3

The confidence in the results is summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	3	4	5	4
PES	4	3	4	4	4
Trajectory of change		4	3	3	4
EIS	3				
SI	3				

The confidence ranges from medium to high with most of the components in the medium-high range.

24.7 IFR SITES WITHIN THE RU

IFR 11 (Mooi River Falls) and IFR 12 (Gracelands) are situated in this RU. The ERC of the evaluated section (segment 26 to 29) is relevant for IFR 11. IFR 12 will be representative of the rest of the unit, that is in a much worse state, probably a D category. Addressing a range of Reserve scenarios will address both IFR 11 and IFR 12. A B, C and D category will therefore be addressed.

25. RU U: BUFFALO RIVER SEGMENT 1 - 26 (Utrecht/Osiswini road bridge to end of Lowland River Zone)

25.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 815.44 mcm

Geomorphology

An upland low gradient channel, often associated with uplifted plateau areas as occur beneath the eastern escarpment.

Riparian vegetation

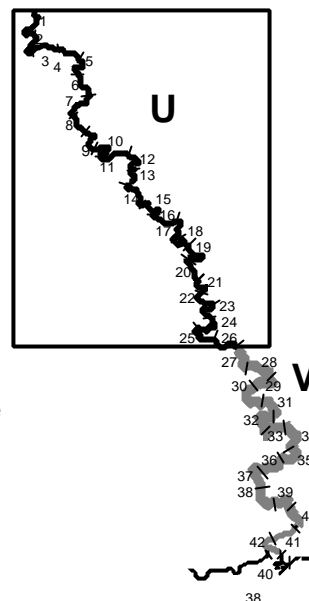
Mainly grassland comprising mixed grasses and forbs. Narrow riparian zone, mostly marginal, comprising reeds and sedges. In flatter areas, patches of alluvial woody species found within the narrow riparian zone. *Salix mucronata* in higher reaches of river and mixed *Combretum erythrophyllum* and *Salix mucronata* in lower reaches.

Fish

Anguilla mossambica, *Barbus anoplus*, *B. natalensis*, *B. paludinosus*, *Labeo rubromaculatus*, *Clarias gariepinus* and *Tilapia sparrmanii* would have been present here under natural conditions.

Aquatic invertebrates

This site should contain a high diversity of organisms, especially mayflies and in particular the species *Elassoneuria*. Several other flow dependent taxa would occur, including Hydropsychidae, Elmidae and Simuliidae.



Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'very high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	0	4	4	4	2

25.2 PES

25.2.1 PES, causes and sources

Table 25.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY PES: D/E					
Habitat change. Change in morphology.	Aggradation.	Catchment land-use, roads, gullies, tracks.	NFL	Catchment land-use management.	3
	Localised changes.	In-channel structures (weir, dam, bridges).	NFL	-	
RIPARIAN VEGETATION PES: D/E					
Reduced and degraded riparian zone. Shift in species composition. Change in distribution.	Farming lands to rivers edge leads to sediment accumulation. Exotic species encroachment. Reed encroachment.	Formal agriculture.	NFL	Improved agricultural practices.	4
		Catchment land-use activities.	NFL	Catchment land-use management and alien control programme.	
		Return flows.	NFL	Improved irrigation practices.	
FISH PES: C					
Fish kill (April 2000) * and population crash (system recovering from this). Population reduction.	Alien species.	Introduction of aliens, and escapees.	NFL	Alien control programme, and prevention of stocking.	3
	Water quality problems.	ISCOR, Newcastle.	NFL	In-house toxic effluent management.	
	Siltation.	Poor land management.	NFL	Erosion control.	
Aquatic Invertebrates PES: C/D					
Decrease in species diversity and altered community structure. High diversity of tolerant organisms but scarcity of intolerant organisms.	Water quality issues.	Catchment land-use activities, particularly coal mines.	NFL	Catchment land-use management activities.	4
	Abstraction.	Upstream impoundments and abstractions.	FL	Proper management of impoundments to supply the Reserve.	

* Note that this fish kill is seen as an isolated event, from which the system is likely to recover. Thus, the trajectory of change for fish is to do with overall conditions and the expectation of change under those.

25.2.2 Trajectory of change

Table 25.2 Trajectory of change, RU U

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Negative	D/E	D/E	D/E	4
	Aggrading, and pools will become shallower.				
Riparian vegetation	Negative	D/E	D/E	E	3
	Further bank erosion, sedimentation and exotic species invasion.				
Fish	Negative	C	C	C/D	3
	Continued water quality problems (and exacerbated by presence of carp which affect instream conditions).				
Aquatic invertebrates	Negative	C/D	C/D	D	3
	Deteriorating sediment conditions are likely to affect rocky biotopes.				

25.2.3 Summary and the resulting Ecostatus

The other drivers to be considered when providing the Ecostatus are:

Hydrology:

PES A.

Present MAR as % of virgin MAR:86%.

Water quality:

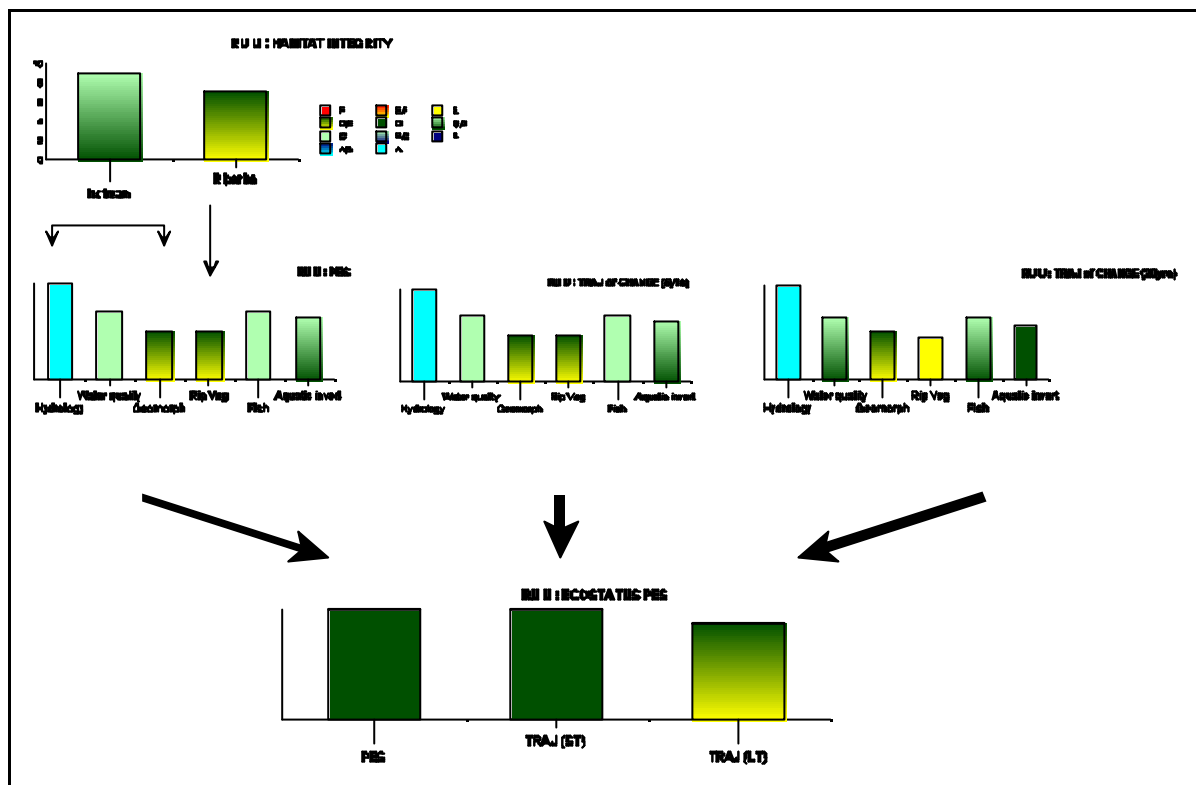
PES C.

(There is an extensive industrial area above the study area, including coal mining, ISCOR (increasing salt levels significant), an Eskom Power station, Karbochem (main impact is high COD levels), spillage from the Sewage Treatment Works into the Ngagane River, and subsequently into the Buffalo River. The Horn and Ngagane Rivers are therefore heavily affected by pollution. The water quality is particularly poor, with dilution in the Buffalo River. The Horn flows into the Ngagane below Chelmsford Dam. The Ngagane flows into the Buffalo).

(The Horn (a tributary of Ngagane which enters the Buffalo above the study area) has high TDS and sulphates due to coal mining in the area. Although this area is above the study area, data from the Horn monitoring point has been used as an indication of the severity of water quality problems which are input into this unit. It is assumed that this data illustrates worse conditions than the water quality in the unit but that it is to some extent reflective of conditions in the Buffalo).

The information on PES for the different components are summarised in Figure 25.1.

Fig 25.1 PES results and the resulting Ecostatus



Rationale for the Ecostatus

Both riparian vegetation and geomorphology is in a D/E state. This is due to non-flow related aspects and therefore does not reflect the hydrology which is in an A PES. The catchment is heavily utilised with land-use including commercial agriculture, coal mining, ISCOR etc. There are water quality problems as a result (PES C). The river is heavily invaded by carp. The geomorphological state is poor (PES D/E) and on a negative trajectory. Habitat integrity instream is a C/D, and riparian vegetation a D/E. The Ecostatus D reflects the overall state of the river and the continuing effect of declining states of geomorphology and water quality.

25.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: Species-rich fauna, with unique species present. Important as a migration route.

SI rating: Moderate
 Confidence: Medium to high
 Determinants: Human dependence on the river for water and plant resources. Sacred or cultural sites on the river.

25.4 AIM

The EIS is **moderate**, the social importance is **moderate** and the PES is a D category. The aim is to maintain the PES of D and to minimise the risk of degradation unless there are overriding reasons to improve conditions.

25.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<p><i>Non-flow related</i></p> <ul style="list-style-type: none"> Land use (aggradation, sedimentation, reed encroachment, exotic vegetation). Industry, coal mines, agriculture, ISCOR (water quality problems). 	<ul style="list-style-type: none"> Catchment land-use management. Alien vegetation eradication programme. Source Directed Controls. 	<ul style="list-style-type: none"> Very difficult. Reasonable. Very difficult.
<p><i>Flow related</i></p> <ul style="list-style-type: none"> Upstream dams (flow regulation). 	<ul style="list-style-type: none"> Operation to release the Reserve. 	<ul style="list-style-type: none"> Difficult.

The individual components are addressed as follows:

Table 25.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	C Y C/D	C	C/D
Geomorphology	D/E Y D/E	D	D/E
Riparian vegetation	D/E Y E	D	D
Fish	C Y C/D	C	C/D
Aquatic invertebrates	C/D Y D	C/D	D
Ecostatus	D Y D/E	D	D/E

Rationale for the Ecostatus

As both geomorphology and riparian vegetation are presently in unacceptable conditions (below D), they must be addressed. However, actions (apart from an alien vegetation control programme) required are considered 'very difficult'. Water quality is deteriorating in this RU and would need to be addressed through source directed controls. Due to the difficulty of addressing these problems, a D in the short term is not deemed attainable.

Note that water quality problems are serious in this section, coupled with a negative trajectory, and that it should be considered necessary to address water quality through Source Directed Controls.

25.6 SUMMARY OF RESULTS

The results are illustrated in Figure 25.2 below.

Fig 25.2 Summary of results

RU U : UTRECHT ROAD TO END OF LOWLAND ZONE							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	C	0	C	C/D	EIS M O D E R A T E	C	C/D
GEOMORPH	D/E	-	D/E	D/E		D	D/E
RIPARIAN VEGETATION	D/E	-	D/E	E		D	D
FISH	C	0	C	C/D	SI M O D E R A T E	C	C/D
AQUATIC INVERTS	C/D	0	C/D	D		C/D	D
ECOSTATUS	D	-	D	D/E		D	D/E

*ATTAINABLE CATEGORY

The confidence in the results are summarised below:

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	0	4	4	4	2
PES	2	3	4	3	4
Trajectory of change	2	4	3	3	3
EIS	4				
SI	3				

The confidence ranges from no confidence (water quality only) to medium-high confidence. Most of confidence range within the medium and medium-high range.

25.7 IFR SITE WITHIN THE RU

IFR 13 (Upper Buffalo) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

26. RU V: BUFFALO RIVER SEGMENT 27 - 42 (Start of Rejuvenated Bedrock Zone to Thukela Confluence)

26.1 REFERENCE CONDITIONS

Hydrology

Virgin MAR = 890.54 mcm

Geomorphology

Segment 27-31: Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.

Segment 32-42: Steepened section within middle reaches of the river caused by uplift, often within or downstream of a gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel activated only during infrequent flood events. A limited floodplain may be present between the active and macro-channel.

Riparian vegetation

A highly rocky riparian zone with limited woody riparian vegetation, mainly *Nuxia oppositifolia* and *Acacia* spp. due to the influence of bedrock on lateral movement of water to riparian zone. Marginal zone is expected in flatter areas characterised by mixed sedges and reeds in patches.

Fish

Anguilla marmorata, *A. mossambica*, *A. bengalensis*, *Barbus natalensis*, *B. trimaculatus*, *Labeo molybdinus*, *L. rubromaculatus*, *Clarias gariepinus* and *Oreochromis mossambicus* would be present under natural conditions.

Aquatic invertebrates

This RU would be dominated by flow-dependent taxa such as *Prosistoma*, *Centroptiloides*, *Anfronurus* and several species of Hydropsychidae. It is noteworthy that Oliff's (1963) data did not show any Hydropsychidae, but this may have been a reflection of the development that had already taken place in the catchment.

Confidence evaluation

The confidence is evaluated according to a score of 0-5 with zero reflecting 'no confidence' and 5 reflecting 'very high' confidence.

	Hydrology	Water quality	Geomorphology	Riparian Vegetation	Fish	Aquatic Invertebrates
Reference conditions	4	3	4	4	4	2

26.2 PES

26.2.1 PES, causes and sources

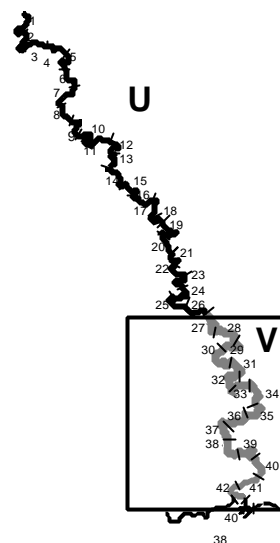


Table 26.1 PES, causes and sources

EFFECT	CAUSES	SOURCES	Flow related	Requirements to address	Confidence
GEOMORPHOLOGY		PES B/C			
Habitat change.	Sediment aggradation.	Upstream catchment land-use.	NFL	Catchment land-use management.	4
RIPARIAN VEGETATION		PES: B/C			
Reduced riparian zone. Reduced vegetation cover.	Trampling and grazing.	Livestock activity and overgrazing.	NFL	Control of livestock.	4
FISH		PES: C			
Fish kill April 2000 (see notes for RU U). Population reduction.	Pollution.	ISCOR, Newcastle.	NFL	In-house toxic effluent management.	3
	Siltation (erosion of upper catchment)	Poor land-use management.	NFL	Erosion control.	
AQUATIC INVERTEBRATES		PES: B			
Only loss of the most sensitive species.	Water quality.	Catchment land-use activities, especially coal mines and agriculture.	NFL	Maintenance of the good water quality status.	3

26.2.2 Trajectory of change

Table 26.2 Trajectory of change, RU V

Component	Trajectory of change	PES	Short-term (5 yrs)	Long-term (20 yrs)	Confidence (0-5)
Geomorphology	Stable	B/C	B/C	B/C	4
	Position in the landscape. Steep gradient. Resilient section.				
Riparian vegetation	Negative	B/C	B/C	C	3
	Continued grazing leading to sedimentation.				
Fish	Stable	C	C	C	3
	Gradient has caused it to accumulate about as much silt as it is likely to. Equilibrium between fish and habitat.				
Aquatic invertebrates	Stable	B	B	B	3
	Biotores unlikely to change on the basis of stable geomorphology.				

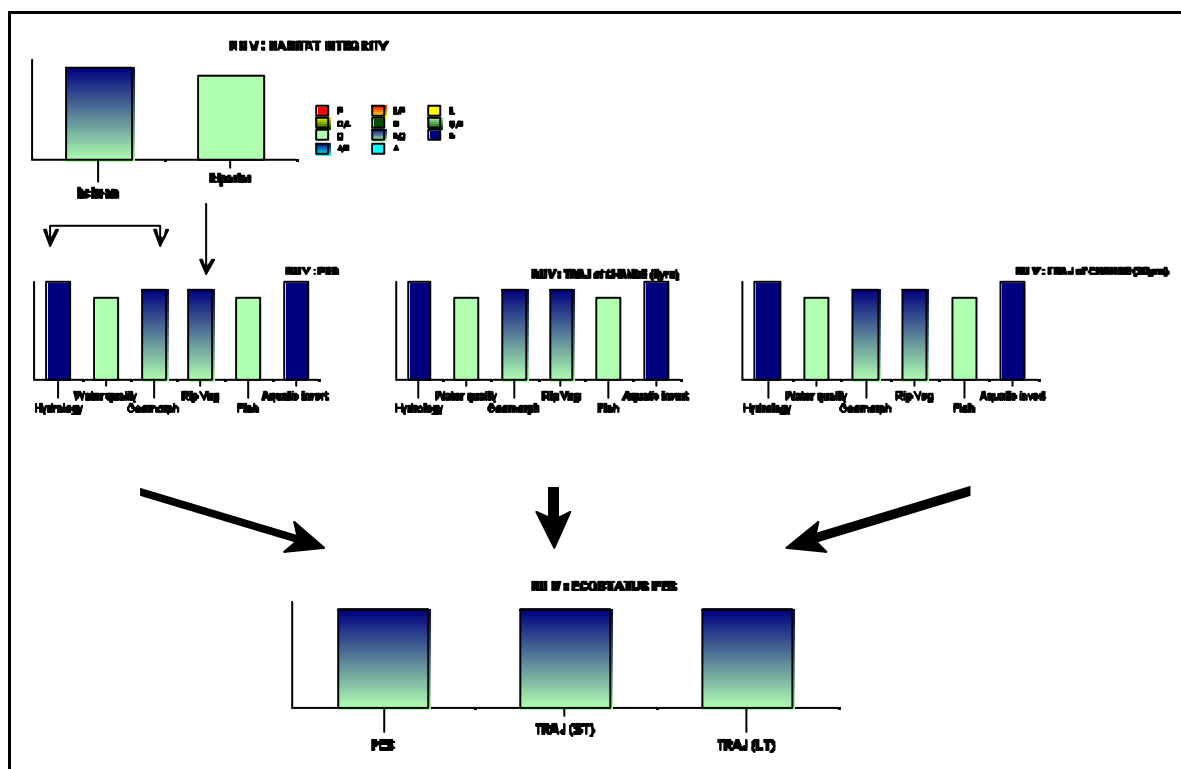
26.2.3 Summary and resulting Ecstatus

The other drivers to be considered when providing the Ecstatus are:

Hydrology: PES B.
 Water quality : PES C.
 (High sulphates, TDS, nutrients. The site is at the lower end of this unit. Low confidence.).

The information on PES for the different components is summarised in Figure 26.1.

Fig 26.1 PES results and the resulting Ecstatus



Rationale for the Ecostatus

The PESs for all the components vary between a C and a B. The drivers are in an B (hydrology), a C (water quality) and a B/C (geomorphology). The instream Habitat Integrity which integrates all the drivers are in a B/C condition and it was decided that this category is representative of the PES of this unit. The Ecostatus was therefore set as a B/C category.

26.3 ECOLOGICAL AND SOCIO-CULTURAL IMPORTANCE

The results of the Socio-Cultural Importance (SI) and Ecological Importance and Sensitivity (EIS) are attached as Appendix G.

EIS rating: Moderate
 Confidence: High
 Determinants: High species richness, with unique and flow-sensitive species present. High habitat diversity and importance as a migration route.

SI rating: High
 Confidence: High
 Determinants: Human dependence on the river for water supplies, plant resources and subsistence fishing. Sacred sites or rituals associated with this section. Places of historical or archaeological importance. Special features or places of beauty in the river, and strong sense of place.

26.4 AIM

The EIS is **high**, the social importance is **high**, and the PES is B/C. Whereas the aim would normally be to maintain the PES and minimise the risk of degradation, the ecological and social importance in this unit is high and there are thus overriding reasons to improve conditions. The aim is therefore to **improve** the PES from a B/C to a B.

26.5 ATTAINABLE ERC

The sources and actions required to address these are summarised below. Reference is made to the related causes, in brackets. The degree of difficulty associated with this are also included.

Sources	Action	Degree of difficulty
<i>Non-flow related</i> <ul style="list-style-type: none"> • Agriculture (sedimentation and aggradation). • ISCOR, Newcastle , agriculture (water quality). 	<ul style="list-style-type: none"> • Land-use management. • Source Directed Controls. 	<ul style="list-style-type: none"> • Very difficult.

The individual components are addressed as follows:

Table 26.3 Ecological Reserve Category (ERC) for each component

Component	PES & traj	ERC to achieve AIM	Attainable category taking degree of difficulty into account
Water quality	C Y C	B	C
Geomorphology	B/C Y B/C	B/C	B/C
Riparian vegetation	B/C Y C	B/C	C
Fish	C Y C	B/C	C
Aquatic invertebrates	B Y B	B	B
Ecostatus	B/C Y B/C	B	B/C

Rationale for the ERC

The overall aim is to improve the RU to a B category. However, to achieve this it will be necessary to improve water quality to a B and to maintain the PES of geomorphology, riparian vegetation and fish. For the latter to be addressed, sedimentation issues will need to be addressed and that is expected to be 'very difficult'. Therefore in the short-term, the focus must be on maintaining the PES, while attempting to attain the ERC of a B in the long-term.

26.6 SUMMARY OF RESULTS

The results are illustrated in Figure 26.2 below.

Fig 26.2 Summary of results

RU V : REJUVENATED BEDROCK ZONE TO THUKELA CONFLUENCE (<i>segm 27 - 42</i>)							
COMPONENTS	PES	TRAJ	SHORT TERM, 5Y	LONG TERM, 20Y	IMP	RECOMMENDED ERC	ATTAIN' CATEG
WATER QUALITY	C	0	C	C	MODERATE	B	C
GEOMORPH	B/C	0	B/C	B/C		B/C	B/C
RIPARIAN VEGETATION	B/C	-	B/C	C		B/C	C
FISH	C	0	C	C	HIGH	C	C
AQUATIC INVERTS	B	0	B	B		B	B
ECOSTATUS	B/C	0	B/C	B/C		B	B/C

*ATTAINABLE CATEGORY

The confidence in the results is summarised below.

	Water quality	Geomorph	Riparian Vegetation	Fish	Aquatic Inverts
Reference conditions	3	4	4	4	2
PES	2	4	4	3	3
Trajectory of change	3	4	3	3	3
EIS	4				
SI	3				

The confidence ranges from medium-low to medium high with most of the components in the medium and medium-high range.

26.7 IFR SITE WITHIN THE RU

IFR 14 (Lower Buffalo) is situated in this RU. The PES of the RU reflects the PES and therefore ERC of the IFR site.

The Reserve scenarios that will be addressed is a B and C.

27. SUMMARY OF RESULTS

The results are summarised below and presented in various figures at the end of the chapter.

27.1 THUKELA RIVER

The best section of the Thukela River is the most upstream section (due to little development) and the section in the gorge upstream of the Bloukrans River confluence (due to inaccessibility). The proposed Jana Dam site is situated in this gorge.

The most modified sections in the Thukela River lie between Driel and Spioenkop Dams (due to the operation of the dams) and the downstream section around Mandini (due to water quality and sedimentation problems).

The only sections with high ecological importance is the gorge section in which Jana Dam site is situated and the river downstream of the Buffalo River. The aim and resulting ERC for the Jana section is therefore an improvement on the PES. The ERC for the river downstream of the Buffalo section is not an improvement on the PES as there is not sufficient motivation.

The section downstream from the Klip River has a higher SI than the EIS. No improvement is however warranted as the PES is a B and the recommended ERC is already a B. The section of river downstream of the Bushmans River also has a high SI compared to the moderate EIS. The improvement that will have to be undertaken to halt the negative trajectory of change should ensure that the present resource utilisation would improve.

27.2 LITTLE THUKELA RIVER

The Little Thukela is in a moderately modified to modified state (C and C/D) mostly due to informal and formal landuse. The importance is moderate and no improvement except to halt negative trajectories are required.

27.3 BUSHMANS RIVER

The Bushmans is presently in a moderately modified to largely natural PES above Wagendrift Dam and in the gorge sections downstream of Wagendrift Dam. In the more accessible areas there are extensive irrigation activities which results in a D PES. The importance is high in the gorge section. Improvement is however not required as maintaining the gorge sections will result in improvement in the other sections.

27.4 SUNDAYS RIVER

The Sundays River is largely modified due to both informal and formal land use as well as specifically water quality problems. The ecological importance is moderate with a high social importance in the lower section. This does not however warrant improvement on the PES as improvement to address the negative trajectory of change will improve the social utilisation aspects.

27.5 MOOI RIVER

The specific section of the Mooi River which forms part of the study area varies from a high PES in the gorge sections to seriously modified areas in the irrigation and rural areas. The Ecological Importance is moderate with high social importance in the downstream areas. Improvement is again not required as addressing the trajectory of change will address the social issues.

27.6 BUFFALO RIVER

The Buffalo River ranges from D category in the upper ranges (mostly due to formal agriculture and water quality problems) to a high PES in the gorge sections (mostly due to its inaccessibility). The high ecological importance in this section warrants improvement and the ERC was therefore set as a half a category higher than the PES.

Table 27.1 Summary of the PES, EIS, SI and ERC results

RU	PES	EIS	SI	ERC (Short term ERC)
THUKELA RIVER				
A	B/C	Moderate	Moderate	B/C
B	D	Moderate	Low	D
C	C	Moderate	Moderate	C
D	C	Moderate	Moderate	C
E	B	Moderate	High	B
F	B/C	High	High	B (B/C)
G	C/D	Moderate/High	Moderate	C/D
H	D	Moderate	Moderate	D
I	C	High	High	C (C/D)
J	C/D	Moderate	Moderate	C/D (D)
KLEIN THUKELA				
L	C	Moderate	Moderate	C (C/D)
M	C/D	Moderate	Moderate	C/D (D)
BUSHMANS				
N	B/C	Moderate	Moderate	B/C
O	D	Moderate	Moderate	D
P	B/C	High	Moderate	B/C
SUNDAYS				
Q	C/D	High	High	C/D
R	D	Moderate	High	D
MOOI				
S	C	Moderate	Moderate	C
T	B/C	Moderate	High	B/C
BUFFALO				
U	D	Moderate	Moderate	D (D/E)
V	B/C	Moderate	High	B (B/C)

Fig 27.1 Upper Thukela Results

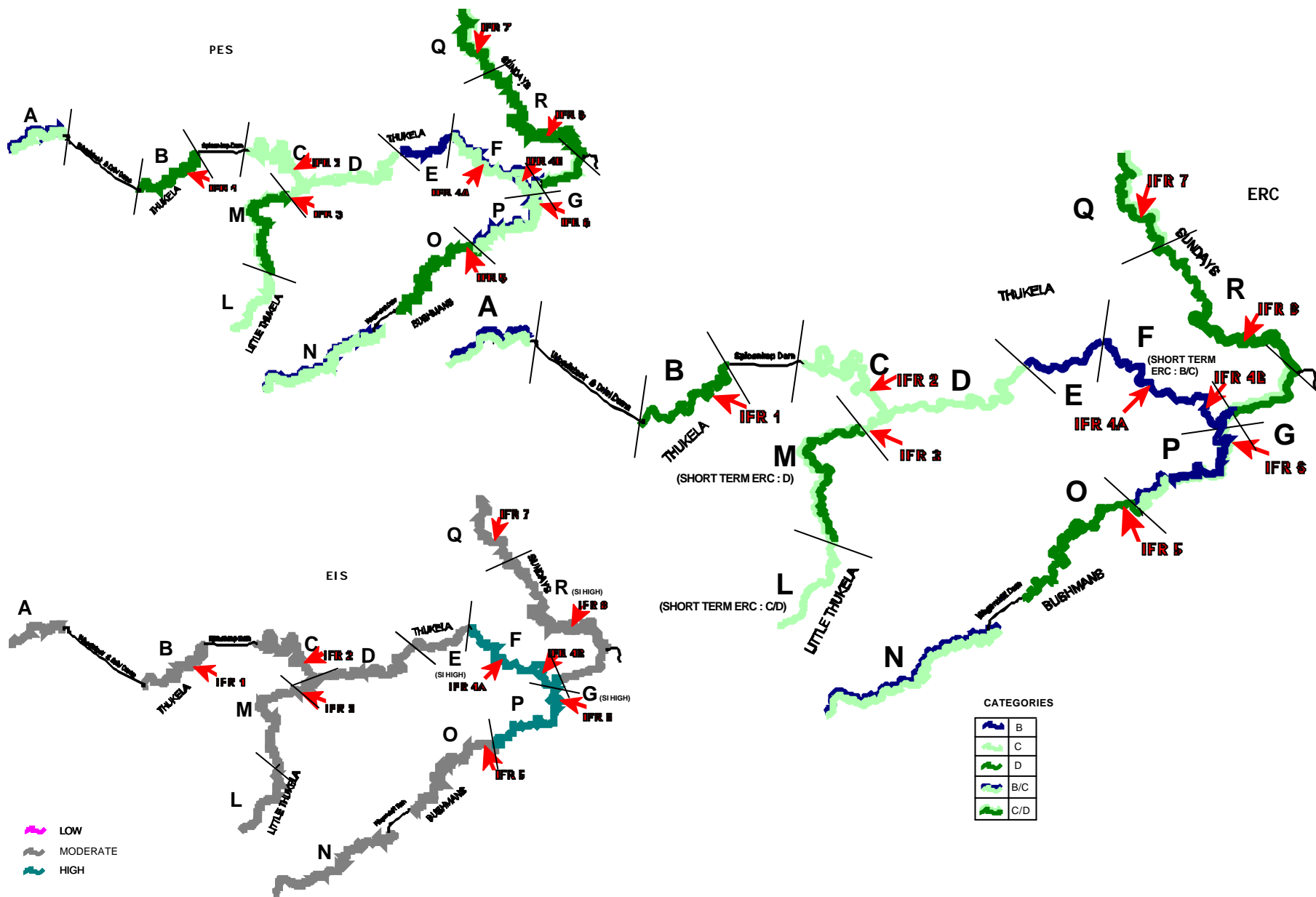
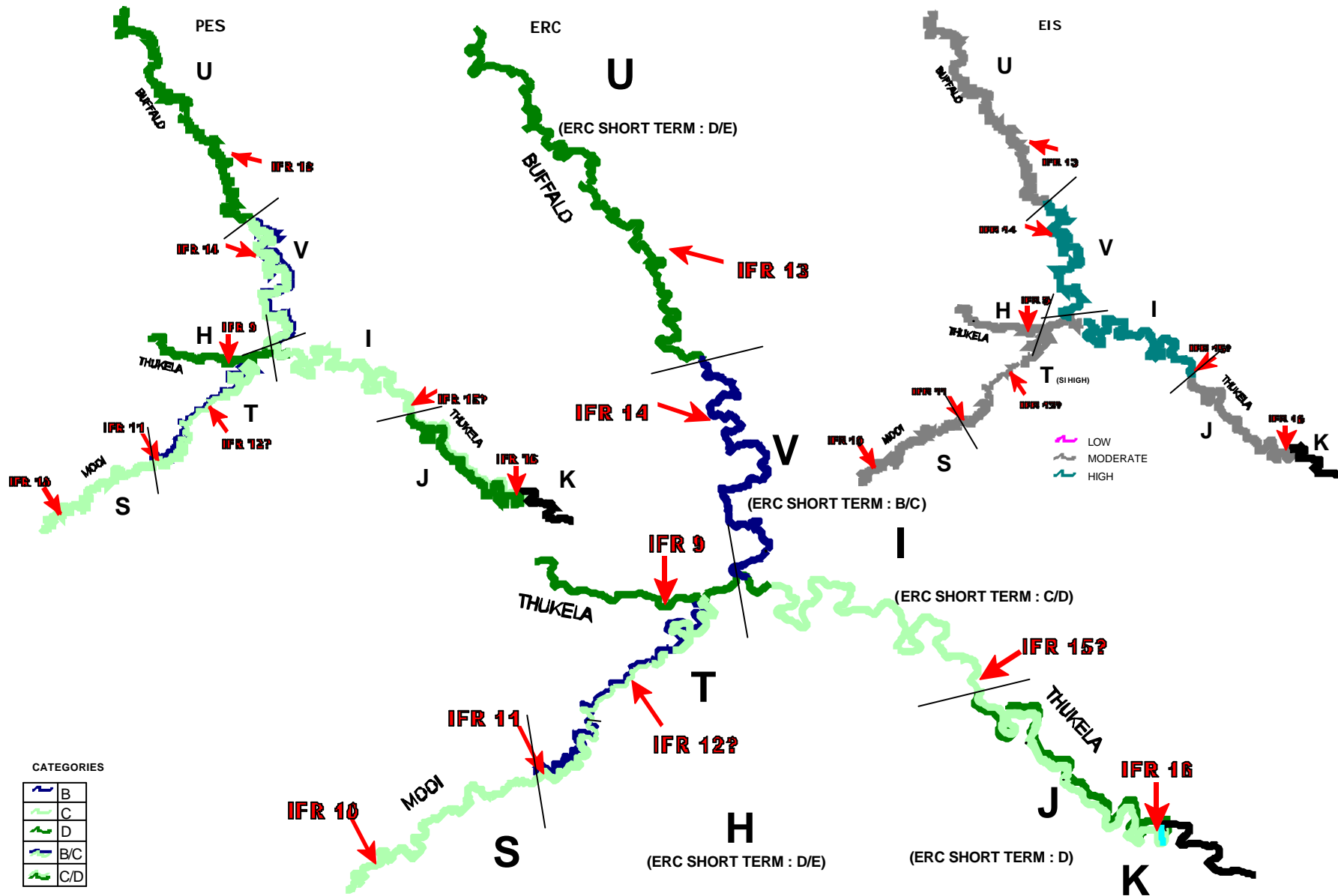


Fig 27.2 Lower Thukela Results



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