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Republic of South Africa
Department of Water Affairs and Forestry

THUKELA WATER PROJECT DECISION SUPPORT PHASE

RESERVE DETERMINATION MODEL

RESOURCE UNIT REPORT

January 2003

Prepared by
IWR Environmental

THUKELA WATER PROJECT DECISION SUPPORT PHASE

RESERVE DETERMINATION STUDY
RESOURCE UNIT REPORT

January 2003

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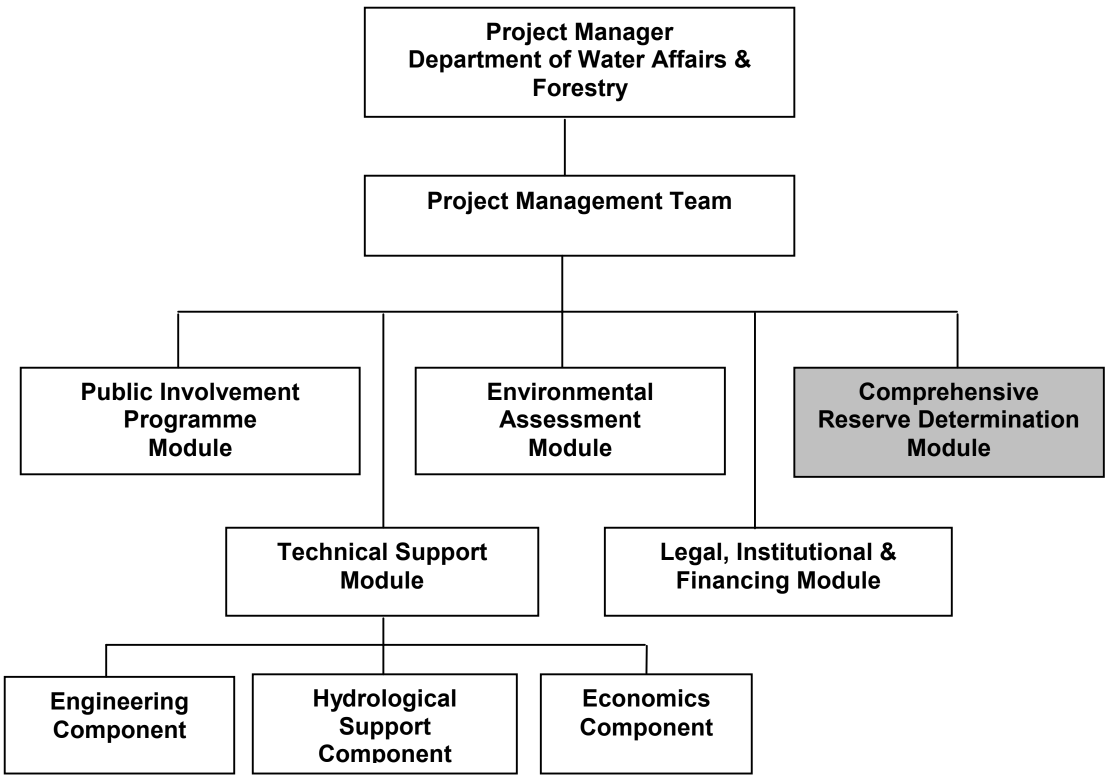
STRUCTURE OF DECISION SUPPORT PHASE



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**

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EXECUTIVE SUMMARY

The Reserve Determination module involves quantification of the water resource required to meet particular objectives for the Thukela system under a series of scenarios that will be defined during the course of the study. From the Reserve Determination study, information will be made available in a manner that will allow the Project Management Team (PMT) of the Thukela Water Project (TWP) to make informed recommendations and decisions for the way forward.

The "Reserve Determination" Module (Module 3 of 5 for the Thukela Water Project Decision Support Phase) is designed to meet the requirements of the National Water Act No 108 of 1998. This Module is one of five inter-related studies required for the TWP Decision Support Phase.

The Thukela system is the 2nd largest South African River (in terms of MAR) and the main Thukela River alone is approximately 500 km long. It is therefore necessary to break the whole catchment into water Resource Units (RUs) which are significantly different from the other to warrant their own specification of the Reserve and to clearly delineate the geographic boundaries of each. Within some of the RU, specific sites are selected where the quantity component of the Ecological Reserve is determined. These sites are called Instream Flow Requirements (IFR) sites.

The purpose of this report is to
- describe the study area;
- describe the process followed to define the RUs;
- provide the quantity and quality RUs;
- describe the process followed to select IFR sites within the RUs.

Study area

The study area is as follows:

- Thukela River from Rugged Glen Nature Reserve.
- Little Thukela River (Injasuthi) downstream from Wonder Valley base to the Thukela River confluence.
- Bushmans River (uMchezi) from Elands Park to the Thukela River confluence.
- Mooi River from the Little Mooi River confluence to the Thukela River confluence.
- Sundays River from the Newcastle/Ladysmith road bridge to the Thukela River confluence.
- Buffalo River (Mzinyathi) from the Utrecht/Ozisweni road bridge to the Thukela River confluence.

Estuary zonation

The estuary is seen as one Resource Unit which is broken down into zones.

The geographical boundaries of an estuary are defined as follows:
- Downstream boundary - the estuary mouth.
- Upstream boundary - the extent of tidal influence, i.e. the point where tidal variation in water levels can still be detected.
- Lateral boundaries - the 5m contour above MSL along each bank.

A map and figures of the estuary are supplied in Chapter 3.

Geomorphological classification

The physical structure of a river system is determined by the geomorphological processes which shape the channel. Geomorphology therefore provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems.

The hierarchical classification system of Rowntree and Wadeson (1999) is based on a combination of desk top and field approaches and aims to provide a scale-based framework linking the various components of the river system, ranging from the catchment to the instream habitat. The system consists of six levels: the catchment, the segment, the zone, (desktop analysis) the reach, the morphological unit, the hydraulic biotope (desktop and field work required). As this classification is a desktop study, it will be undertaken to a zonal level. The results are provided in Figures 4.5a and b.

River Habitat integrity

The habitat integrity is an assessment of the amount of change in habitat condition from reference conditions which has taken place. The habitat integrity method that was used is the established method as determined by CJ Kleynhans (DWAF, 1999) by assessing the river longitudinally by means of a continuous aerial video taken at low level from a helicopter. A detailed assessment of the habitat integrity for the instream and riparian components of the rivers within the selected study area on a 5 km basis is supplied.

The results are supplied in Figures 5.17 and 5.18.

Quantity Resource Units

The breakdown of a catchment into RUs for the purpose of determining the Reserve for rivers is done primarily on a biophysical basis, according to the occurrence of different ecological regions (eco-regions) within the catchment. Since the endpoint of a Reserve determination is an ecological one, the idea is to break down the catchment into units which are relatively homogenous on an ecological basis, to ensure the ecological Reserve is set in appropriate terms. (DWAF, 99, vol. 3)

The breakdown into RUs via ecoregions and/or geohydrological response units could then be further resolved into smaller RUs which are suited to management requirements. (DWAF 99, vol 3). An example could be where large dams occur in the area and/or transfer schemes. The difference in operation of different river reaches also result in biophysically different river reaches and should be considered.

The process for determining Rus considers a variety of factors, as well as results of the Habitat Integrity assessment (Chapter 5). Overlaying all the data does not necessarily result in a logical and clear delineation and expert judgement, a consultative process and local knowledge are required to determine the RUs. The practicalities of dealing with numerous reaches within one study must also be considered to determine a logical and practical suite of RUs.

The following were considered when selecting the RU:

- Ecoregions (provided by IWQS, DWAF) (see chapter 6).
- Geomorphological classification (see chapter 4).
- Operation of the systems.
- Hydrology .
- Habitat integrity (see chapter 5).
- Local knowledge and expert judgement.

The results of the RU are provided in the figures at the end of the executive summary.

Quality Resource Units

The identified river reaches homogenous in terms of water quality which will form water quality RUs are documented. The initial selection of water quality RUs will be influenced by activities in the catchment, the availability of water quality data and the length of the data series. The following process is followed to select the water quality RUs.

- Determine the location of DWAF water quality monitoring points, and their proximity to IFR sites.
- Determine the availability of water quality data.
- Assess the quality of data (e.g. length of data series).
- Identify sites in the study area requiring additional water quality data collection.
- Identify catchment characteristics e.g. tributaries, dams.
- Identify catchment activities and sites with potential quality problems.
- Access information on the "system operational rules" (e.g. dam management) of the catchment, and identify potential effects on water quality.
- Assess additional data collection from catchment excursions and evaluate identified Quality RUs.
- Final selection of quality RUs.

The following quality RUs differed from the quantity RUs. Note : The quantity RUs are the driving force for the study and the numbered units (A to V) always refer to the quantity RUs.
RU B: Consists of two quality RUs.
RU F: Consists of two quality RUs.
RU H: Consists of two quality RUs.
RU M: Consists of two quality RUs.
RU O: Consists of two quality RUs and the downstream RUs end point does not coincide with the border of RU O.
RU P: Consists of two quality RUs of which the upstream quality unit continues from the downstream quality unit in RU O.
RU Q :Consists of a quality RU which end point does not coincide with the border of RU O.
RU R: Consists of two quality RUs of which the upstream quality unit continues from the quality unit in RU Q.
RU S: Consists of two quality RUs and the downstream RUs end point does not coincide with the border of RU S.
RU T: Consists of two quality RUs of which the upstream quality unit continues from the downstream quality unit in RU S.

IFR sites

IFRs are set at specific points at the river. These points are called IFR sites and are critical sites within a reach of river. The IFR sites should answer to certain criteria and a sequential process to determine the IFRs are required. The criteria is listed below:

- The locality of gauging weirs with good quality hydrological data.
- The locality of the proposed developments.
- The locality and characteristics of tributaries.
- The habitat integrity/conservation status of the different river reaches.
- The reaches where social communities depend on a healthy river ecosystem.
- The suitability of the sites for follow-up monitoring.
- **The habitat diversity for aquatic organisms, marginal and riparian vegetation.**
- **The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially low flows.**
- **Accessibility of the sites.**
- **An area or site that could be critical for ecosystem functioning. This is often a riffle which will stop flowing during periods of low or no flow. Cessation of flow constitutes a break in the functioning of the river. Those biota dependant on this habitat and/or on continuity of flow will be adversely affected. Pools are not considered as critical since they are still able to function as refuge habitats during periods of no flow.**
- The locality of geomorphological reaches and representative reaches within the geomorphological reaches.

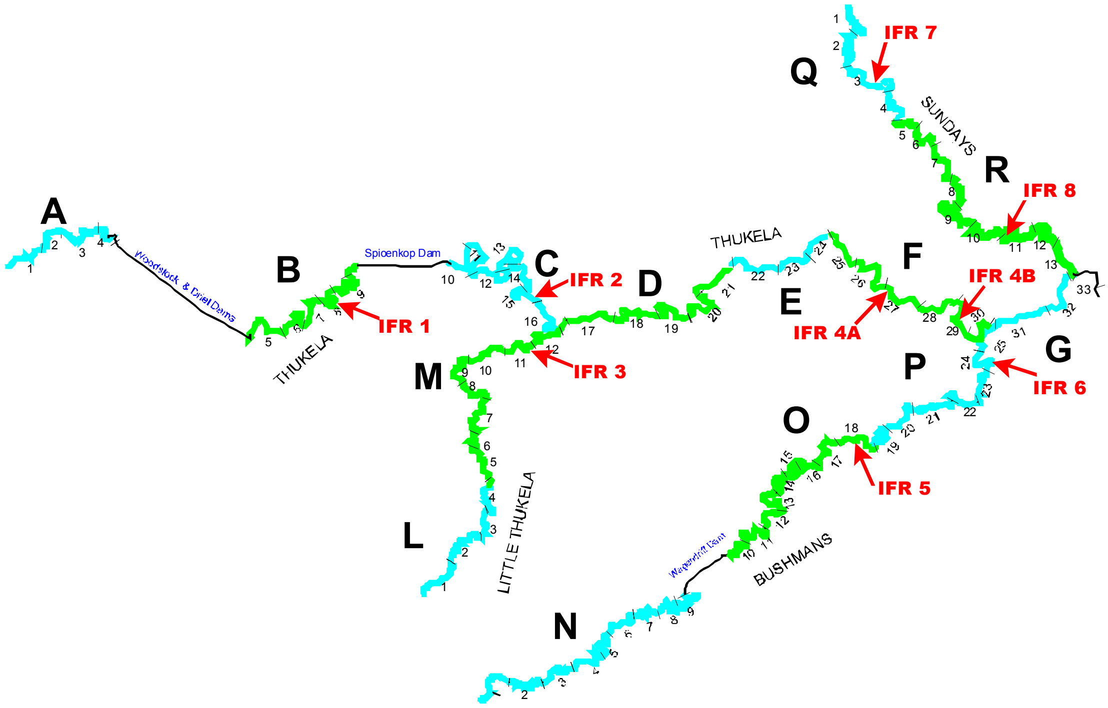
The criteria in bold are the most important and therefore the overriding criteria.

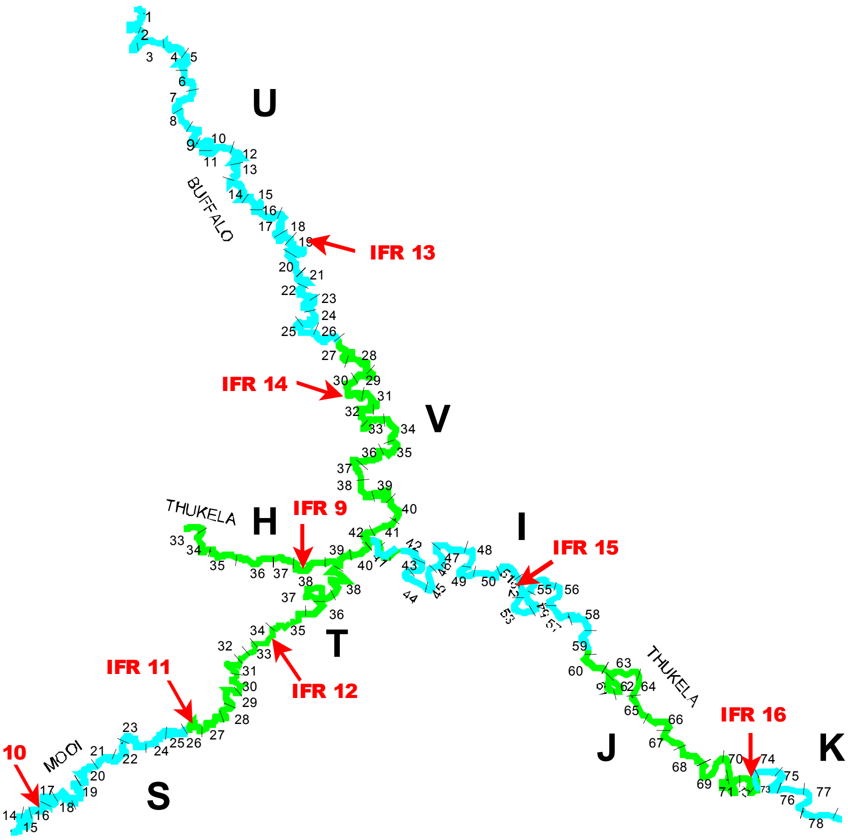
Seventeen IFR sites were selected, nine in the Upper Thukela and eight in the lower Thukela. The following sites are existing sites for which some level of relevant information is available.

- IFR 1
- IFR 2
- IFR 4A
- IFR 4B
- IFR 5
- IFR 6
- IFR 9
- IFR 10
- IFR 11
- IFR 12

The localities of the IFR sites are illustrated in the figures at the end of the executive summary.

The sites were selected from an aerial video and groundtruthed through site visits.


A
B
C
D
E
F
G
L
M
N
O
P
Q
R
THUKELA
THUKELA
SUNDAYS
LITTLE THUKELA
BUSHMANS
Spioenkop Dam
IFR 1
IFR 2
IFR 3
IFR 4A
IFR 4B
IFR 5
IFR 6
IFR 7
IFR 8


U
V
H
I
T
S
J
K
BUFFALO
THUKELA
THUKELA
MOOI
IFR 9
IFR 10
IFR 11
IFR 12
IFR 13
IFR 14
IFR 15
IFR 16

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

CMS	Catchment Management Strategy
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
ERC	Ecological Reserve Category
GPS	Global Positioning System
IFR	Instream Flow Requirement
IWQS	Institute for Water Quality Services
HIS	Hydrological Information System
LB	Left Bank
MAR	Mean Annual Runoff
MSL	Mean Sea Level
mybp	Million years before present
PES	Present Ecological State
PMT	Project Management Team
WQ	Water Quality
RB	Right Bank
RC	Reference Condition
RU	Resource Unit
SASS	South African Scoring System
TDS	Total Dissolved Salts
TSS	Total Suspended Solids
TWP	Thukela Water Project

1. INTRODUCTION

In this Chapter:

1.1 BACKGROUND

The Reserve Determination module involves quantification of the water resource required to meet particular objectives for the Thukela system under a series of scenarios that will be defined during the course of the study. From the Reserve Determination study, information will be made available in a manner that will allow the Project Management Team (PMT) of the Thukela Water Project (TWP) to make informed recommendations and decisions for the way forward.

The Reserve Determination Module is designed to meet the requirements of the National Water Act No 108 of 1998. This Module is one of five inter-related studies required for the TWP Decision Support Phase.

The Thukela system is the 2nd largest South African river (in terms of MAR) and the main Thukela River alone is approximately 500 km long. It is therefore necessary to break the whole catchment into water Resource Units (RUs) which are significantly different from the other to warrant their own specification of the Reserve and to clearly delineate the geographic boundaries of each. Within some of the RU, specific sites are selected where the quantity component of the Ecological Reserve is determined. These sites are called Instream Flow Requirements (IFR) sites.

1.2 PURPOSE OF THE REPORT

The purpose of this report is

- to describe the study area;
- to describe the process followed to define the RUs;
- to provide the quantity and quality RUs;
- to describe the process followed to select IFR sites within the RUs.

1.3 REPORT STRUCTURE

This report combines various aspects of the study area (see Chapter 2) that relates to delineation of the resource units and IFR sites. The chapters are summarised as follows:

1.3.1 Estuary zonation (Chapter 3)

The estuary is seen as one Resource Unit which is broken down into zones.

The geographical boundaries of an estuary are defined as follows:

- Downstream boundary - the estuary mouth.
- Upstream boundary - the extent of tidal influence, i.e. the point where tidal variation in water levels can still be detected.
- Lateral boundaries - the 5m contour above MSL along each bank.

In this chapter the boundaries are mapped using aerial photographs and/or orthophoto maps.

1.3.2 Geomorphological classification (Chapter 4)

The physical structure of a river system is determined by the geomorphological processes which shape the channel. Geomorphology therefore provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems.

The hierarchical classification system of Rowntree and Wadeson (1999) is based on a combination of desk top and field approaches and aims to provide a scale-based framework linking the various components of the river system, ranging from the catchment to the instream habitat. The system consists of six levels: the catchment, the segment, the zone, (desktop analysis) the reach, the morphological unit, the hydraulic biotope (desktop and field work required). As this classification is a desktop study, it will be undertaken to a zonal level and described in this chapter.

1.3.3 River Habitat integrity (Chapter 5)

This chapters provides a detailed assessment of the habitat integrity for the instream and riparian components of the rivers within the selected study area on a 5 km basis.

The habitat integrity is an assessment of the amount of change in habitat condition from reference conditions which has taken place. The habitat integrity method that will be used is the established method as determined by CJ Kleynhans (DWAF, 1999) by assessing the river longitudinally by means of a continuous aerial video taken at low level from a helicopter. .

1.3.4 Define the quantity RUs (Chapter 6)

The process that is used to define the RU is described as well as all the factors that are used to determine the RU. The results are provided in map format.

1.3.5 Define the quality RUs (Chapter 7)

In this chapter the identified river reaches homogenous in terms of water quality which will form water quality RUs are documented. Ecological classes will be set for the identified water quality RUs in terms of water quality, and the selection of sites for scenario modelling will be influenced by available water quality data. The initial selection of water quality RUs will be influenced by activities in the catchment, the availability of water quality data and the length of the data series.

1.3.6 IFR site selection (Chapter 8)

IFRs are set at specific points at the river. These points are called IFR sites and are critical sites within a reach of river. The IFR sites should answer to certain criteria and a sequential process to determine the IFRs are required. The results and process are documented in this chapter.

2. STUDY AREA

In this Chapter:
Study area description

The study area has broadly been defined as the Thukela catchment. The Thukela Catchment is however too large to address in a cost-effective way at a comprehensive level. The main Thukela River is therefore addressed as well as the major portions of the most significant (from a hydrology viewpoint) tributaries:

- Thukela River from Rugged Glen Nature Reserve.
- Little Thukela River (Injasuthi) downstream from Wonder Valley base to the Thukela River confluence.
- Bushmans River (uMchezi) from Elands Park to the Thukela River confluence.
- Mooi River from the Little Mooi River confluence to the Thukela River confluence.
- Sundays River from the Newcastle/Ladysmith road bridge to the Thukela River confluence.
- Buffalo River (Mzinyathi) from the Utrecht/Ozisweni road bridge to the Thukela River confluence.

The study area is illustrated in the Figures 2.1 to 2.3.

Fig 2.1: Thukela Reserve study area

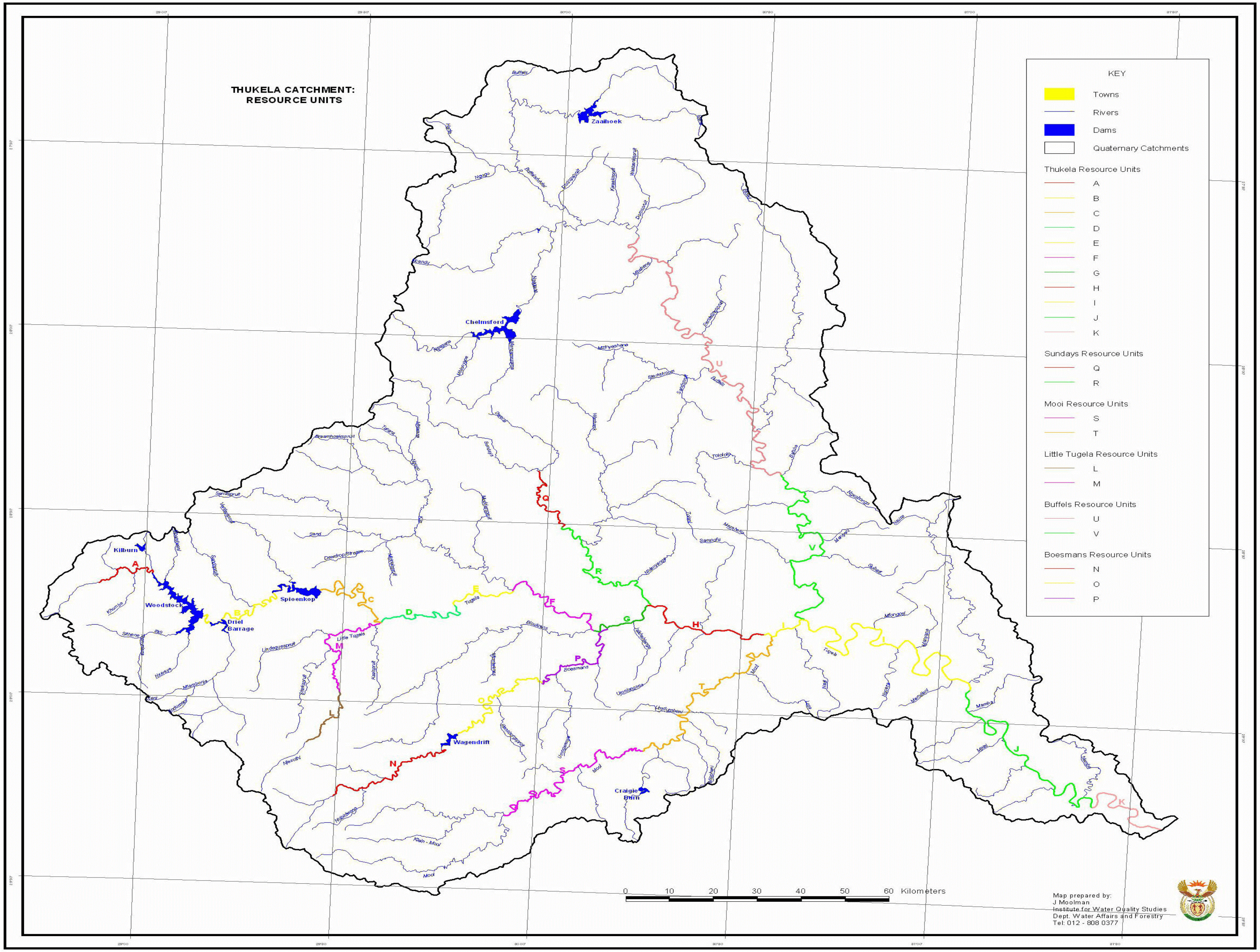


Fig 2.2: Upper Thukela Reserve study area

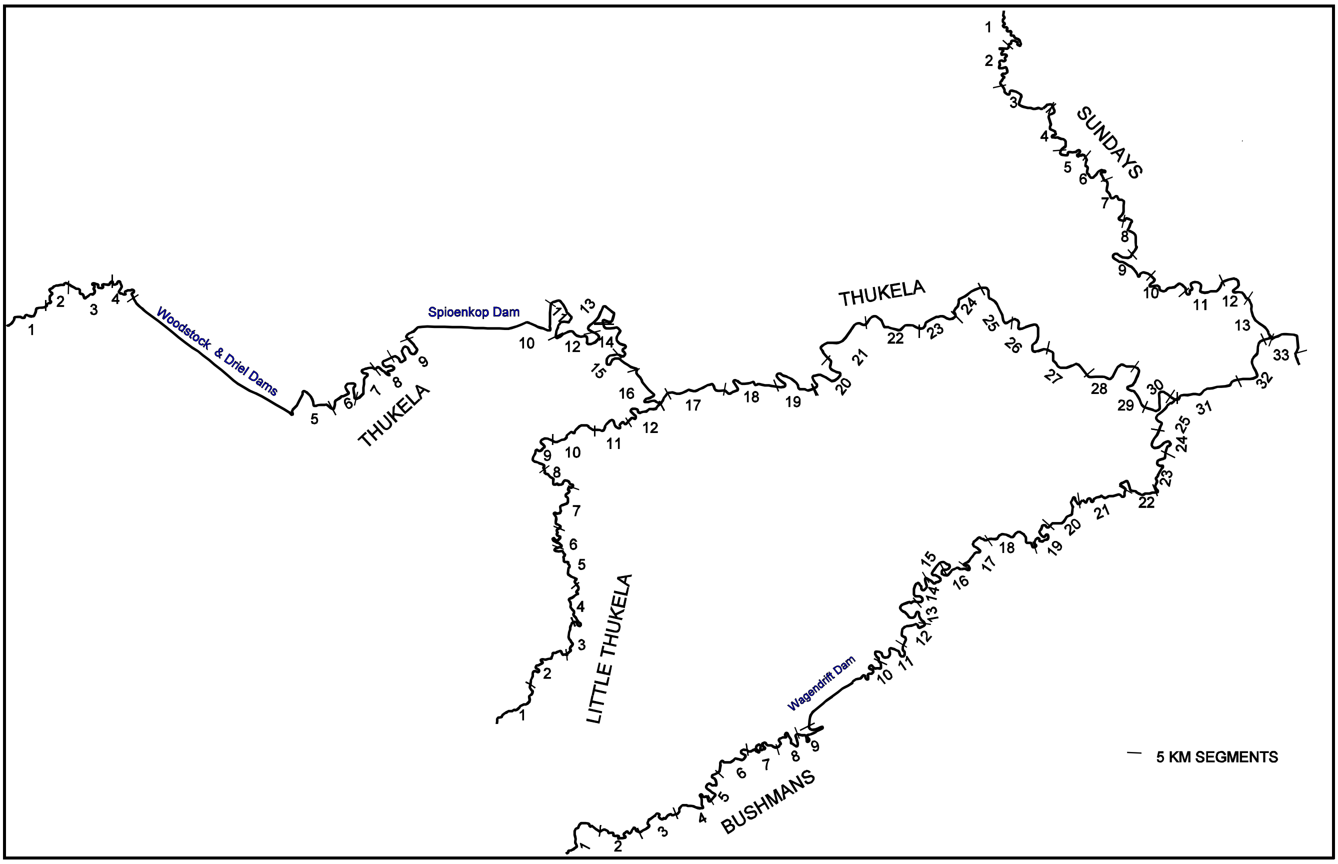
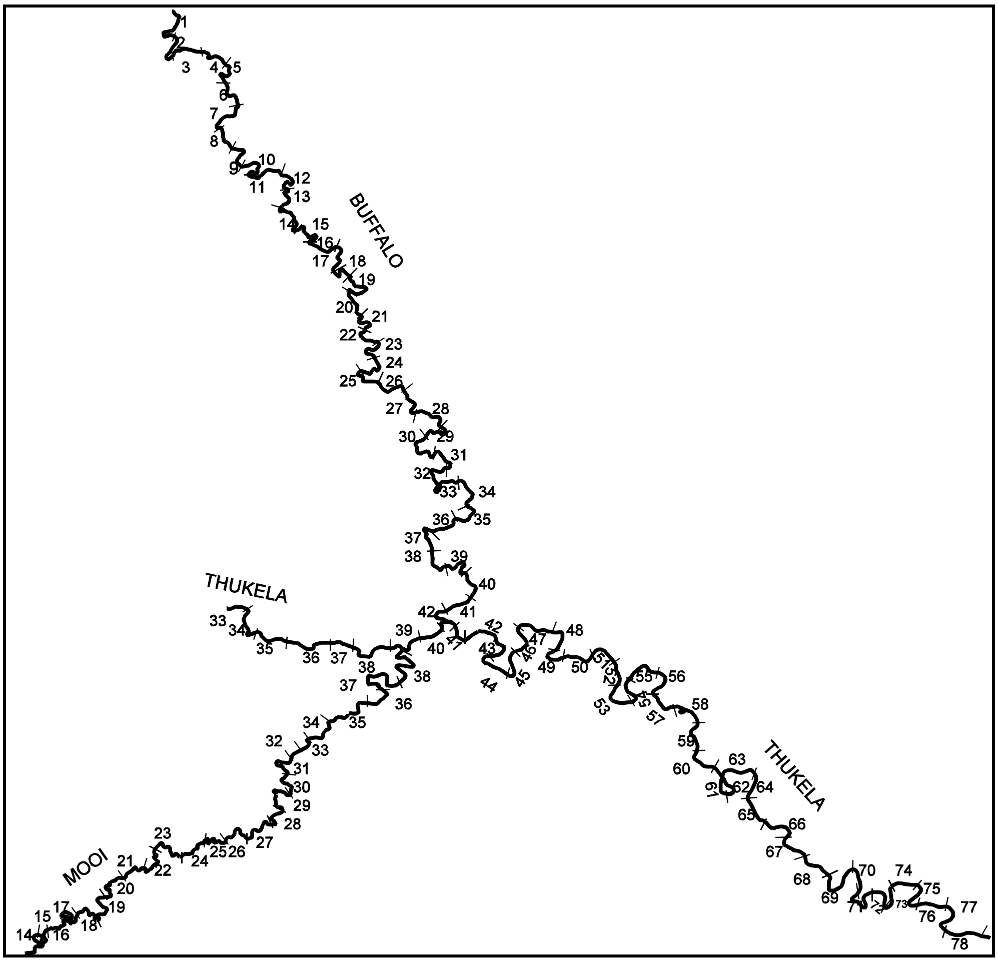


Fig 2.3: Lower Thukela Reserve study area



Note that the study area was delineated into two sections, Upper and Lower (Figure 2.2 and 2.3). This was done for purely practical purposes due to the size of the study area. The delineation was based on size and an equal amount of IFR sites in each section. The logical break was the Sundays River confluence.

The Upper Thukela therefore includes the Thukela River to the Sundays confluence, the Little Thukela, Bushmans and Sundays Rivers. The Lower Thukela includes the rest of the Thukela River, the Buffalo and Mooi Rivers.

3. ESTUARY DELINEATION

> ***In this Chapter:***
> 3.1 Background information
> 3.2 Geographical boundaries

3.1 BACKGROUND INFORMATION

The Thukela Estuary lies midway between Durban and Richards Bay, 10km to the east of the national road bridge, 14km to the south east of the town of Mandini and 104 km from Durban (Quinn and Whitfield 1999).

The estuary is classified as a subtropical river mouth (Whitfield 1998, Whitfield 2000), while Harrison (2000) classifies the system as medium/large normally open system. The riverine input usually dominates the physical process within this estuary and although the mouth is normally open, the tidal prism is usually small with sea water seldom penetrating any distance upstream. When flooding occurs, freshwater conditions can extend well into the nearshore environment. Mouth closure probably hardly ever occurred during virgin conditions but under present day conditions, occurs occasionally (Huizinga and Van Niekerk 1999).

3.2. GEOGRAPHICAL BOUNDARIES

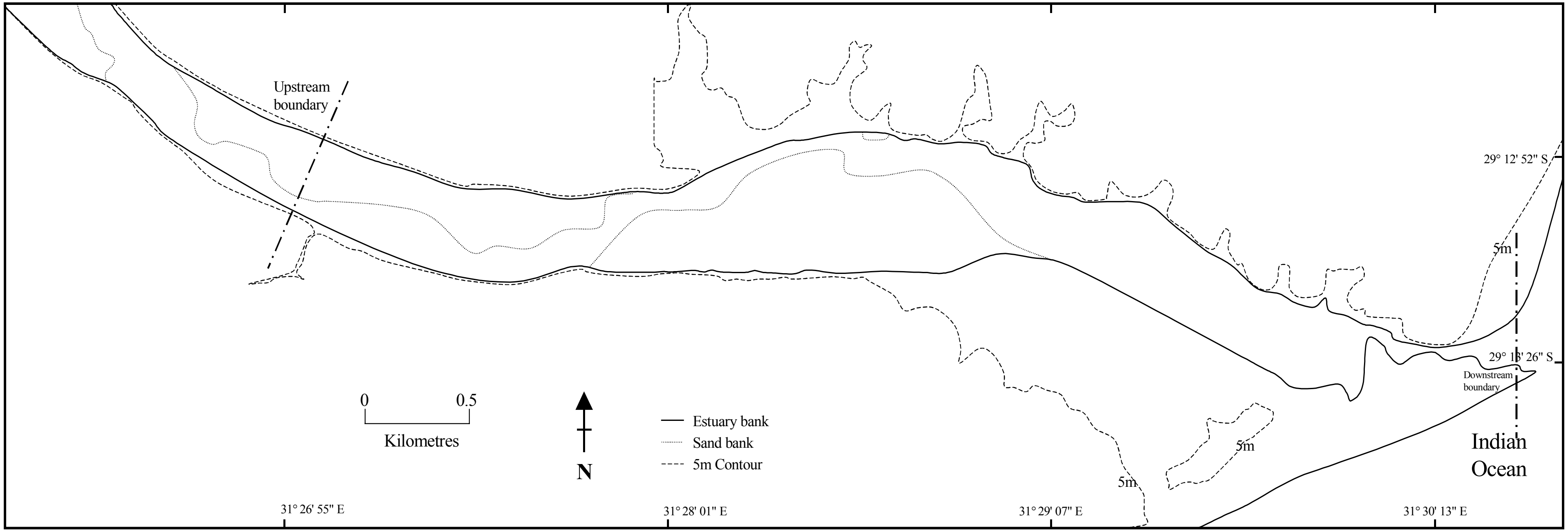
In terms of the RDM methodology an estuary's geographical boundaries are defined by the mouth, the highest extent of tidal influence and the 5m contour along each bank. For the purposes of this study the geographical boundaries were defined as follows:

- **Downstream boundary:** The estuary mouth (Figure 3.1). It should, however, be noted that the riverine nature of the Thukela Estuary means that it has very strong ecological links with the nearshore environment. The abstraction of water from the estuary will almost certainly impact on the nearshore environment.
- **Upstream boundary:** The head of tidal influence, approximately 6km from the mouth (Figure 3.1). Due to the dynamic nature of the Thukela this 6km boundary will be far shorter in high flow conditions and may in very low flows be slightly longer.

- **Lateral boundaries:** The 5m contour above mean sea level along the banks. This delineation was readily referenced from an orthophoto map of the area (Figure 3.1).

The above is also illustrated in Figure 3.2.

Fig 3.1 Thukela Estuary Delineation Map



4. GEOMORPHOLOGICAL CLASSIFICATION

4.1 INTRODUCTION

In this Chapter:
4.1 Introduction
4.2 Geomorphological classification

The physical structure of a river ecosystem is determined by the geomorphological processes which shape the channel. They determine the material from which the channel is formed, the shape of the channel and the stability of the bed and banks. The channel geomorphology in turn determines the substrate conditions for the stream fauna and flora and the hydraulic conditions for any given flow discharge. Geomorphology therefore provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems. In addition, while rivers are resilient to temporary flow reductions (such as droughts) and to water quality problems, often recovering in a matter of months, structural changes to the river channel due for example to damage to the riparian zone, to sediment inputs from catchment erosion or to reservoir induced changes in the flow regime, often cause long term irreversible effects (O`Keeffe; Kochel, 1988).

Geomorphological features are the result of the interaction of processes which operate over a range of time and space scales. In common with many natural phenomena, they do not fall into discreet classes, but rather form a continuum in both time and space. Rowntree and Wadeson (1999) have developed a hierarchical classification system which is based on a combination of desk top and field approaches and aims to provide a scale-based framework linking the various components of the river system, ranging from the catchment to the instream habitat. The system consists of six levels: the catchment, the segment, the zone, the reach, the morphological unit, the hydraulic biotope. These levels are defined in Table 4.1. Catchment, segment and zone classifications are derived from desk-top studies using available secondary data sources. Reach, morphological unit and hydraulic biotope classifications are applied to specific sites, based largely on field assessment backed up by reference to large scale maps (normally 1: 50 000) and aerial photographs.

Table 4.1 Definition of geomorphological classification levels (after Rowntree and Wadeson, 1999)

Hierarchical unit	Description	Scale
Catchment	The catchment is the land surface which contributes water and sediment to any given stream network.	Can be applied to the whole river system, from source to mouth, or to a lower order catchment above a specified point of interest.
Segment	A segment is a length of channel along which there is no significant change in the flow discharge or sediment load.	Segment boundaries will tend to be co-incident with major tributary junctions.
Longitudinal zone	A zone is a sector of the river long profile which has a distinct valley form and valley slope.	Sectors of the river long profile.
Reach	The reach is a length of channel characterised by a particular channel pattern and channel morphology, resulting from a uniform set of local constraints on channel form.	>00s of meters.

Hierarchical unit	Description	Scale
Morphological Unit	The morphological units are the basic structures recognised by fluvial geomorphologists as comprising the channel morphology and may be either erosional or depositional features.	Morphological units occur at a scale of an order similar to that of the channel width.
Hydraulic biotope	Hydraulic biotopes are spatially distinct instream flow environments with characteristic hydraulic attributes.	Hydraulic biotopes occur at a spatial scale of the order of 1 m^2 to 100 m^2 and are discharge dependent.

The hierarchical classification of Rowntree and Wadeson (1999) has been applied routinely in various aspects of Reserve determinations (Rowntree and Wadeson, 1998). Whilst reach, morphological unit and hydraulic biotope classifications have been used to describe and classify field sites, the zone has found widespread application in preliminary desk top studies for the Intermediate and Comprehensive determinations. River zonation describes the longitudinal variation of physical characteristics and associated biological distributions down the length of a river. In the Intermediate and Comprehensive determination of the Ecological Reserve, geomorphological zones are used to guide the spatial framework for the delineation of water resource units, the assessment of habitat integrity, and site selection.

This hierarchical classification is a generic classification which describes the type of river; it does not assess the condition of the river. It is, however, used as the template against which the natural state can be predicted and is applied in the determination of the Ecological Reserve Category (ERC). The method for determining ERCs with respect to geomorphology is under development.

4.2 GEOMORPHOLOGICAL CLASSIFICATION

4.2.1 The Thukela River Catchment

This section provides a broad overview of catchment conditions within the Thukela basin. A number of different variables are considered; physiography, geology, geomorphology, climate, vegetation and soil. These variables interact together to determine the morphology of the fluvial system. This catchment “audit” provides important information for the classification of the system and hence assists in the selection of representative field sites.

The Thukela catchment drains an area of 29 039 km^2, rising on the escarpment of the Kwa-Zulu Natal Drakensburg range and flowing approximately 512 km through the eastern slopes until it discharges into the Indian Ocean 80km north of the city of Durban (Figure 2.1).

- *Physiography*

Morphologically, South Africa may be divided into the Interior Plateau and the surrounding Marginal Regions (Du Toit, 1954; Wellington, 1955). The two are separated by the Great Escarpment which can be traced as an arc roughly parallel to the coast. Along the southeastern seaboard of South Africa, the Marginal Region is gently undulating to rolling. From the sea to the interior it rises in a series of steps, each separated from the next by a more or less distinct scarp running parallel to the coast. It has been dissected by rivers which are short and lack well developed tributary systems. They flow directly to the sea through narrow valleys cut transversely across the steps and scarps.

The Thukela catchment is an exception to this general pattern in that two large drainage systems, those of the Upper Thukela and Buffalo Rivers drain extensive interior basins. The Buffalo River follows the general trend of the eastern rivers in that it flows in a southeasterly direction. In contrast, the Upper Thukela flows due east and has developed a drainage pattern which is oblique to that of the other rivers in the area. This is attributed to the great Thukela Fault which runs in a east - west direction through the catchment as far as Colenso (Wellington, 1955). It appears as though this fault created a plane of weakness along which the Thukela River cut deeply and rapidly into the underlying strata. This rapid down cutting created an increased gradient and energy for the Buffalo River.

The Upper Thukela and its tributaries have incised valleys far inland and now drain a catchment approximately twice the size of the Buffalo River. The Drakensburg escarpment has been forced back by vigorous headward erosion by the Thukela and its tributaries, of which the Mooi, Bushmens and Little Thukela Rivers are the largest. The Thukela River itself rises at an altitude of 3100m in the most westerly reaches of the catchment at the foot of Mont-aux-Sources. Through retreat of the escarpment, it has captured the headwaters of a tributary of the Orange River.

- *Geology and Soil*

The Karoo system which straddles the Palaeozoic (500 mybp) and Mesozoic(100 mybp) eras, occupies about half the area of South Africa and almost 90% of the Thukela catchment. It is of continental origin and is subdivided into four successive sedimentary series; the Dwyka, Ecca, Beaufort and Stormberg Series.

The Dwyka tillite is an uncommon rock within the Thukela catchment. Much of the Thukela is underlain by the Ecca formation, which extends in the north through the Buffalo and Sundays catchment to the central Thukela. This Ecca formation consists predominantly of shales and mudstones which give rise to highly erodible Mispah soils (Figure 4.1). The Mispah soils in the Thukela basin primarily support grassland and *Acacia* Thornveld. Severe sheet erosion is common in mismanaged areas.

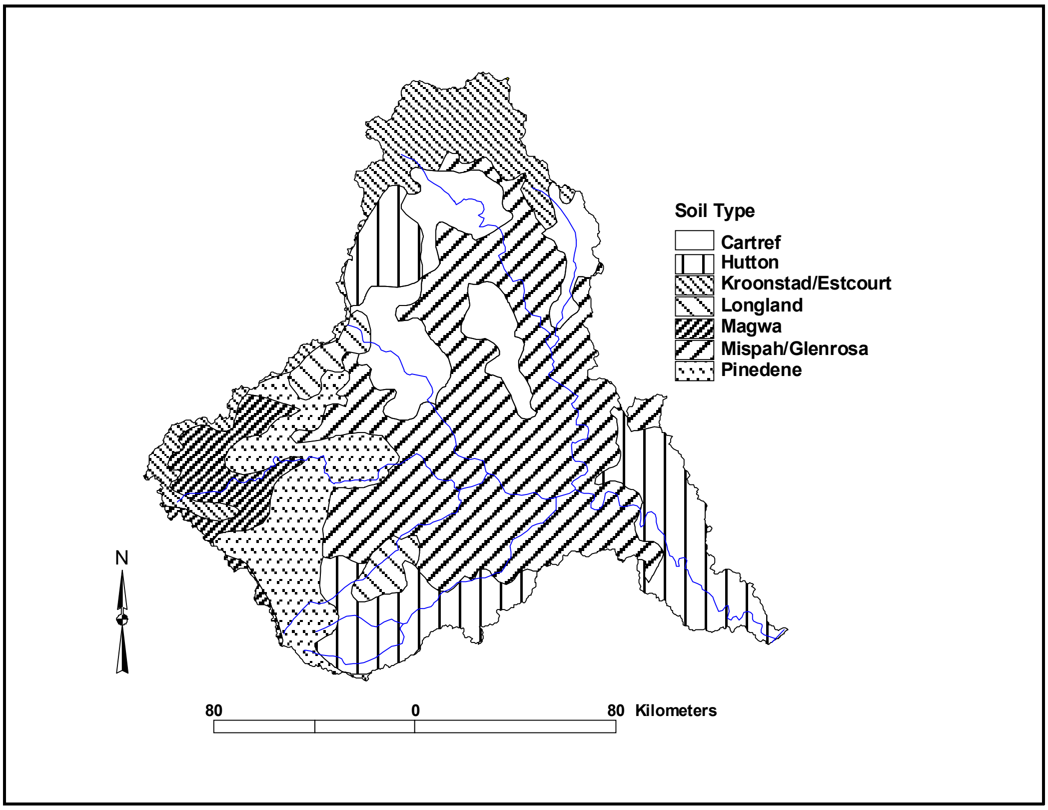
The Beaufort Series is exposed in a broad belt surrounding the Lesotho plateau. It occupies about 25% of the Thukela Catchment, covering a wide section in the southwest which extends to the north and includes the Low Drakensberg, Biggarsberg and Belelasberg. The Series consists of mudstones and shales alternating with beds of fine to medium grained felspathic sandstone. This geology gives rise to Cartref, Kroonstad, Estcourt or Hutton soils of moderate to high erodibility in the upper catchment and ridges. The soils are susceptible to erosion by wind under continuous cultivation. They also show some tendency towards surface crust formation under raindrop impact on bare soil which can lead to water erosion.

The Stormberg Series is found principally in the upper catchment of the Drakensberg. All occurrences are similar with thick bands of cave sandstone forming sheer kranses. These are underlain by slopes of crumbly red shale and red micaceous sandstone.

During the Early Jurassic, the Karoo sediments were overlain by the Stormberg lavas. These volcanic beds constitute the Lesotho plateau bounding the Thukela Catchment in the southwest. Although exposed to weathering for 100 million years, their thickness is still 1200 to 1400m in the high Drakensberg.

Where the volcanic lavas failed to reach the surface, they solidified in fissures and along bedding planes of the underlying sediments forming hard and resistant dolerite. These occur as innumerable intrusions in the Thukela Catchment, either as horizontal or inclined sheets or as vertical dykes. Horizontal sills follow the bedding planes of the invaded sediments and where exposed often cap plateaux and messa.

Fig 4.1 Soil Map of the Thukela Catchment



- *Geomorphology*

Diversity of opinion has been expressed regarding the number and ages of the erosion cycles that have molded Kwa-Zulu Natal, and the extent of the planed surfaces which each has left behind. For simplicity we will use King's chronology (King, 1982), a summary of which is given here.

1. After deposition of the Stormberg lavas the surface of South Africa lay exposed to denudation for the entire Jurassic period (195 mybp). Remnants of the resulting smooth landscape are preserved on the highest flat crested mountains of Lesotho.
2. In the late Jurassic to early Cretaceous times (136 mybp) the landmass was broken up into modern southern hemisphere continents. A fresh erosion cycle was initiated by the base level of the new ocean and a newly formed monoclinal depression along the Kwa-Zulu Natal coast.
3. Mid-Cretaceous (95 mybp) continental uplift ushered in a new erosion cycle. The monocline developed an erosion scarp which retreated 160 - 240km to the west. Re elevated in more recent times it was to develop into the present day high Drakensberg escarpment.
4. At the beginning of the Miocene (26 mybp), moderate and almost uniform uplift initiated the first of two late Tertiary erosion phases which largely destroyed the African surface.
5. At the beginning of the Pliocene (7 mybp), renewed uplift enlarged the monocline and generated the second late Tertiary erosion phase which included

the excavation of the two large Interior Basins. Creation of the Thukela Catchment proper commenced when the Lower Thukela, which so far had meandered freely through the subdued Tertiary landscape, incised its meanders into the rising valley floor, thereby carrying the new lower base level up its thalweg to the interior beyond the outlet between Kranskop and Qudeni. This was followed by rejuvenation of the Upper Thukela, the Buffalo, and their tributaries which cut deep gorges and ravines. As the streams approached grade, the originally steep and narrow valleys opened out to attain a stable declivity. All valley sides then became hillslopes retreating laterally away from the streams.

6. Towards the end of the Pliocene and continuing into the Quaternary (2 mybp)a large upheaval is believed to have elevated the continental interior with tilting of the eastern marginal regions towards the Indian Ocean. This strong seaward tilting caused immediate rejuvenation of the main rivers along their entire length through the coast hinterland, into which they cut steep, deep sided valleys. The lower Thukela spectacularly incised its old meanders to cut the Thukela Gorge 900 to 1200m deep between the Kranskop and Qudeni plateaux. Beyond this gorge the Quaternary erosion cycle proceeded upstream along the Thukela and the lower courses of the Mooi, Bushmans, Bloukrans, Klip, Sundays and Buffalo Rivers. The cycle has penetrated into the interior as far as Middelrus, above Estcourt, below Frere, Colenso, Ladysmith and Elandslaagte and a little below Rorke's Drift. At all these places waterfalls or rapids mark the head of the Quaternary valley incision. Deeper penetrations into the southern catchment has been retarded by the huge dolerite barrier northeast of Colenso. Here the Thukela and Klip Rivers form a series of falls above which slow downcutting has produced the Colenso-Frere plain and the Ladysmith basin.

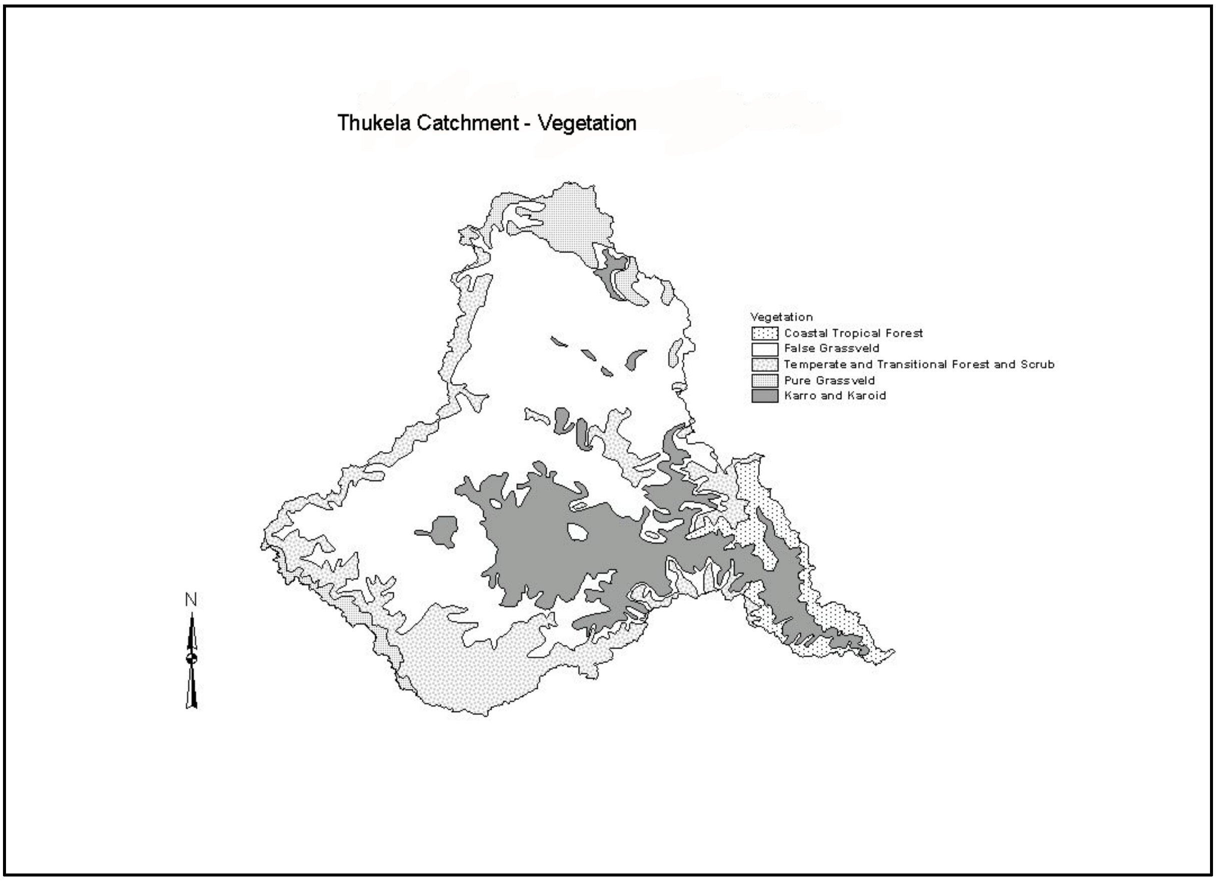
- *Climate*

The Thukela catchment lies in the high rainfall region of South Africa with a mean annual precipitation of 871mm. In the interior approximately 85% of the annual precipitation falls between October and March. Temperatures and rainfall in the Thukela Catchment are greatly influenced by altitude, topography and distance from the sea.

- *Vegetation*

The vegetation map (Figure 4.2) of Acocks (1988) illustrates that vegetation pattern is largely determined by climate. Moist and cool regions of the Thukela Catchment are grassland while the vegetation of the dry and/or hot regions ranges from savanna to woodland and scrub. According to Acocks (1953) the present day sour grassveld of the Highlands, Mistbelt and Coast Hinterland is believed to have replaced forest or scrub-forest. The mixed grassveld of the drier parts as well as the sour grassveld of the sandy areas took the place of bushveld.

Figure 4.2 Vegetation map of the Thukela Catchment



4.2.2 Runoff and Sediment Production

The catchment produces the runoff and sediment which control channel morphology, thereby contributing to the maintenance of habitat integrity at any site along the river. Mean annual precipitation over the Thukela catchment is shown in Figure 4.3. Areas of high rainfall and runoff production are coincident with the escarpment. The eastern slopes are drier and produce commensurately less runoff.

Natural sediment production is related to rainfall, slope gradient, soils and vegetation. The higher areas of the catchment have a low sediment production potential due to less erodible soils and a good ground cover (figure 4.5) whereas a high potential sediment production occurs lower down the catchment due to the combination of highly erodible soils, a sparse vegetation cover, dense rural settlement and steep valley side slopes due to a rejuvenated system.

The runoff and sediment yield characteristics have important implications for geomorphological change along the system. Ever increasing demands on a finite water resource will act to reduce flow volumes whilst sediment yields increase as more and more pressure is applied on the land.

Figure 4.3 Thukela River Catchment - Rainfall

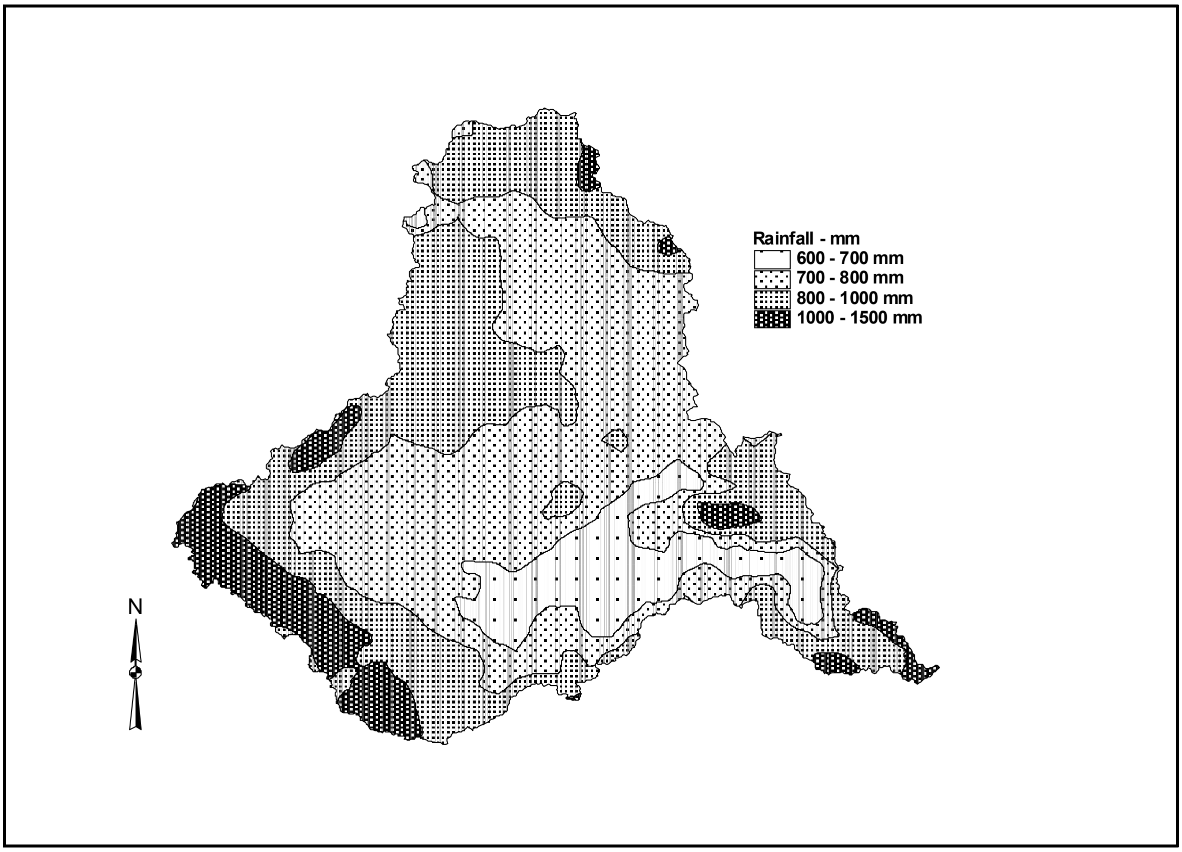
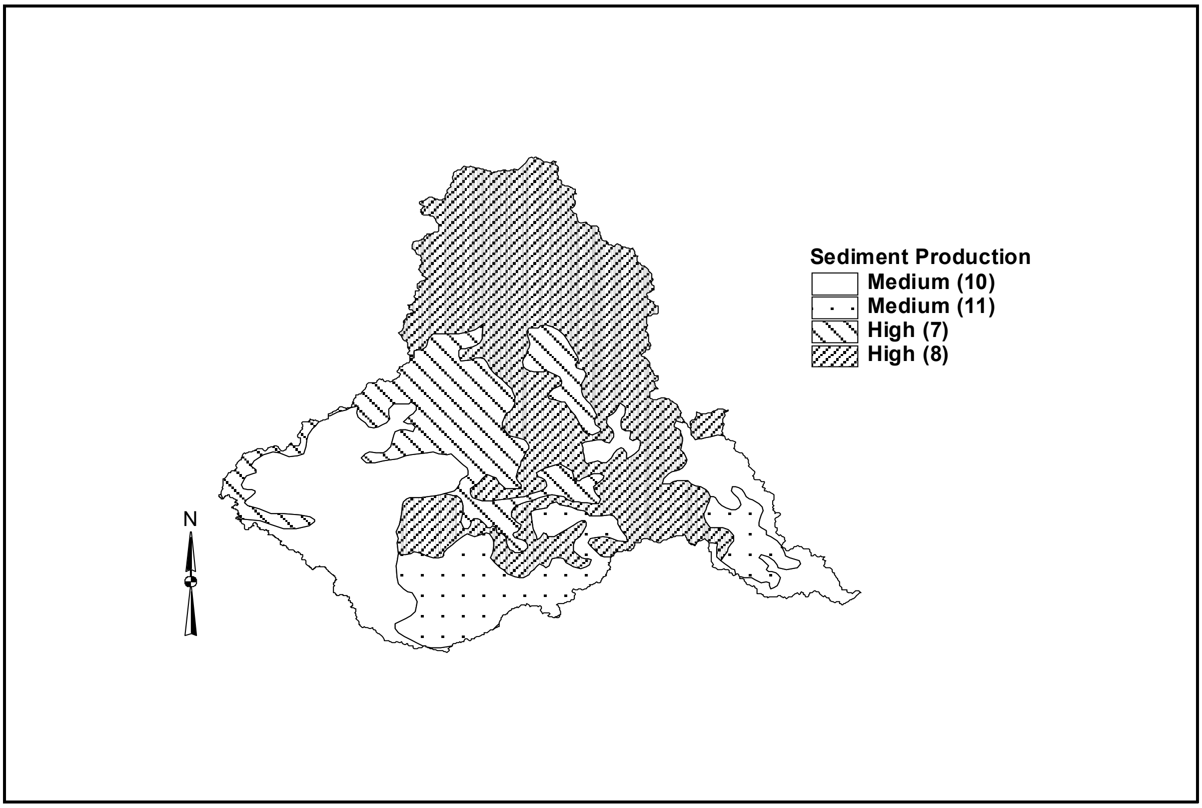


Figure 4.4 Thukela Catchment - Potential Sediment Production



4.2.3 Geomorphological River Zonation

The longitudinal zonation of South African rivers reflects regional geology, tectonic events and long term fluvial action which together have affected the shape of their long profiles. The classic concave long profile may be disrupted by a number of features including outcrops of more resistant rock and rejuvenation due to tectonic uplift or a fall in sea-level. As outlined in the geomorphology section of 4.2.1, the Thukela river has a steepened long profile with a concave upper section above a steeper gorged lower section (Figure 4.6). This disrupts the classic bed material sequence so that sand bed channels in the lower reaches may be replaced by bedrock, boulder and cobble. Extended alluvial lowland reaches with typical flood plain development are generally absent from South African rivers.

Other considerations relating to the long profile concern the downstream increases in streamflow and sediment loads. The Thukela catchment shows a marked difference between the high rainfall headwater area and the low rainfall semi-arid lowland area. It is believed that this pattern may cause a steepening of the channel gradient in order to maintain sufficient stream power to transport the available sediment (Knighton, 1998). The distribution of sediment input is also not uniform along the channel.

Rowntree and Wadeson (1999) have developed a zonal classification system for South Africa based on work carried out on a number of different rivers around the country (Table 4.2).

Table 4.2 Geomorphological Zonation of River Channels

Zone	Zone class	Gradient class	Characteristic channel features
A. Zonation associated with a 'normal' profile			
Source zone	S	not specified	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	A	> 0.1	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades.
Mountain stream	B	0.04 - 0.099	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool, approximate equal distribution of 'vertical' and 'horizontal' flow components.
Transitional	C	0.02 - 0.039	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 flood plain development.
Upper Foothills	D	0.005 - 0.019	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 flood plain of sand, gravel or cobble often present.

Zone	Zone class	Gradient class	Characteristic channel features
Lower Foothills	E	0.001 - 0.005	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. Flood plain often present.
Lowland river	F	0.0001- 0.0009	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks.
B. Additional zones associated with a rejuvenated profile			
Rejuvenated bedrock fall / cascades	ABCr	>0.02	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.
Rejuvenated foothills:	DEr	0.001 - 0.019	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.
Upland flood plain	Fr	< 0.005	An upland low gradient channel, often associated with uplifted plateau areas as occur beneath the eastern escarpment.

Each of the major tributaries to be considered in this study have been analysed according to channel gradient and valley form. The longitudinal profiles together with the geomorphological zones are illustrated in figures 4.7a, b, c, d, e and f.

Figure 4.5a Zonation of the Upper Thukela River Catchment

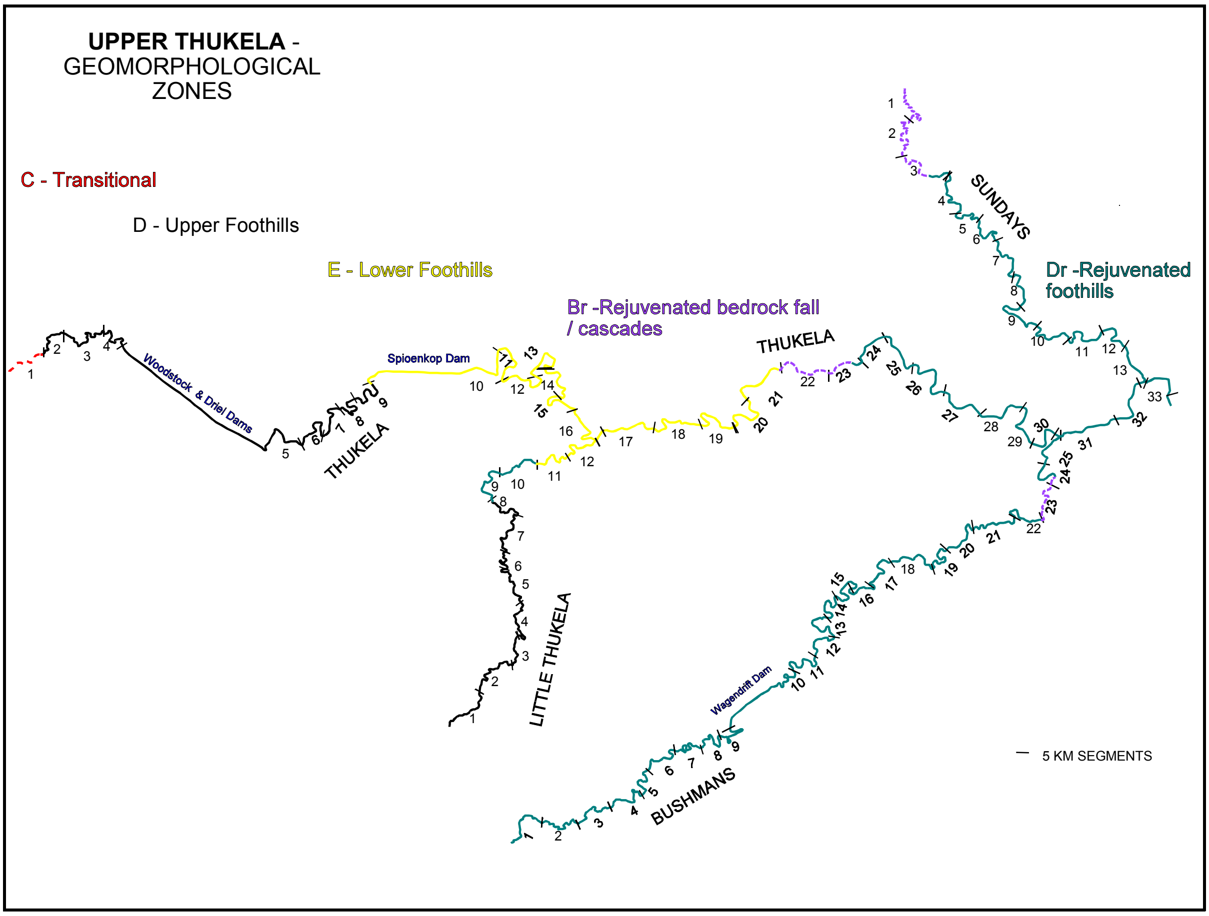


Figure 4.5b Zonation of the Lower Thukela River Catchment

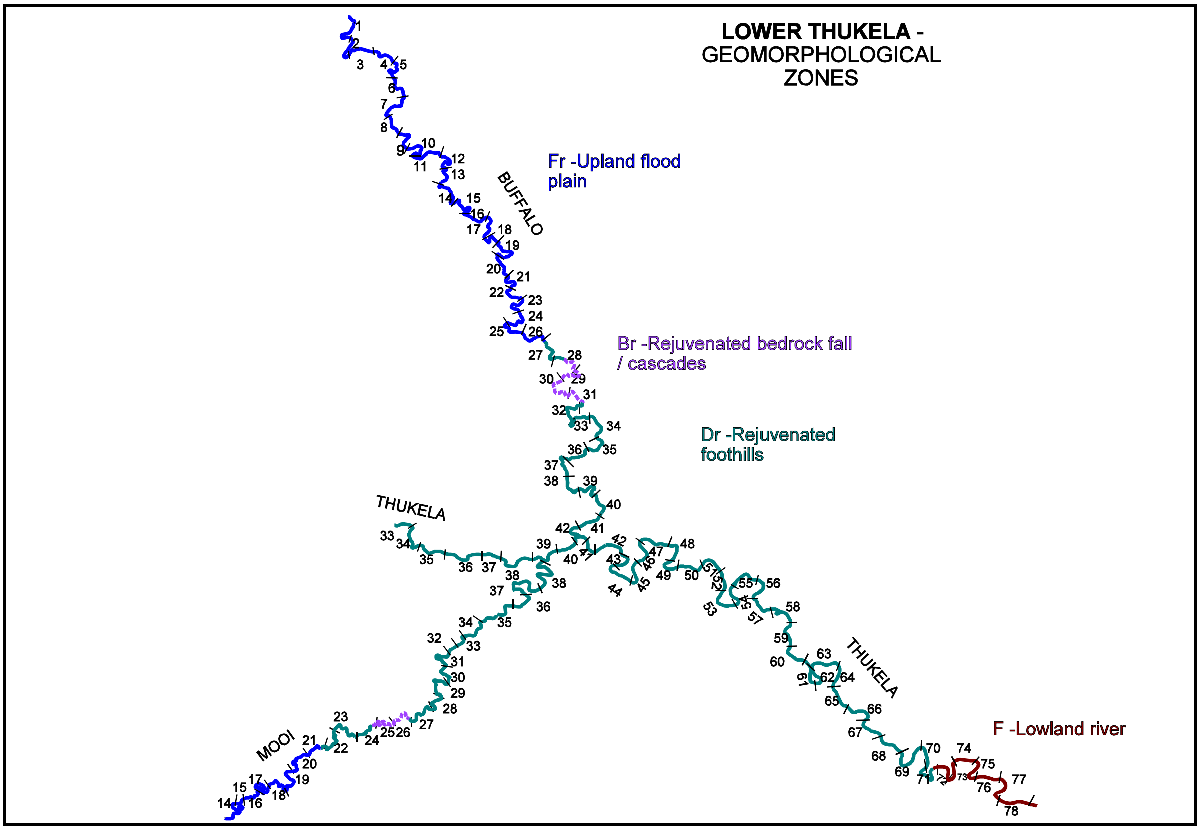


Figure 4.6a Longitudinal Profile of the Thukela River

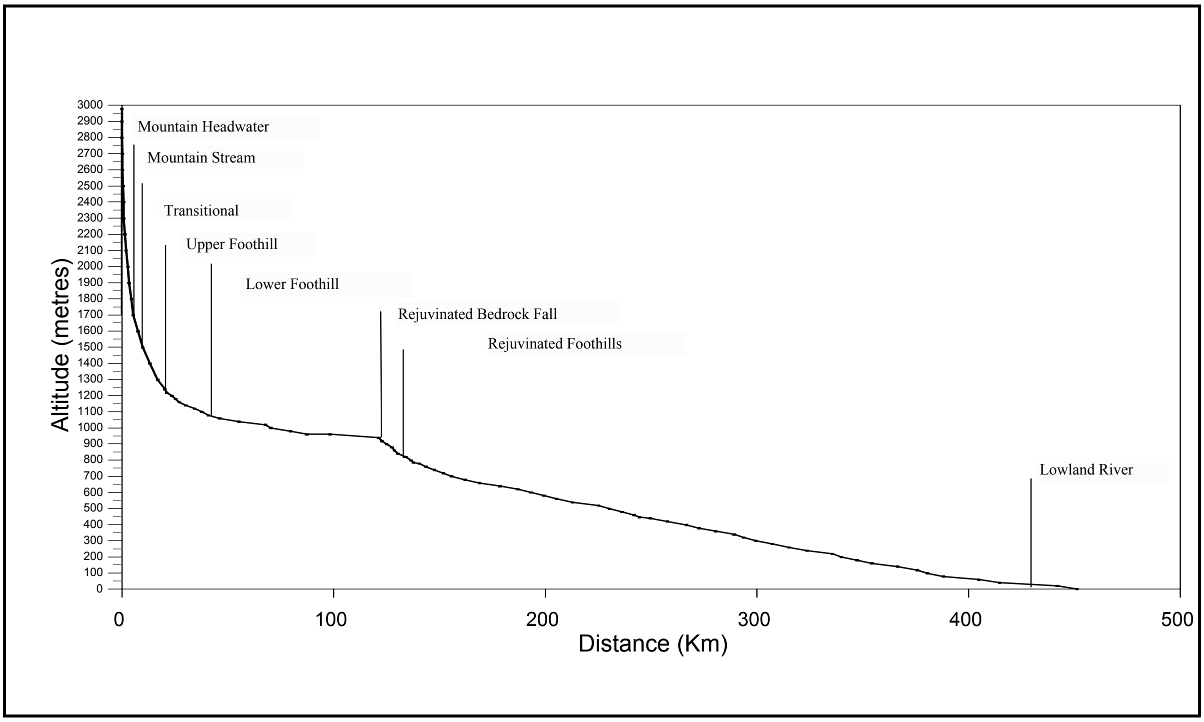


Figure 4.6b Longitudinal Profile of the Little Thukela River

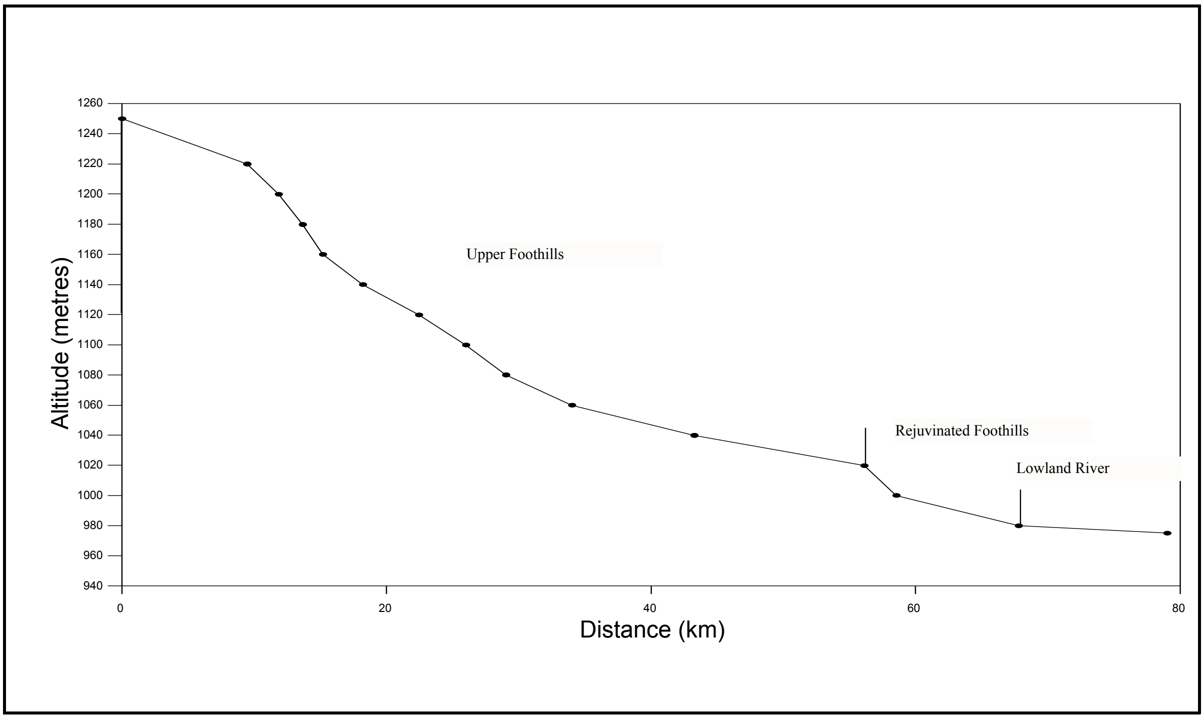


Figure 4.6c Longitudinal Profile of the Bushmans River

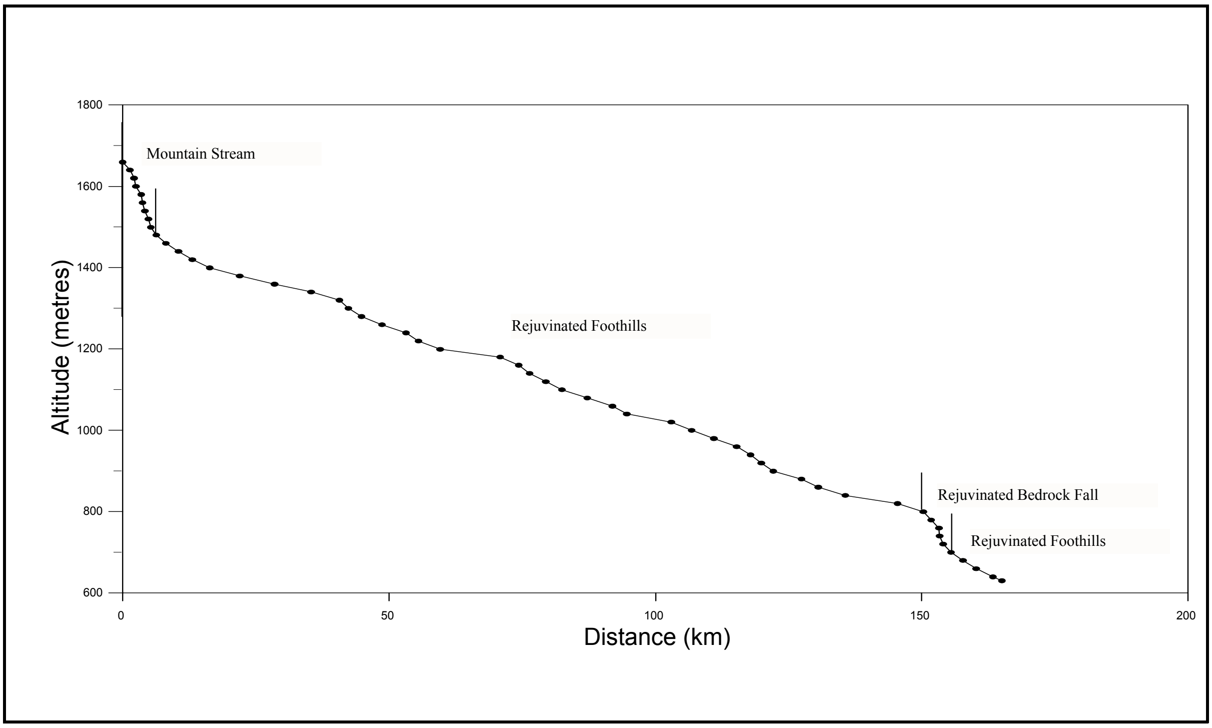


Figure 4.6d Longitudinal Profile of the Sundays River

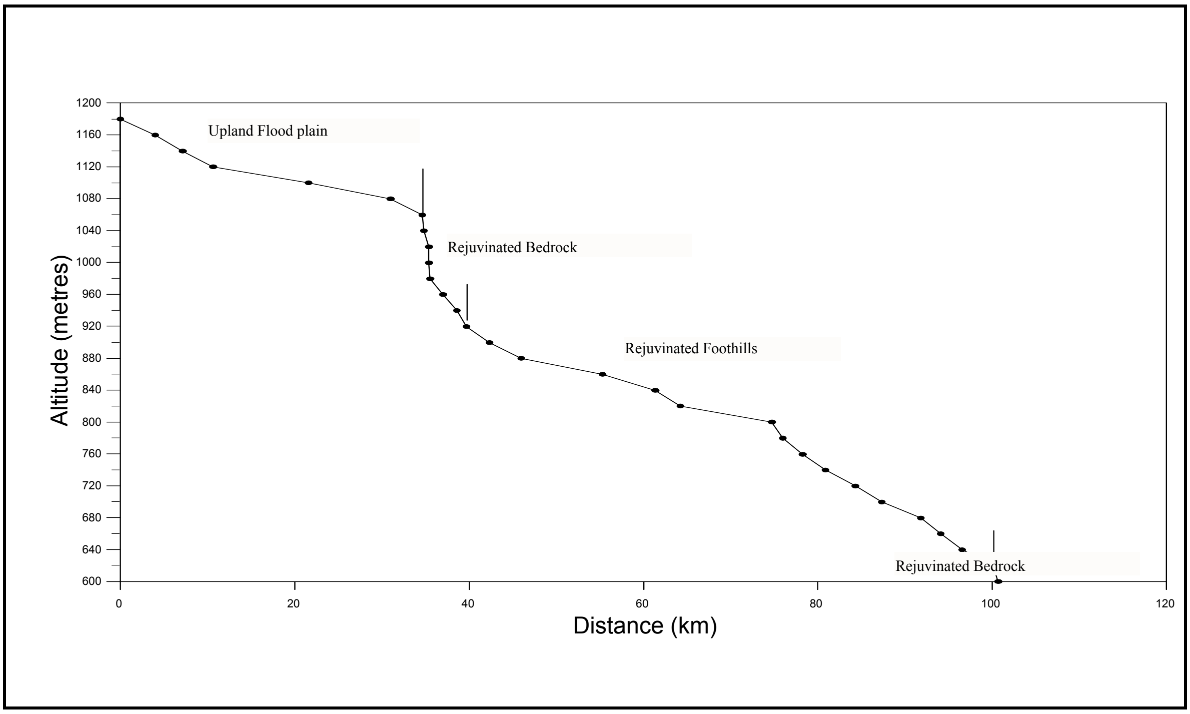


Figure 4.6e Longitudinal Profile of the Mooi River

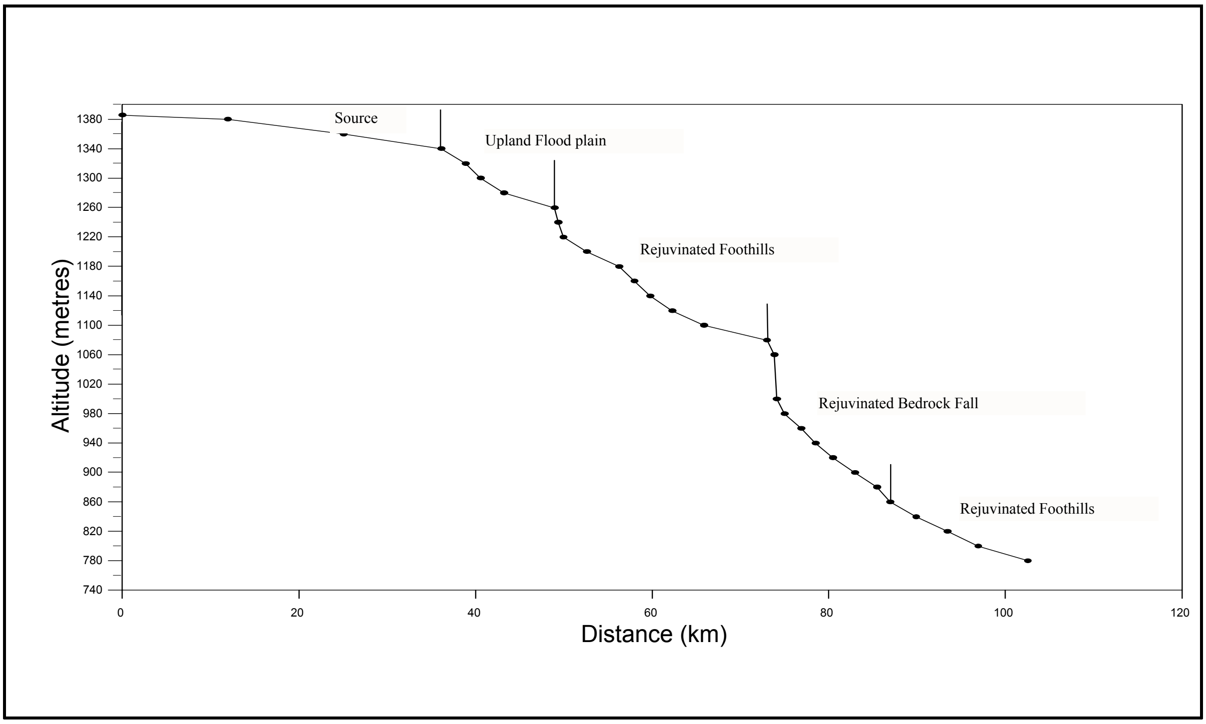
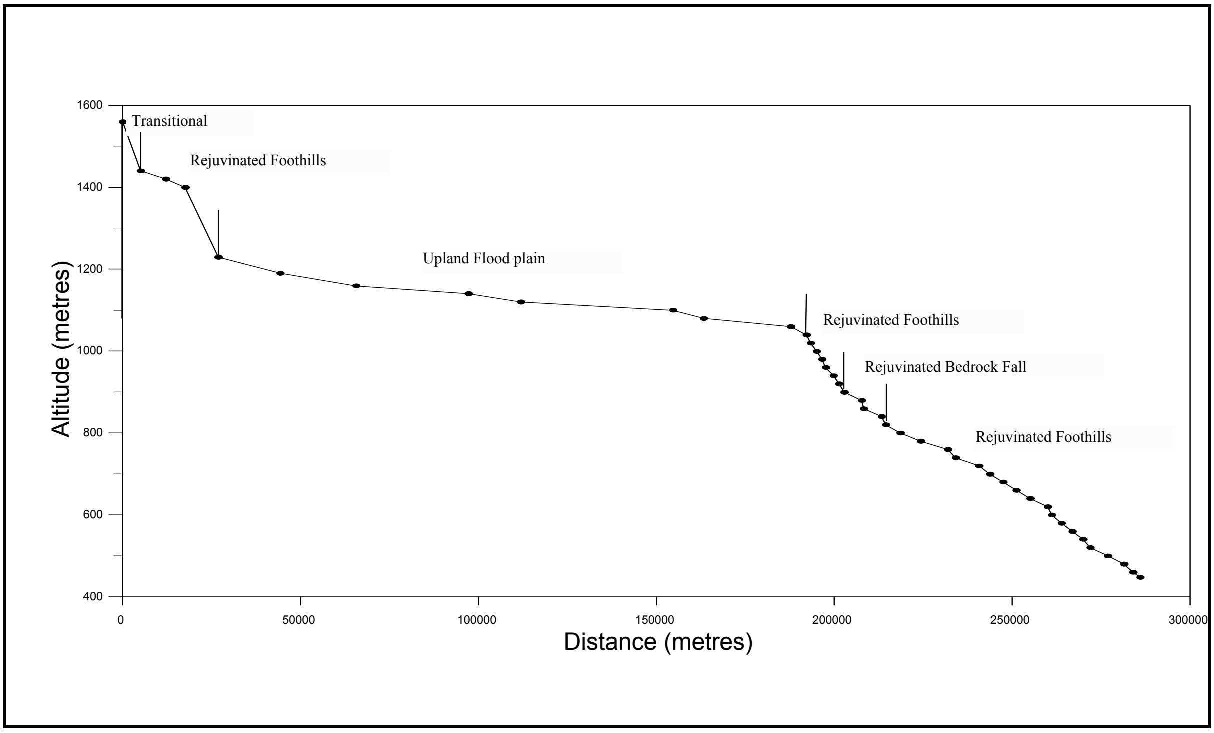


Figure 4.6f Longitudinal Profile of the Buffalo River



4.2.4 River Reaches

A river reach is a length of channel characterised by a particular channel pattern and morphology, resulting from a uniform set of local constraints on channel form. The boundary of reaches can be identified on a 1: 50 000 map using channel pattern, sinuosity and width indicators. In the field reaches are further classified in terms of channel type and channel morphology.

A desk top river reach classification has been carried out for the Thukela catchment. It is not practical or useful to present the coarse data within this document. Suffice is to say that a number of different reaches exist within the various rivers of the Thukela catchment. Site specific reach information will be presented within the specialist geomorphological starter documents.

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5. RIVER HABITAT INTEGRITY

5.1 INTRODUCTION

In this Chapter:

This report is a contribution to the Thukela Ecological Reserve Module of the Thukela Water Project. The purpose of this report is to assess the current habitat integrity of the Thukela River and its main tributaries based on selected key indicator criteria in pre-determined segments of the rivers. This assessment will also serve as a baseline that will be used to monitor the integrity of the river following future modifications to the flow regime as a consequence of future developments or the implementation of a catchment management strategy (CMS).

The ecological integrity of a river is defined as its ability to support and maintain a balanced, integrated composition of physico-chemical and habitat characteristics, as well as biotic components on a temporal and spatial scale that is comparable to the characteristics of natural ecosystems of a specific region (Kleynhans et al, 1988). This definition is based on the concept of biological integrity that has been described as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organisation comparable to that of natural habitat of the region (Karr and Dudley 1981). Habitat integrity refers to the maintenance of a balanced, integrated composition of physico-chemical and habitat characteristics on a temporal and spatial scale that is comparable to the characteristics of natural habitats of the region. Essentially, the habitat integrity of a river will provide the template for a certain level of biotic integrity to be realised. In this sense the assessment of the habitat integrity of a river can be seen as a precursor of the assessment of biotic integrity. It follows that habitat integrity and biotic integrity together constitutes ecological integrity.

This approach differs from the initial approach used for the assessment of river conservation status that was defined as an assessment of the degree to which the river has been modified from its hypothetical natural state. The habitat integrity assessment places less emphasis on the hypothetical natural (e.g. pristine) state of the river as a baseline against which to measure deterioration or modification. Instead, more importance is placed on the functionality of the river to provide suitable living conditions for biota within the context of the temporal and spatial scale of the habitat compared with what is considered likely to have been the case in the absence of artificially created disturbance regimes. The determination of the natural baseline conditions (including natural disturbance regimes) is essentially based on three data sources (listed in the order of decreasing applicability to the particular river under investigation):

1. Recent and historical information on the specific river itself. This includes information on the hydrology, hydraulics, water quality, catchment characteristics, development, exotic or alien biota, etc.

2. Recent and historical information on neighbouring rivers within the same region. This would include information on hydrology, hydraulics, water quality, catchment characteristics, development, etc.

3. Recent and historical information on rivers in the same region. This would include information on hydrology, hydraulics, water quality, catchment characteristics, development, etc.

Prior to the assessment of the Levuvhu river in 1994 (Kleynhans & Engelbrecht, 1994), previous assessments considered the conservation status of the abiotic and biotic components with no separation of the riparian zone and the instream channel (Kleynhans, 1992; Kleynhans and Engelbrecht, 1993).

5.2 METHODS

The method employed for this study was essentially that described by Kleynhans (1996). The same method has subsequently been applied on a number of rivers throughout South Africa namely the Mvoti River (Kemper, 1996), the Komati River (Kemper, 1998) and the Mkomazi River (Kemper, 1998). For the sake of convenience, the description of the method employed was directly transcribed to this report with the necessary additions and changes applicable to this study

5.2.1 Information sources

Primary information on the integrity of the Thukela River system was collected during a low level helicopter survey of the river conducted during mid 2001. Prior to the survey the rivers were divided into 5 km segments from the top to the bottom of the predefined study areas on each. The co-ordinates of these segment breaks were determined and stored in a GPS to assist with navigation of the river during the survey. A continuous video recording was made of the segmented portion of the river. The survey was carried out at a height of approximately 17 to 67m above ground level and the flight path followed the middle of the stream channel as far as possible. To assist with the determination of the exact location of potential IFR sites from the video, a continuous GPS track log was also maintained during the survey.

Additional data for the assessment was gleaned mostly from other reports associated with the Reserve process, namely the hydrology, water quality, riparian vegetation and fish reports which also form part of the starter report for the specialist meeting.

5.2.2 Data Management and Analysis

During the subsequent viewing of the video material, all assessment data from the survey and the video were transcribed onto field data forms. Information on the following aspects as well as an assessment of the severity of modifications was transcribed for each segment of the river:

Flow (relative abundance); dry (0), none (1), little (2), moderate (3), strong (4).
Water habitat types and relative abundance; Types - fast flowing, pools and ponds, weirs and impoundments; abundance - none (1), few (2), moderate (3), common (4), exclusive (5).
Number of; weirs, impoundments and pumps.
Impact of; roads and bridges, rubbish dumping, bed and channel modification, stream bank erosion, removal of natural riparian vegetation, encroachment by exotic riparian vegetation, presence of cultivated lands and plantations on stream bank and presence of exotic aquatic macrophytes.

General remarks were also made on the following, species of exotic and indigenous riparian vegetation and exotic macrophytes observed, water fauna observed, general description of stream bed, general description of stream bank, general assessment of habitat diversity (including the stream bank) according to, low (1), moderate (2), large (3), very large (4), unique (5).

Criteria considered indicative of the habitat integrity were selected on the basis that modification of their characteristics can generally be regarded as the primary causes of degradation of the habitat integrity of the river. The severity of certain modifications will, therefore, have a detrimental impact on the habitat integrity of a river. The method is primarily habitat oriented with emphasis on a qualitative interpretation of the habitat quality, size, diversity, variability and predictability as influenced by various human made modifications.

An assessment of the severity of impact of modifications is based on six descriptive classes with scores ranging from 0, indicating no impact and 21-25, signifying extremely severe impact. Scoring is guided by a description of the severity of the impact of the modification for each score. Based on the relative importance of the criteria, scores are weighted. Scores for riparian zone and in-stream criteria are summed separately and expressed as a percentage of the maximum (100%) possible. This figure is subtracted from 100 to arrive at an estimate of the habitat integrity. The general descriptive procedure that was used to estimate the impact of modifications is indicated in Table 5.1.

Table 5.1 Descriptive classes for the assessment of modification to habitat integrity

Impact class	Description	Score
None	No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined are affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

The criteria used as indicators of the status of the instream facet of the river and the weights assigned to these criteria are reflected in Table 5.2.

Table 5.2 Criteria and weights used for the assessment of instream and riparian zone habitat integrity (Kleynhans 1996)

Instream criteria	Weight	Riparian zone criteria	Weight
Principle criteria:		Principle criteria	
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	13
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water Quality	14	Water abstraction	13
Inundation	10	Inundation	11
Supplementary criteria:		Supplementary criteria:	
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	100	TOTAL	100

Relative impact was estimated as follows:
Rating for the criteria/maximum value (25) x the weight (%) e.g., it is found that water abstraction is critical and it receives a score of 25. In such a case it has a weight of 14%. If

a score of 10 was awarded, the calculation proceeds as follows:
10/25 x 14=5,6

In the case of in-stream criteria, provision was made for principal and supplementary criteria. Principal instream criteria are regarded as being of fundamental importance to the maintenance of the habitat integrity of this facet with consideration to the maintenance of the quality and structural characteristics of the habitat. Supplementary instream criteria are considered to be of relatively lower importance.

A preliminary assessment of the habitat integrity was made based on these weights. However, as a cautionary measure, the final estimate of the principal criteria of the in-stream facet received an additional negative weight if their impacts were considered to be large, serious or critical. The aim of this approach was to accommodate the possible cumulative (and integrated) negative effects of such impacts. The following arbitrary rules (Kleynhans, 1996) were followed in this respect:

Impact = Large, lower status by 33% of the weight for each criterion of this nature.
Impact = Serious, lower status by 67% of the weight for each criterion of this nature.
Impact = Critical, lower status by 100% of the weight for each criterion of this nature.

These negative weights were added for each facet, where applicable, and the total negative weight subtracted from the provisionally determined status to arrive at a final status estimate. For comparative purposes, both the provisional and final status estimates are indicated for each river.

The eventual scores for the in-stream component are used to place the habitat integrity in a specific descriptive habitat integrity class. Thus, the result of the assessment is primarily descriptive and not quantitative. The habitat integrity assessment classes are indicated in Table 5.3.

Table 5.3 Habitat integrity assessment classes

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F.	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

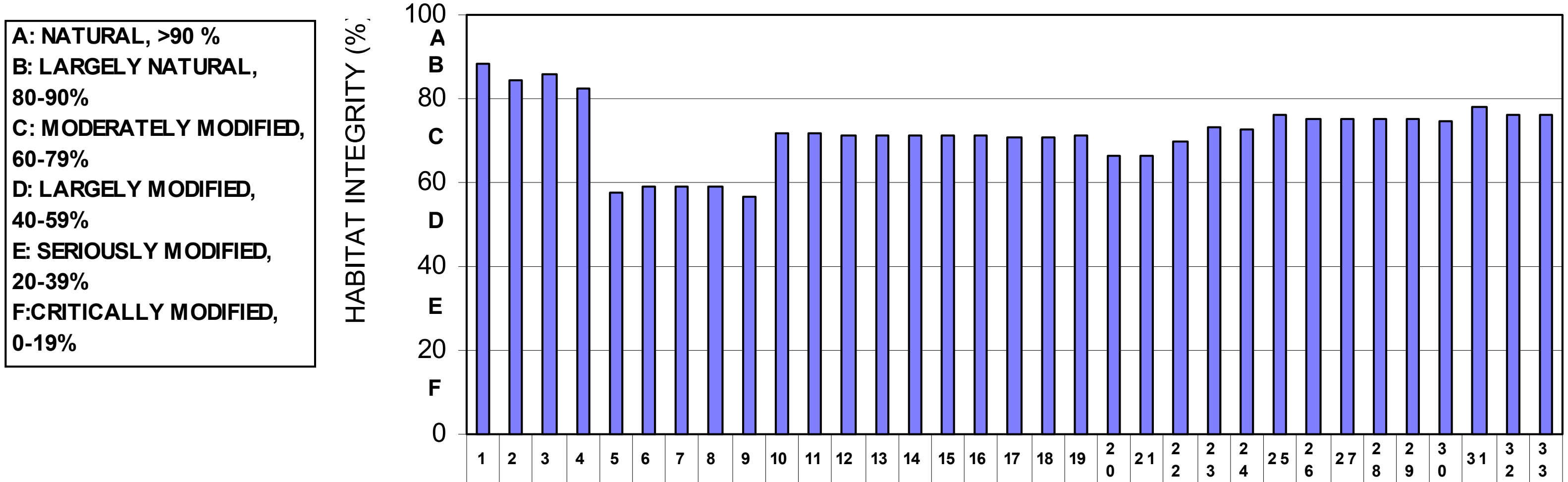
All calculations were carried out and associated graphics produced with the aid of an Microsoft Excel spreadsheet shell (Kleynhans, 2001). The results are also illustrated on Figures 5.17 and 5.18.

5.3 ASSESSMENT RESULTS

5.3.1 Thukela River

5.3.1.1 Instream component - upper Thukela River

Fig 5.1: Upper Thukela River, Instream Habitat Integrity



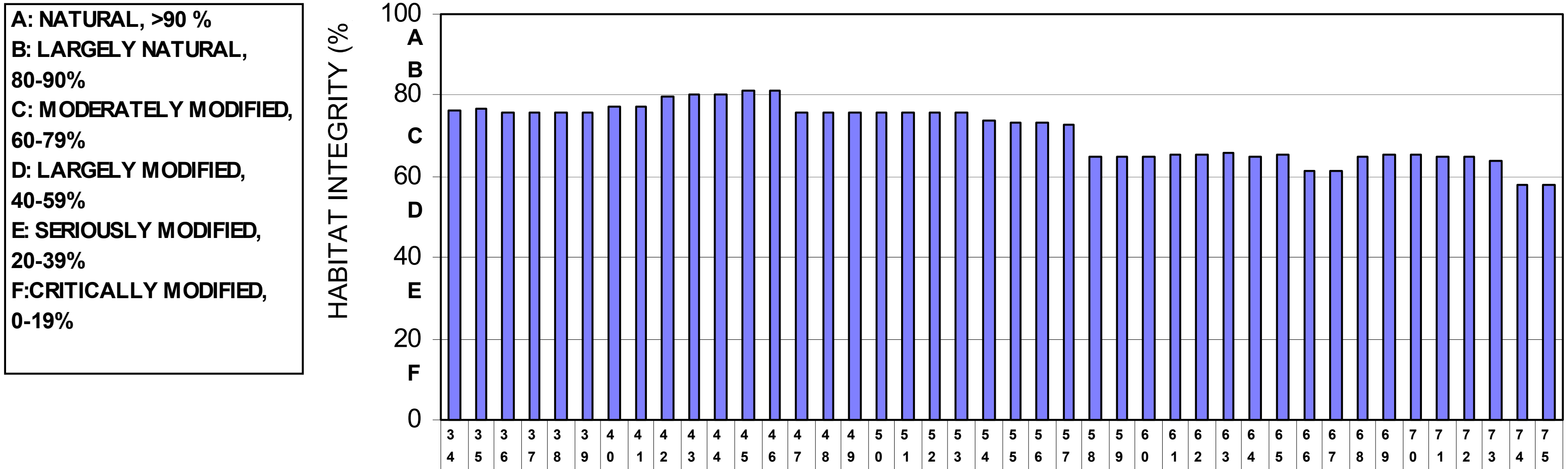
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
INSTREAM HABITAT INTEGRITY (%)	88	84	86	83	57	59	59	59	57	72	72	71	71	71	71	71	71
WATER ABSTRACTION (IMPACT 1 - 25)	2	2	2	2	13	13	13	13	13	13	13	13	13	13	13	13	12
FLOW MODIFICATION ((IMPACT 1 - 25)	0	5	5	5	21	21	21	21	21	13	13	13	13	13	13	13	12
BED MODIFICATION (IMPACT 1 - 25)	10	10	10	10	6	6	6	6	6	6	6	7	7	7	7	7	8
CHANNEL MODIFICATION (IMPACT 1 - 25)	5	8	5	5	10	6	6	6	6	1	1	1	1	1	1	1	1
WATER QUALITY (IMPACT 1 - 25)	2	2	2	2	6	6	6	6	6	6	6	6	6	6	6	6	8
INUNDATION (IMPACT 1 - 25)	0	0	0	8		0	0	0	8	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
INSTREAM HABITAT INTEGRITY (%)	71	71	66	66	70	73	73	76	75	75	75	75	75	78	76	76
WATER ABSTRACTION (IMPACT 1 - 25)	12	12	12	12	13	13	13	10	10	10	10	10	10	8	8	8
FLOW MODIFICATION ((IMPACT 1 - 25)	12	12	12	12	12	12	12	9	9	9	9	9	9	6	6	6
BED MODIFICATION (IMPACT 1 - 25)	8	8	8	8	5	5	5	6	6	6	6	6	6	11	11	11
CHANNEL MODIFICATION (IMPACT 1 - 25)	1	0	0	0	0	0	1	0	2	2	2	2	1	1	5	5
WATER QUALITY (IMPACT 1 - 25)	8	8	8	10	10	6	6	12	12	12	12	12	12	9	9	9
INUNDATION (IMPACT 1 - 25)	0	0	2	4	2	0	0	0	0	0	0	0	2	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	10	4	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	0	0	4	4	2	0	0	0	0	0	0	0	0	0	0	0
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.1.2 Instream component - lower Thukela River

Fig 5.2: Lower Thukela River, Instream Habitat Integrity



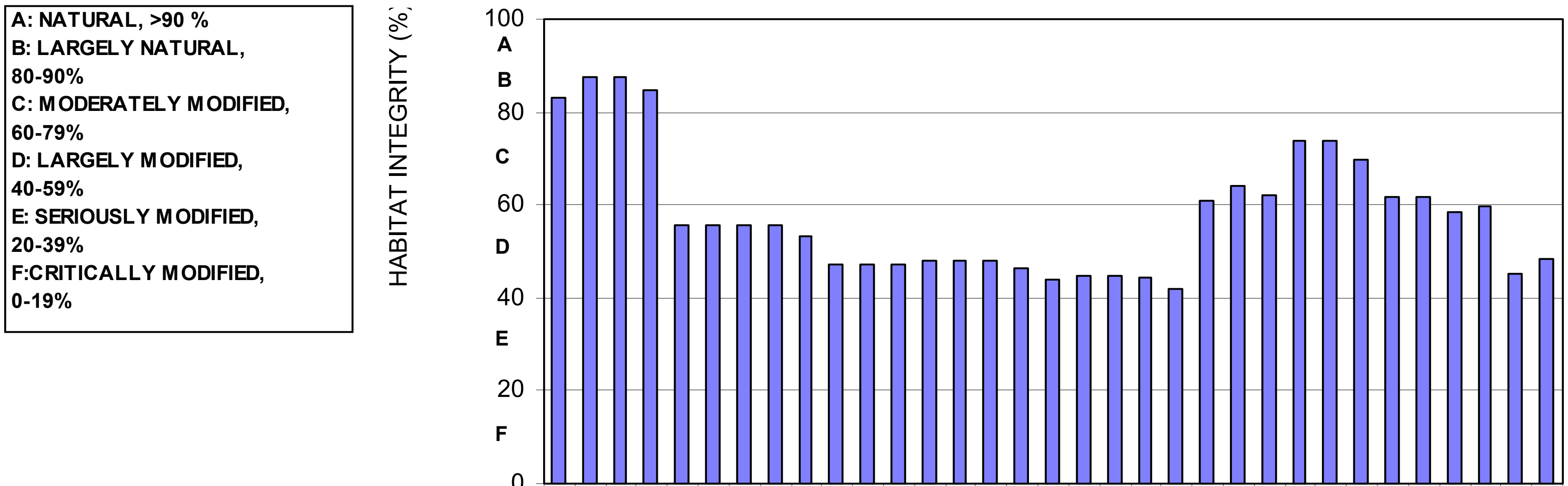
	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
INSTREAM HABITAT INTEGRITY (%)	76	77	76	76	76	76	77	77	80	80	80	81	81	76	76	76	76	76	76	76	74
WATER ABSTRACTION (IMPACT 1 - 25)	7	7	7	7	7	7	6	6	5	5	5	4	4	7	7	7	7	7	7	7	7
FLOW MODIFICATION ((IMPACT 1 - 25)	4	4	4	4	4	4	3	3	3	2	2	2	2	4	4	4	4	4	4	4	4
BED MODIFICATION (IMPACT 1 - 25)	12	12	12	14	14	14	15	15	12	12	12	12	12	14	14	14	14	14	14	14	14
CHANNEL MODIFICATION (IMPACT 1 - 25)	5	3	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5
WATER QUALITY (IMPACT 1 - 25)	10	10	8	8	8	8	8	8	7	7	7	7	7	8	8	8	8	8	8	8	8
INUNDATION (IMPACT 1 - 25)	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
EXOTIC FAUNA (IMPACT 1 - 25)	0	0	0	2	2	2	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
INSTREAM HABITAT INTEGRITY (%)	73	73	73	65	65	65	65	65	66	65	65	61	61	65	66	66	65	65	64	58	58
WATER ABSTRACTION (IMPACT 1 - 25)	7	7	7	14	14	14	13	13	12	12	11	11	11	10	9	9	9	7	7	12	12
FLOW MODIFICATION ((IMPACT 1 - 25)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
BED MODIFICATION (IMPACT 1 - 25)	14	14	14	14	14	14	14	14	14	15	15	16	16	17	17	17	18	18	19	19	19
CHANNEL MODIFICATION (IMPACT 1 - 25)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
WATER QUALITY (IMPACT 1 - 25)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	7	8	9	10	10	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	12
EXOTIC FAUNA (IMPACT 1 - 25)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	7	8	8

SECTOR NO (---> FLOW DIRECTION)

5.3.1.3 Riparian zone component - upper Thukela River

Fig 5.3: Upper Thukela River, Riparian zone Habitat integrity



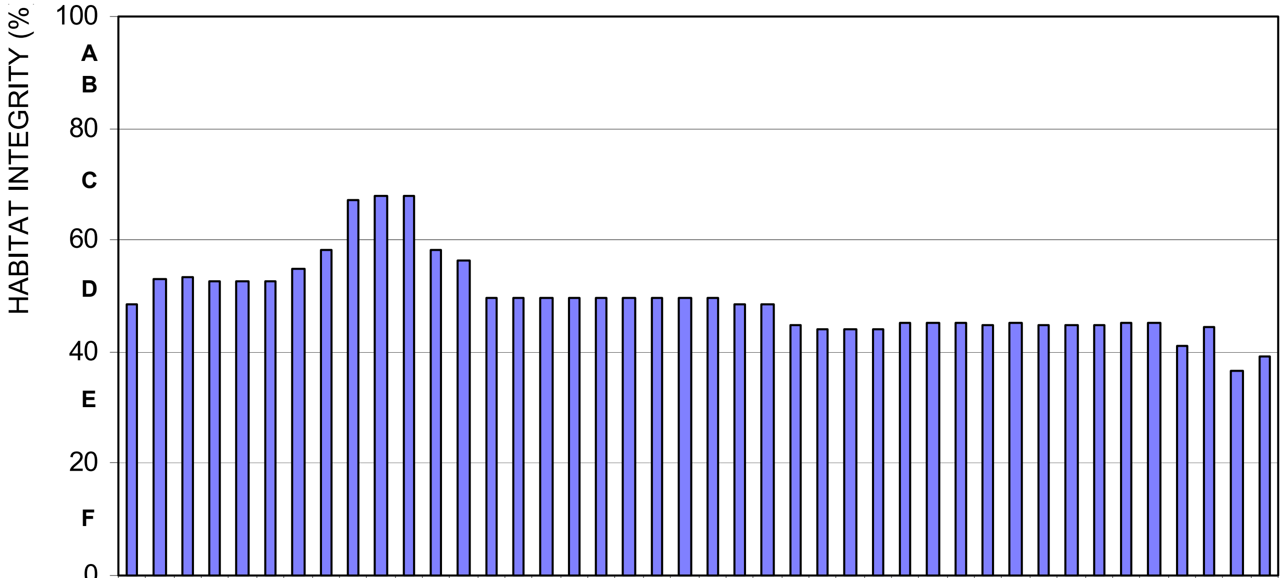
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
RIPARIAN ZONE HABITAT INTEGRITY	83	87	87	85	56	56	56	56	53	47	47	47	48	48	48	46	44	45	45	44	42	61	64	62	74	74	70	62	62	59	60	45	48
VEGETATION REMOVAL (IMPACT 1 - 25)	5	5	5	5	5	5	5	5	5	12	12	12	12	12	12	12	12	12	12	12	15	10	10	10	10	10	10	11	11	15	15	15	15
EXOTIC VEGETATION (IMPACT 1 - 25)	6	6	6	6	6	6	6	6	6	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0	0	0	5	5	5	5	5	5	5
BANK EROSION (IMPACT 1 - 25)	10	10	10	10	5	5	5	5	5	2	2	2	0	0	0	5	2	0	0	0	0	0	0	4	0	0	4	4	4	4	3	14	16
CHANNEL MODIFICATION (IMPACT 1 - 25)	10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	6	6
WATER ABSTRACTION (IMPACT 1 - 25)	2	2	2	2	13	13	13	13	13	8	8	8	8	8	8	8	12	12	12	12	12	13	13	13	10	10	10	10	10	10	9	9	8
INUNDATION (IMPACT 1 - 25)	0	0	0	6	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	1	3	10	0	0	0	0	0	0	0	1	0	0	0
FLOW MODIFICATION (IMPACT 1 - 25)	0	0	0	0	17	17	17	17	17	17	17	17	17	17	17	17	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	12	10
WATER QUALITY (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR (-> FLOW DIRECTION)

5.3.1.4 Riparian zone component - lower Thukela River

Fig 5.4: Lower Thukela River, Riparian zone Habitat Integrity

A: NATURAL, >90 %
B: LARGELY NATURAL, 80-90%
C: MODERATELY MODIFIED, 60-79%
D: LARGELY MODIFIED, 40-59%
E: SERIOUSLY MODIFIED, 20-39%
F: CRITICALLY MODIFIED, 0-19%



SECTOR	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
RIPARIAN ZONE HABITAT INTEGRITY	48	53	53	53	53	53	55	58	67	68	68	58	56	50	50	50	50	50	50	50	50
VEGETATION REMOVAL (IMPACT 1 - 25)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
EXOTIC VEGETATION (IMPACT 1 - 25)	5	5	5	5	5	5	5	3	3	3	3	3	4	5	5	5	5	5	5	5	5
BANK EROSION (IMPACT 1 - 25)	17	15	13	15	15	15	13	11	10	9	9	11	13	16	16	16	16	16	16	16	16
CHANNEL MODIFICATION (IMPACT 1 - 25)	6	4	6	6	6	6	6	3	3	3	3	3	3	6	6	6	6	6	6	6	6
WATER ABSTRACTION (IMPACT 1 - 25)	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
INUNDATION (IMPACT 1 - 25)	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FLOW MODIFICATION (IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
WATER QUALITY (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

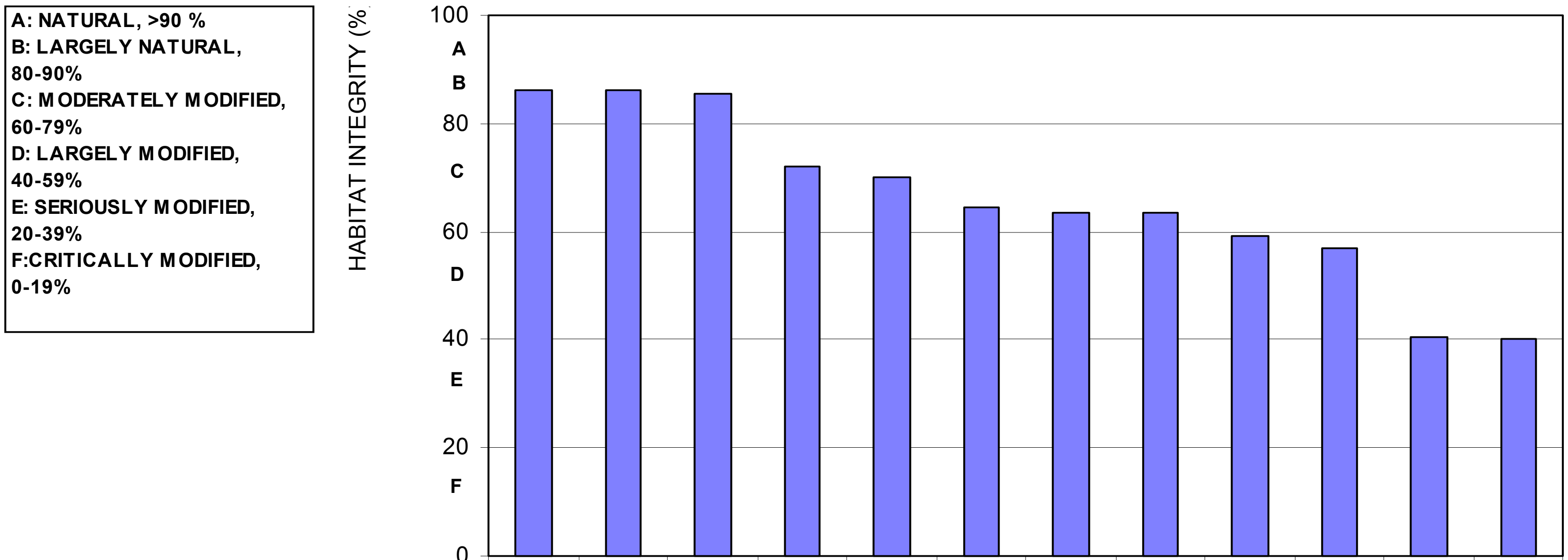
SECTOR	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
RIPARIAN ZONE HABITAT INTEGRITY	50	48	48	45	44	44	44	45	45	45	45	45	45	45	45	45	45	41	45	37	39
VEGETATION REMOVAL (IMPACT 1 - 25)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	16	16	16	16
EXOTIC VEGETATION (IMPACT 1 - 25)	5	5	5	5	5	5	5	5	5	5	8	8	9	9	9	9	9	9	10	10	10
BANK EROSION (IMPACT 1 - 25)	16	16	16	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
CHANNEL MODIFICATION (IMPACT 1 - 25)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
WATER ABSTRACTION (IMPACT 1 - 25)	6	9	9	10	10	10	10	9	9	9	9	8	8	8	8	7	7	7	7	10	10
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	10	0
FLOW MODIFICATION (IMPACT 1 - 25)	9	9	9	12	13	13	13	12	12	12	11	11	11	11	11	11	11	11	10	12	12
WATER QUALITY (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR (-> FLOW DIRECTION)

5.3.2 Little Thukela River

5.3.2.1 Instream component

Fig 5.5: Little Thukela river, Insteam Habitat Integrity

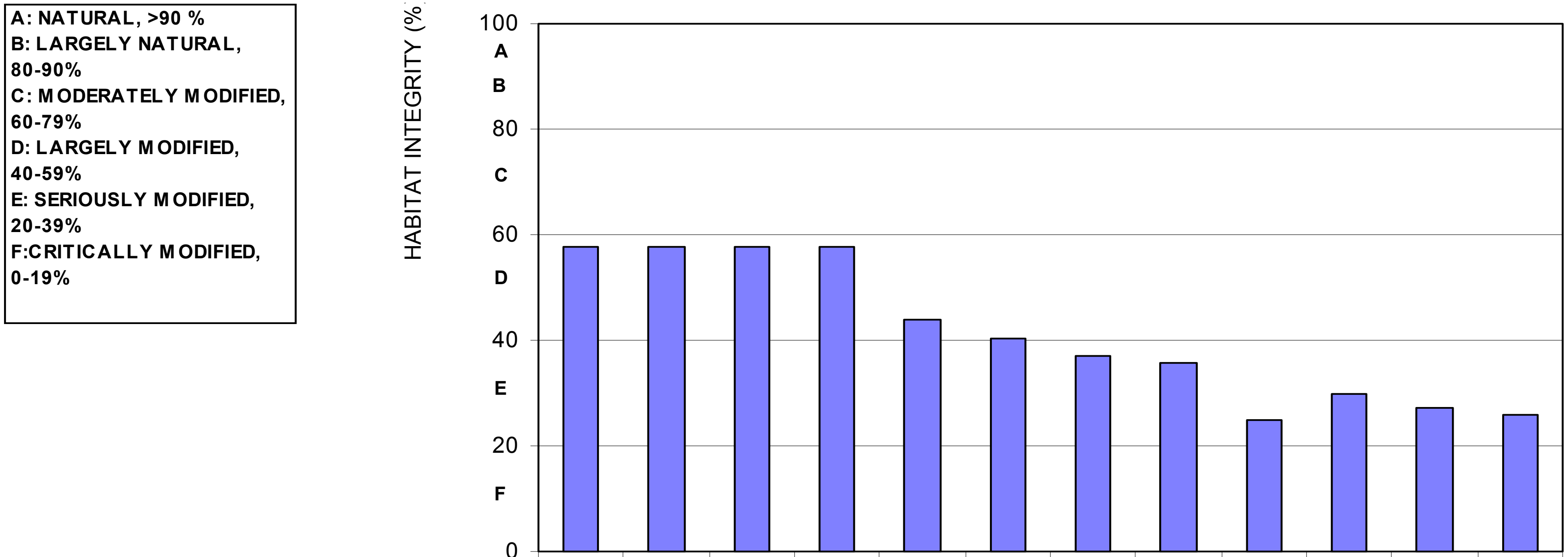


	1	2	3	4	5	6	7	8	9	10	11	12
INSTREAM HABITAT INTEGRITY (%)	86	86	86	72	70	64	63	63	59	57	41	40
WATER ABSTRACTION (IMPACT 1 - 25)	5	5	5	8	10	10	11	11	11	11	14	12
FLOW MODIFICATION ((IMPACT 1 - 25)	5	5	5	7	8	9	9	8	8	9	20	17
BED MODIFICATION (IMPACT 1 - 25)	3	3	4	14	15	16	15	15	15	15	15	16
CHANNEL MODIFICATION (IMPACT 1 - 25)	3	3	3	8	8	9	9	9	10	11	13	15
WATER QUALITY (IMPACT 1 - 25)	5	5	5	5	5	6	6	7	10	9	12	11
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	3	3	3	3	5	0
EXOTIC FAUNA (IMPACT 1 - 25)	8	8	8	8	8	8	8	8	8	7	10	10
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	10	8	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.2.2 Riparian zone component

Fig 5.6: Little Thukela River, Riparian zone Habitat Integrity



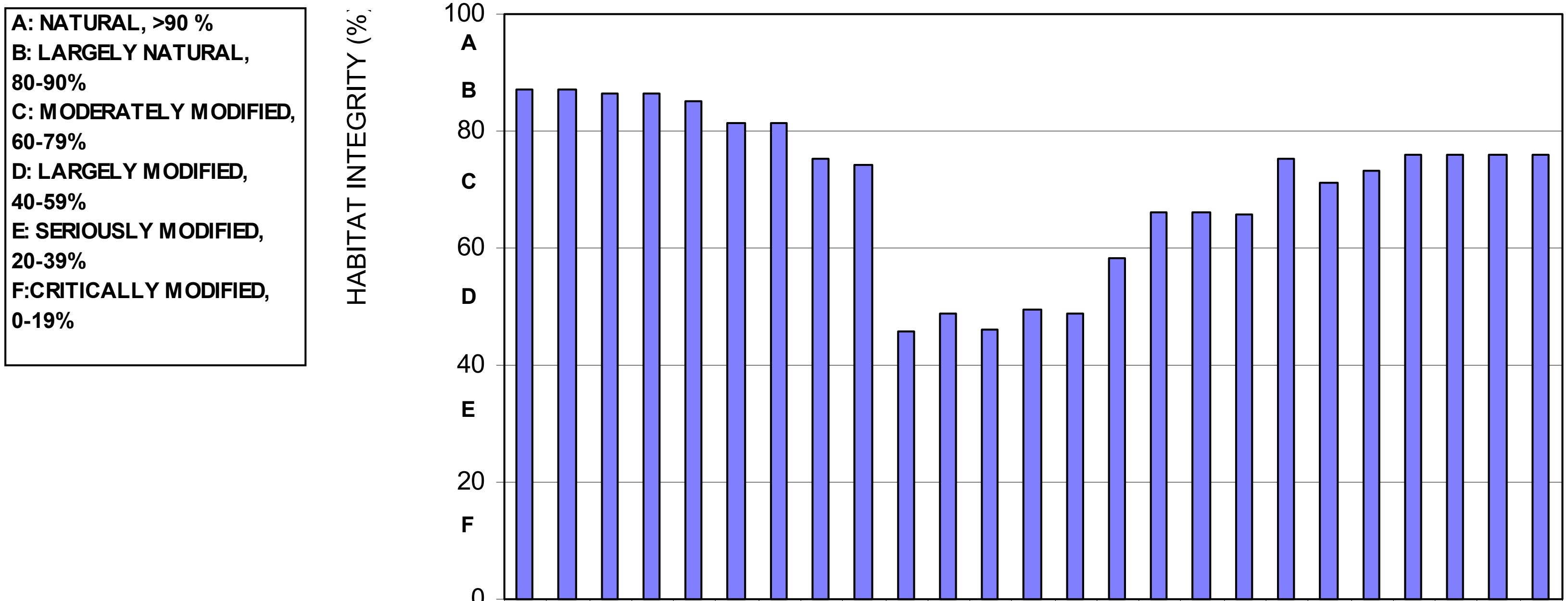
	1	2	3	4	5	6	7	8	9	10	11	12
RIPARIAN ZONE HABITAT INTEGRITY	58	58	58	58	44	40	37	36	25	30	27	26
VEGETATION REMOVAL (IMPACT 1 - 25)	12	12	12	12	13	14	15	15	15	15	16	16
EXOTIC VEGETATION (IMPACT 1 - 25)	7	7	7	7	13	15	16	17	18	18	17	18
BANK EROSION (IMPACT 1 - 25)	12	12	12	12	14	15	14	15	16	11	11	11
CHANNEL MODIFICATION (IMPACT 1 - 25)	3	3	3	3	8	8	8	6	6	8	7	8
WATER ABSTRACTION (IMPACT 1 - 25)	5	5	5	5	5	7	7	8	8	11	11	12
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	1	2	2	2	2
FLOW MODIFICATION (IMPACT 1 - 25)	5	5	5	5	6	6	7	8	8	7	7	7
WATER QUALITY (IMPACT 1 - 25)	6	6	6	6	7	7	7	7	11	9	9	9

SECTOR (-> FLOW DIRECTION)

5.3.3 Bushmans River

5.3.3.1 Instream component

Fig 5.7: Bushmans River, Insteam Habitat Integrity

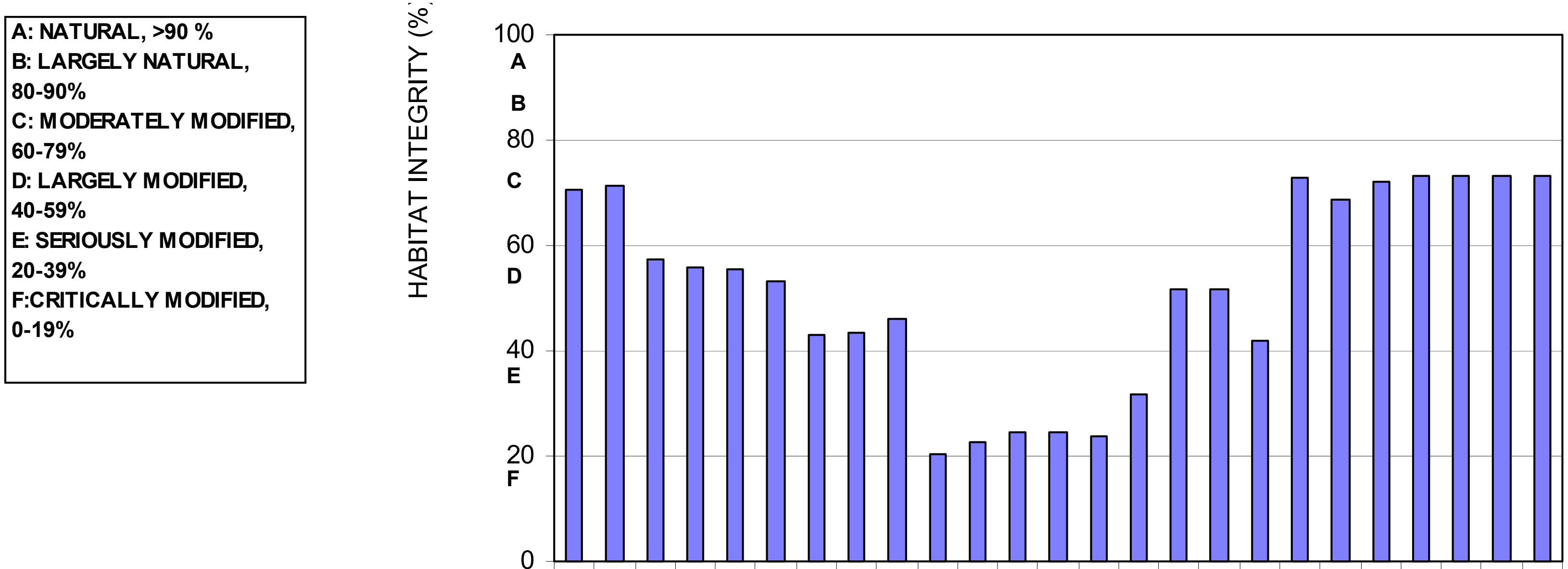


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
INSTREAM HABITAT INTEGRITY (%)	87	87	87	87	85	81	81	75	74	46	49	46	49	49	58	66	66	66	75	71	73	76	76	76	76
WATER ABSTRACTION (IMPACT 1 - 25)	5	5	5	5	5	7	7	8	8	15	14	12	14	14	12	8	8	8	8	8	8	8	8	8	8
FLOW MODIFICATION ((IMPACT 1 - 25)	5	5	5	5	5	7	7	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
BED MODIFICATION (IMPACT 1 - 25)	2	2	3	3	5	7	7	10	10	15	15	16	15	15	10	8	8	9	9	10	10	9	9	9	9
CHANNEL MODIFICATION (IMPACT 1 - 25)	3	3	3	3	3	5	5	6	6	15	13	15	13	13	10	7	7	7	9	10	10	8	8	8	8
WATER QUALITY (IMPACT 1 - 25)	6	6	6	6	6	6	6	7	7	12	12	11	11	12	12	12	12	12	6	6	6	6	6	6	6
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	6	8	5	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	8	8	8	8	8	8	8	8	8	0	0	3	0	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	5	5	5	5	6	5	5	5	5	10	10	10	10	10	10	10	10	10	7	7	7	7	7	7	7
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.3.2 Riparian zone component

Fig 5.8: Bushmans River, Riparian zone Habitat Integrity



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
RIPARIAN ZONE HABITAT INTEGRITY	70	71	57	56	55	53	43	43	46	20	23	25	24	24	32	52	52	42	73	69	72	73	73	73	73
VEGETATION REMOVAL (IMPACT 1 - 25)	2	2	4	4	5	5	5	4	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
EXOTIC VEGETATION (IMPACT 1 - 25)	12	11	14	15	15	15	22	20	14	10	10	10	10	10	10	6	6	6	6	6	6	6	6	6	6
BANK EROSION (IMPACT 1 - 25)	10	10	13	14	14	14	14	15	16	11	11	11	11	11	11	6	6	6	6	6	6	6	6	6	6
CHANNEL MODIFICATION (IMPACT 1 - 25)	3	3	3	3	3	5	5	6	6	15	13	15	13	13	10	7	7	7	9	10	10	8	8	8	8
WATER ABSTRACTION (IMPACT 1 - 25)	5	5	5	5	5	7	7	8	8	15	14	12	14	14	12	8	8	14	10	10	10	10	10	10	10
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	6	8	5	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
FLOW MODIFICATION (IMPACT 1 - 25)	5	5	5	5	5	7	7	8	8	20	20	17	17	17	17	16	16	16	10	10	10	10	10	10	10
WATER QUALITY (IMPACT 1 - 25)	6	6	6	6	6	6	6	7	7	12	12	11	11	12	12	12	12	12	8	8	8	8	8	8	8

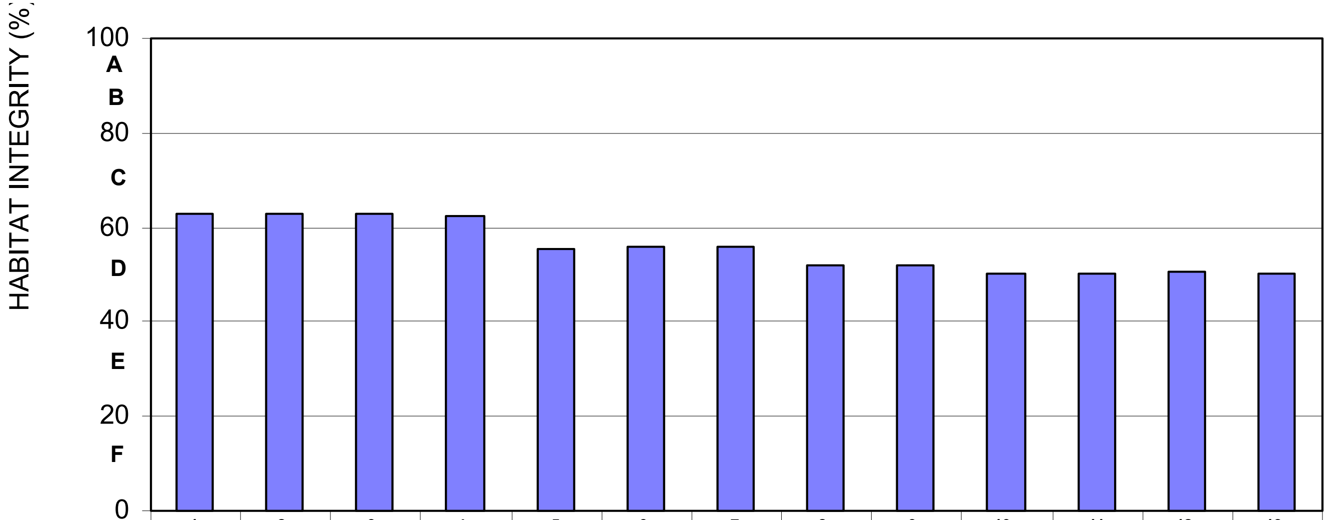
SECTOR (-> FLOW DIRECTION)

5.3.4 Sundays River

5.3.4.1 Instream component

Fig 5.9: Sundays River, Instream Habitat Integrity

A: NATURAL, >90 %
B: LARGELY NATURAL, 80-90%
C: MODERATELY MODIFIED, 60-79%
D: LARGELY MODIFIED, 40-59%
E: SERIOUSLY MODIFIED, 20-39%
F:CRITICALLY MODIFIED, 0-19%

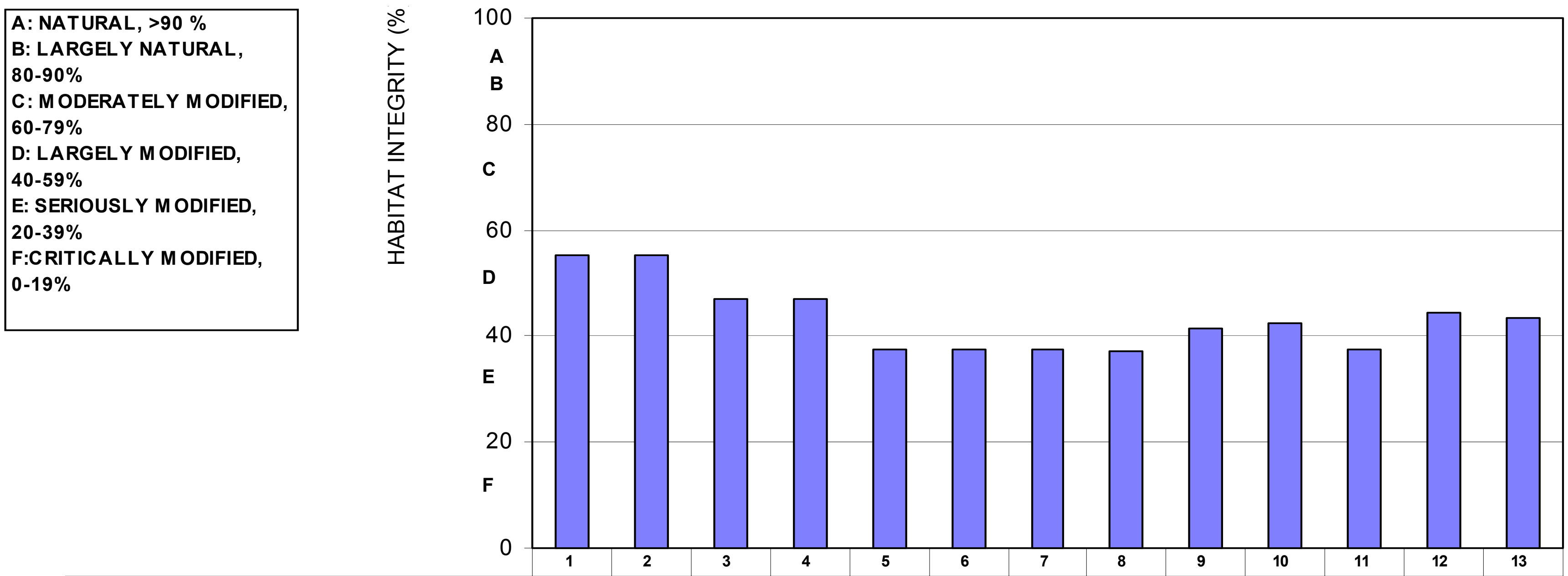


	1	2	3	4	5	6	7	8	9	10	11	12	13
INSTREAM HABITAT INTEGRITY (%)	63	63	63	62	55	56	56	52	52	50	50	51	50
WATER ABSTRACTION (IMPACT 1 - 25)	8	8	8	8	8	8	9	9	9	9	9	9	9
FLOW MODIFICATION ((IMPACT 1 - 25)	8	8	8	8	8	8	8	8	8	8	8	8	8
BED MODIFICATION (IMPACT 1 - 25)	14	14	14	15	15	15	15	16	16	16	16	16	16
CHANNEL MODIFICATION (IMPACT 1 - 25)	12	12	12	12	13	13	13	13	13	13	13	13	14
WATER QUALITY (IMPACT 1 - 25)	8	8	8	8	13	13	12	13	13	14	13	13	13
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	9	9	10	10	11	10	10	10	9	10	11	10	10
EXOTIC FAUNA (IMPACT 1 - 25)	5	5	5	5	6	5	5	5	5	10	10	10	10
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.4.2 Riparian zone component

Fig 5.10: Sundays River, Riparian zone Habitat Integrity



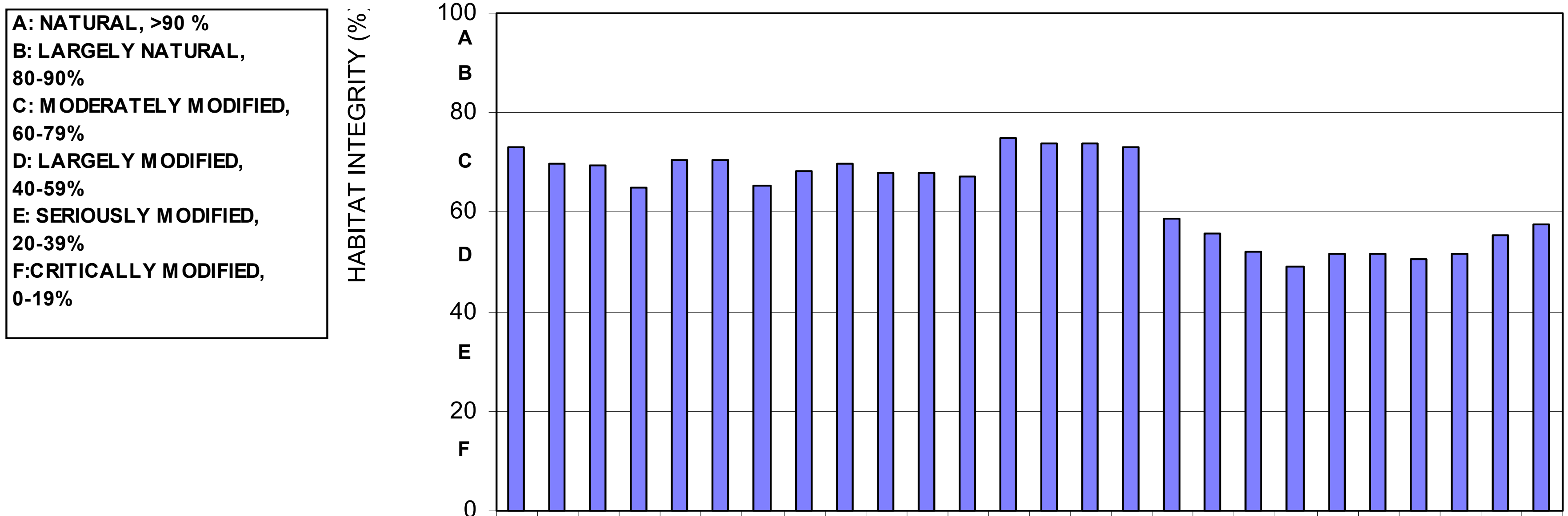
	1	2	3	4	5	6	7	8	9	10	11	12	13
RIPARIAN ZONE HABITAT INTEGRITY	55	55	47	47	37	37	37	37	41	42	37	44	44
VEGETATION REMOVAL (IMPACT 1 - 25)	12	12	12	12	13	13	13	12	13	13	13	12	13
EXOTIC VEGETATION (IMPACT 1 - 25)	9	9	9	9	10	10	10	9	10	10	11	10	10
BANK EROSION (IMPACT 1 - 25)	10	10	11	11	11	11	11	11	11	11	11	11	11
CHANNEL MODIFICATION (IMPACT 1 - 25)	11	11	11	11	11	11	11	11	11	11	11	11	11
WATER ABSTRACTION (IMPACT 1 - 25)	5	5	5	5	7	7	7	7	8	8	8	8	8
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	5	7	4	0	0	0
FLOW MODIFICATION (IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9
WATER QUALITY (IMPACT 1 - 25)	6	6	6	6	11	11	11	11	10	10	10	10	10

SECTOR (-> FLOW DIRECTION)

5.3.5 The Mooi River

5.3.5.1 Instream component

Fig 5.11: Mooi River, Instream Habitat Integrity

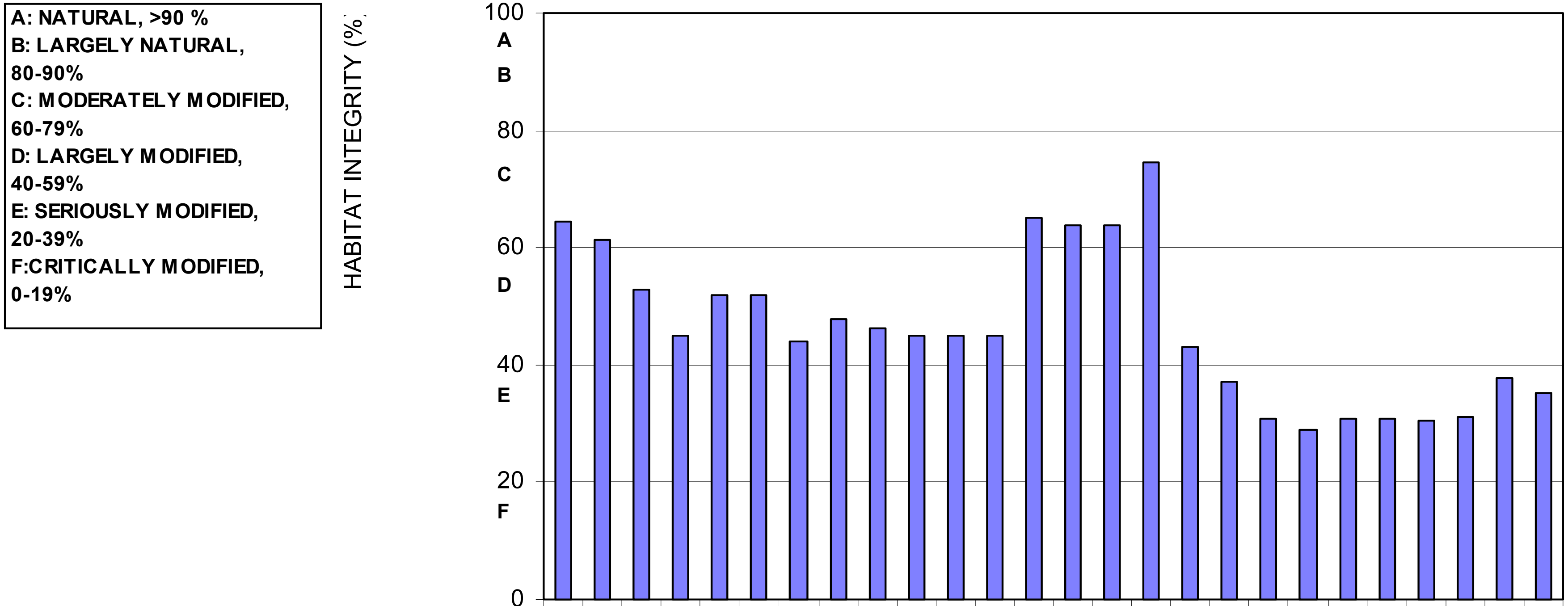


	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
INSTREAM HABITAT INTEGRITY (%)	73	70	70	65	71	71	65	68	70	68	68	67	75	74	74	73	59	56	52	49	52	52	51	52	55	58
WATER ABSTRACTION (IMPACT 1 - 25)	5	10	10	11	10	10	11	10	11	6	10	10	5	5	5	5	11	11	11	11	11	11	11	11	10	15
FLOW MODIFICATION ((IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10
BED MODIFICATION (IMPACT 1 - 25)	12	12	12	12	12	12	12	12	8	12	12	12	10	9	9	9	12	12	12	12	12	12	12	12	12	9
CHANNEL MODIFICATION (IMPACT 1 - 25)	7	7	7	7	7	7	7	7	4	8	8	8	5	5	5	5	10	11	11	11	11	11	11	11	11	8
WATER QUALITY (IMPACT 1 - 25)	6	5	5	5	5	5	5	5	5	6	6	6	6	9	9	9	10	10	11	11	11	11	11	11	11	11
INUNDATION (IMPACT 1 - 25)	0	3	0	0	0	0	3	6	8	5	0	0	0	0	0	0	0	0	0	8	0	0	3	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	5	5	7	8	8	8	10	10	10	10	11	11	11	11	11	11	11
EXOTIC FAUNA (IMPACT 1 - 25)	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.5.2 Riparian zone component

Fig 5.12: Mooi River, Riparian zone Habitat Integrity



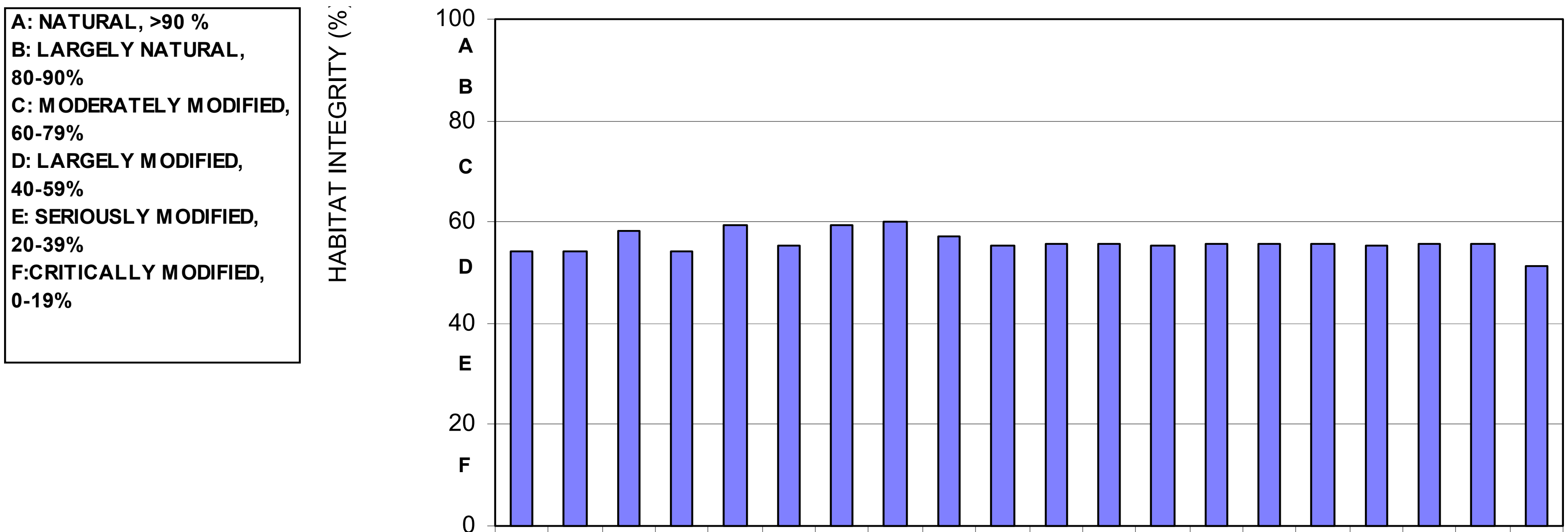
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
RIPARIAN ZONE HABITAT INTEGRITY	65	61	53	45	52	52	44	48	46	45	45	45	65	64	64	75	43	37	31	29	31	31	31	31	38	35
VEGETATION REMOVAL (IMPACT 1 - 25)	12	12	12	12	12	12	12	12	8	12	12	12	8	8	8	8	13	13	13	13	13	13	13	13	13	13
EXOTIC VEGETATION (IMPACT 1 - 25)	6	6	6	6	6	6	6	10	10	12	12	12	8	8	8	8	14	14	14	14	14	14	13	13	13	13
BANK EROSION (IMPACT 1 - 25)	10	10	13	14	14	14	14	15	16	11	11	11	11	11	11	6	6	6	6	6	6	6	6	6	6	6
CHANNEL MODIFICATION (IMPACT 1 - 25)	7	7	7	7	7	7	7	7	4	8	8	8	5	5	5	5	10	11	11	11	11	11	11	11	11	8
WATER ABSTRACTION (IMPACT 1 - 25)	5	10	10	11	10	10	11	10	11	6	10	10	5	5	5	5	11	11	11	11	11	11	11	11	10	15
INUNDATION (IMPACT 1 - 25)	0	3	0	0	0	0	3	6	8	5	0	0	0	0	0	0	0	0	0	8	0	0	3	0	0	0
FLOW MODIFICATION (IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10
WATER QUALITY (IMPACT 1 - 25)	6	5	5	5	5	5	5	5	5	6	6	6	6	9	9	9	10	10	11	11	11	11	11	11	11	11

SECTOR (-> FLOW DIRECTION)

5.3.6 The Buffalo River

5.3.6.1 Instream component - upper Buffalo River

Fig 5.13: Upper Buffalo River, Instream Habitat Integrity

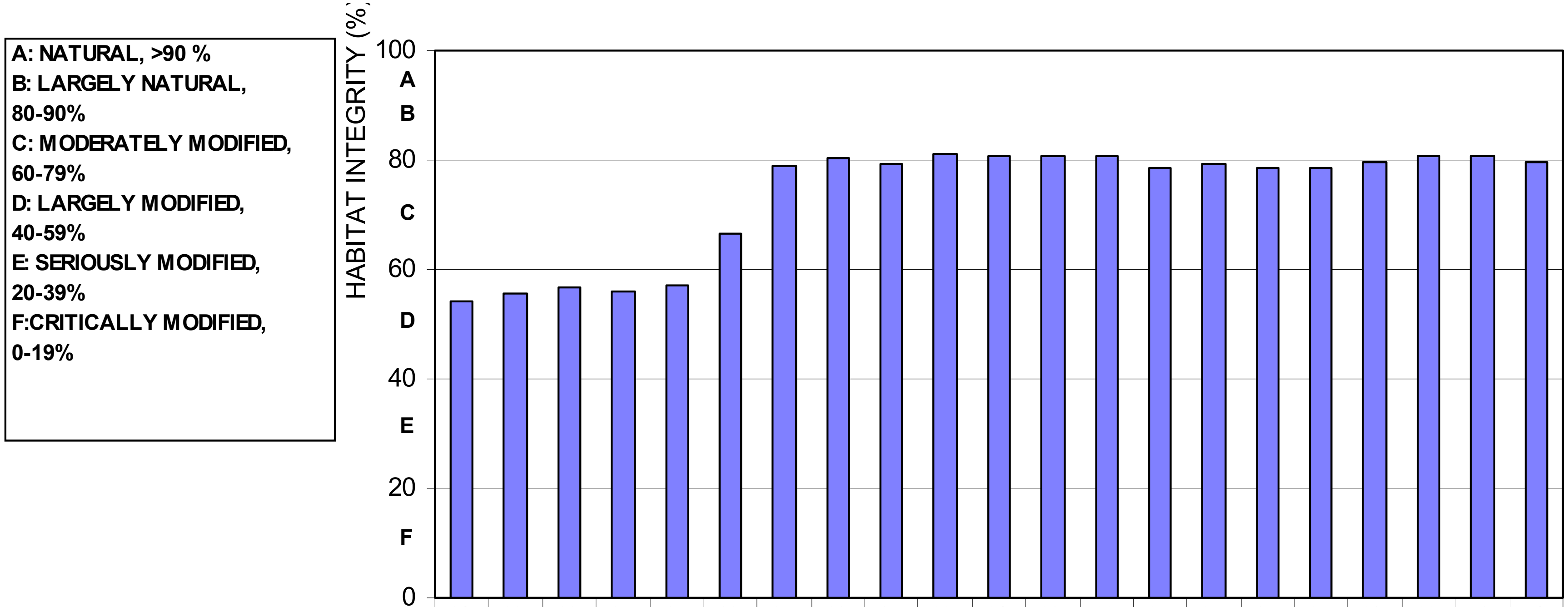


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
INSTREAM HABITAT INTEGRITY (%)	54	54	58	54	60	55	60	60	57	55	56	56	55	56	56	56	55	56	56	51
WATER ABSTRACTION (IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
FLOW MODIFICATION ((IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
BED MODIFICATION (IMPACT 1 - 25)	16	16	15	16	15	17	15	14	14	17	16	16	17	16	16	16	17	16	16	17
CHANNEL MODIFICATION (IMPACT 1 - 25)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
WATER QUALITY (IMPACT 1 - 25)	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
EXOTIC FAUNA (IMPACT 1 - 25)	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.6.2 Instream component - lower Buffalo River

Fig 5.14: Lower Buffalo River, Instream Habitat Integrity

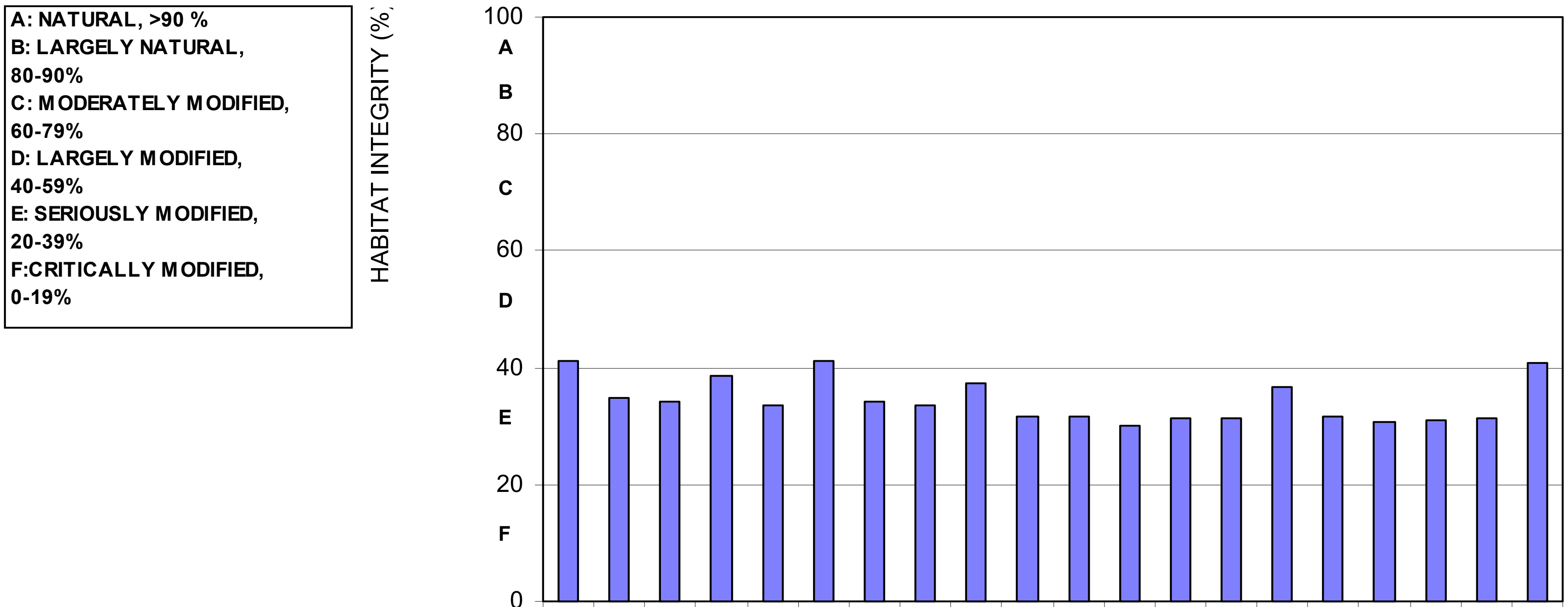


	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
INSTREAM HABITAT INTEGRITY (%)	54	56	57	56	57	67	79	80	79	81	81	81	81	79	79	79	79	80	81	81	80
WATER ABSTRACTION (IMPACT 1 - 25)	9	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FLOW MODIFICATION ((IMPACT 1 - 25)	8	8	8	8	8	8	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6
BED MODIFICATION (IMPACT 1 - 25)	17	17	17	17	17	12	8	7	6	5	5	6	5	7	7	6	5	5	3	4	4
CHANNEL MODIFICATION (IMPACT 1 - 25)	12	12	12	12	11	9	5	4	7	4	4	3	5	6	5	7	7	6	6	5	7
WATER QUALITY (IMPACT 1 - 25)	12	13	12	13	12	12	12	12	12	12	13	13	12	13	13	13	13	12	12	13	13
INUNDATION (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0
RUBBISH DUMPING (IMPACT 1 - 25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

5.3.6.3 Riparian zone component - upper Buffalo River

Fig 5.15: Upper Buffalo River, Riparian zone Habitat Integrity



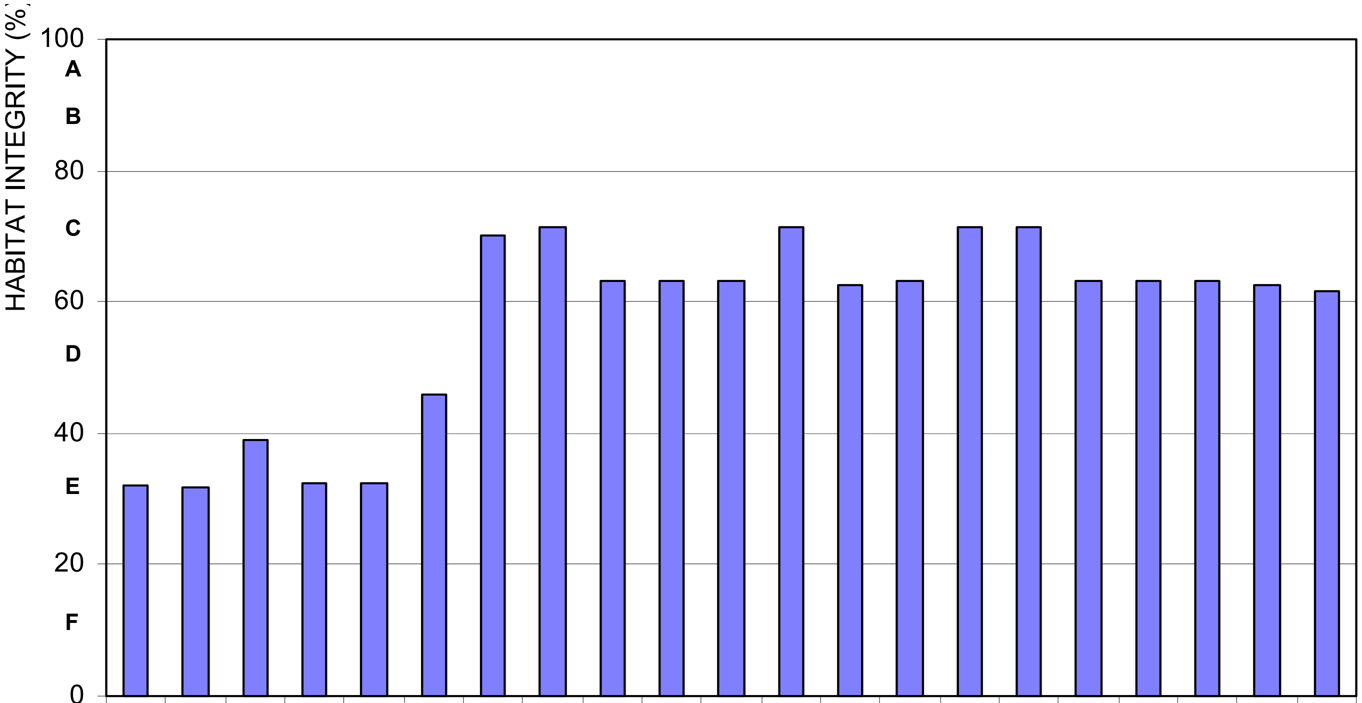
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
RIPARIAN ZONE HABITAT INTEGRITY	41	35	34	39	34	41	34	34	37	32	32	30	31	31	37	32	31	31	31	41
VEGETATION REMOVAL (IMPACT 1 - 25)	10	11	12	10	11	10	12	11	10	11	11	12	11	11	10	11	12	12	11	10
EXOTIC VEGETATION (IMPACT 1 - 25)	3	3	3	6	8	3	3	8	8	3	3	7	5	5	8	3	5	3	5	3
BANK EROSION (IMPACT 1 - 25)	15	15	15	15	15	15	15	15	15	16	16	16	16	16	16	16	16	16	16	15
CHANNEL MODIFICATION (IMPACT 1 - 25)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
WATER ABSTRACTION (IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
INUNDATION (IMPACT 1 - 25)	0	0	0	6	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	1
FLOW MODIFICATION (IMPACT 1 - 25)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
WATER QUALITY (IMPACT 1 - 25)	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14

SECTOR (-> FLOW DIRECTION)

5.3.6.4 Riparian zone component - lower Buffalo River

Fig 5.16: Lower Buffalo River, Riparian zone Habitat Integrity

A: NATURAL, >90 %
B: LARGELY NATURAL, 80-90%
C: MODERATELY MODIFIED, 60-79%
D: LARGELY MODIFIED, 40-59%
E: SERIOUSLY MODIFIED, 20-39%
F:CRITICALLY MODIFIED, 0-19%



	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
RIPARIAN ZONE HABITAT INTEGRITY	32	32	39	33	32	46	70	71	63	63	63	71	62	63	71	71	63	63	63	62	62
VEGETATION REMOVAL (IMPACT 1 - 25)	11	11	10	11	12	11	9	10	11	11	11	10	12	11	10	10	11	11	11	12	13
EXOTIC VEGETATION (IMPACT 1 - 25)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
BANK EROSION (IMPACT 1 - 25)	17	17	17	17	17	12	7	4	4	4	4	4	4	4	4	4	4	4	4	4	4
CHANNEL MODIFICATION (IMPACT 1 - 25)	12	12	12	12	11	9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
WATER ABSTRACTION (IMPACT 1 - 25)	9	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INUNDATION (IMPACT 1 - 25)	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FLOW MODIFICATION (IMPACT 1 - 25)	8	8	8	8	8	8	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6
WATER QUALITY (IMPACT 1 - 25)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

SECTOR (-> FLOW DIRECTION)

Fig 5.17 Upper Thukela Instream and Riparian Habitat Integrity results

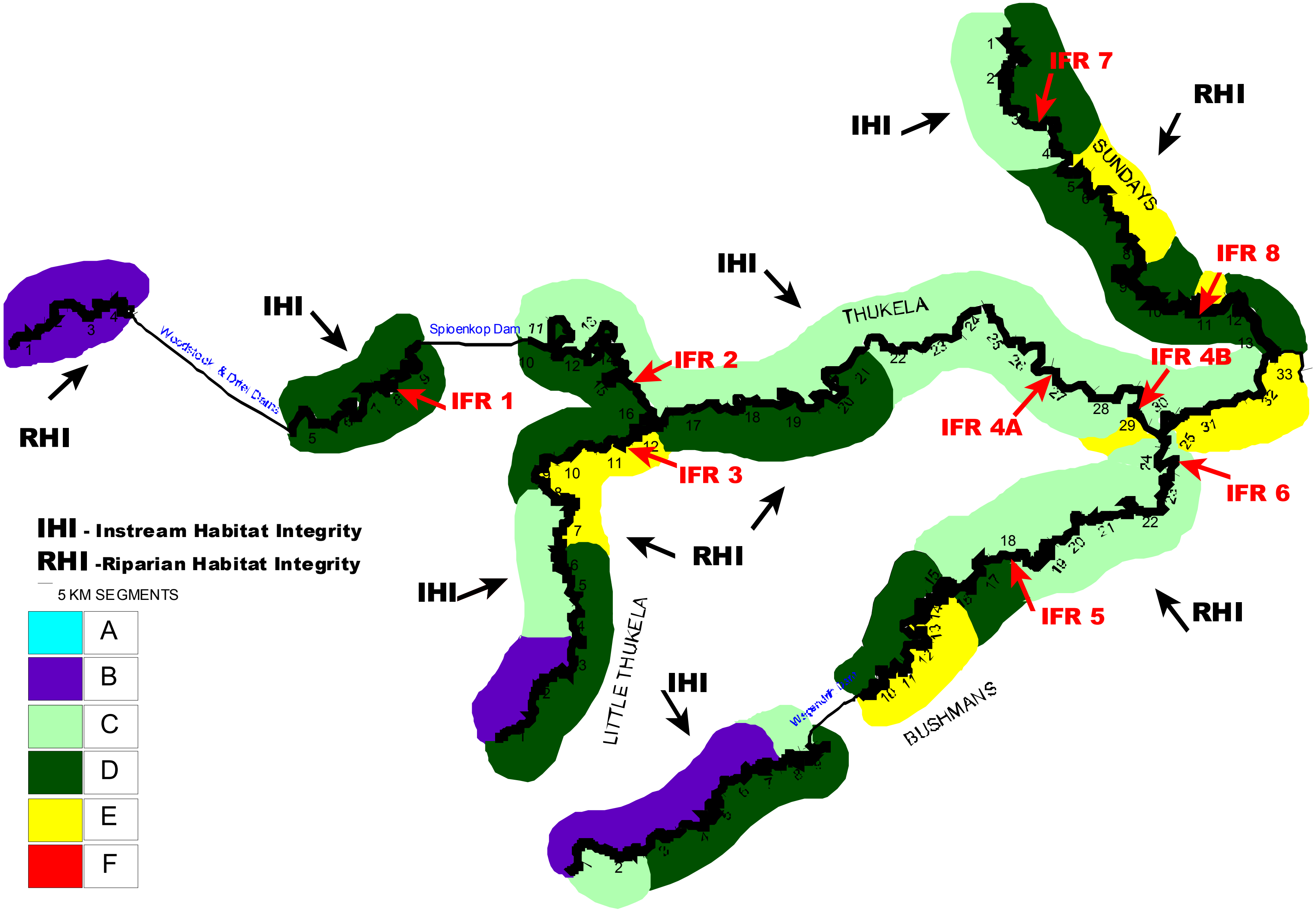
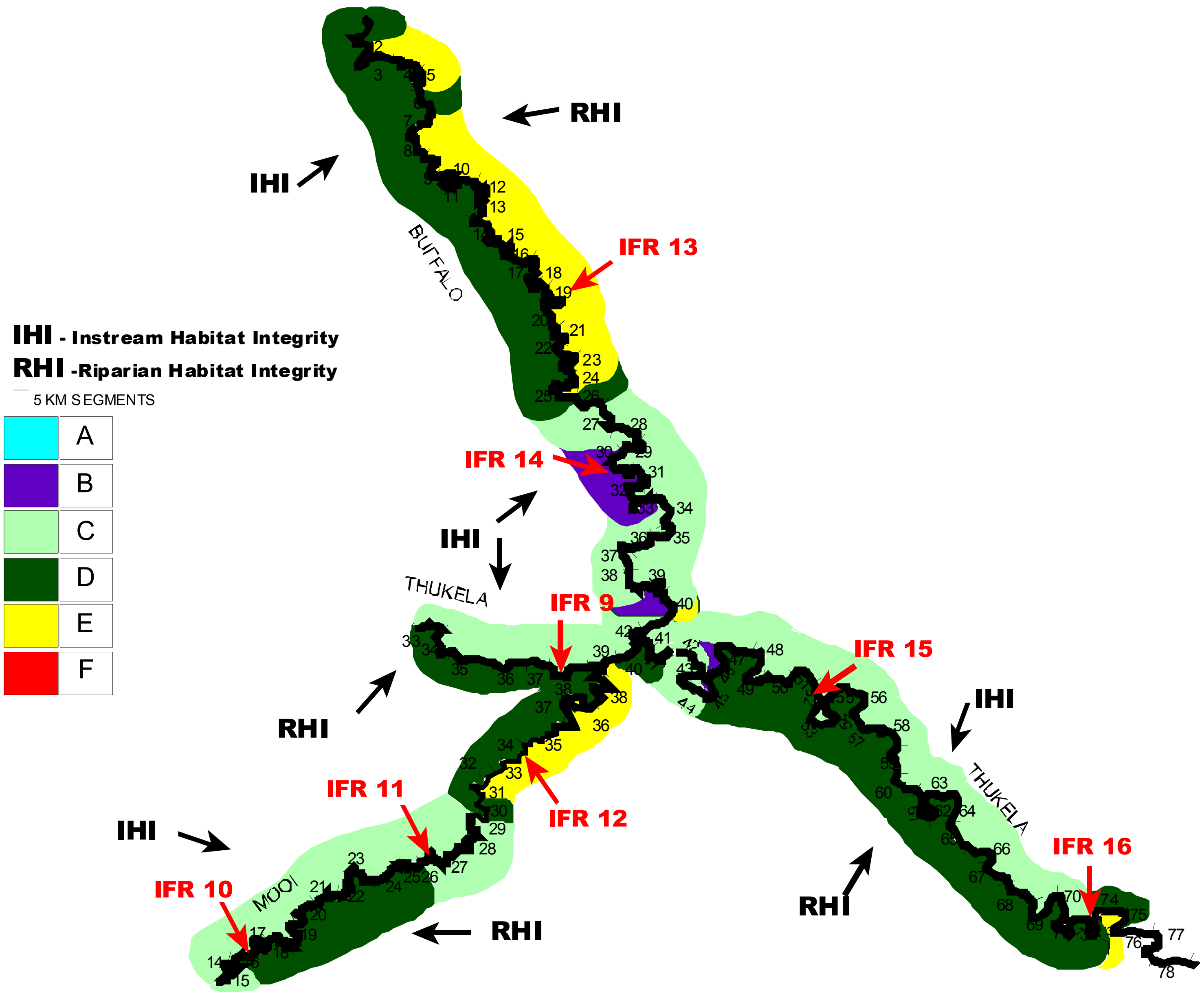


Fig 5.18 Lower Thukela Instream and Riparian Habitat Integrity results



5.4 DISCUSSION

5.4.1 Thukela river

The instream habitat integrity of the Thukela River (figures 5.17 and 5.18) has been significantly modified by the presence of dams in the system. The operation of the Woodstock / Driel and the Spioenkop Dams in the upper reaches of the river have resulted in a highly regulated river for some distance downstream with the unseasonal and unnatural inundation and exposure of important habitat types. The inflow of various important tributaries in the system serves to improve the situation as one proceeds down the system. River bed and channel habitats have also been significantly impacted by the introduction and accumulation of sediments in the system particularly from poor management practices in the main catchment of the Thukela as well as those of the various tributaries. The aggradation of sediments along with the modified flow regime and the influence of runoff in some areas has brought about the encroachment of macrophytes and the loss or change in marginal habitat environments. Exotic fish have also had an impact on the integrity of instream habitats.

The riparian zone of the Thukela River has been significantly impacted by the devastating force of large historical flood events which have left some areas without suitable substrate for the re-colonisation of riparian vegetation. Bank erosion, resulting mainly from the impact of livestock activities, subsistence and formal agriculture, and the excessive utilisation of river resources has been significant in the further degradation of the riparian zone as well as serving to prevent its natural recovery after large floods. The riparian zone has also been impacted by the regulation and modification of the flow regime, which has largely resulted in the changes in the marginal zone habitats. Exotic riparian species have had a major impact on the availability of riparian habitats for indigenous trees and have therefore also retarded the natural recovery of the riparian zone.

5.4.2 Little Thukela River

The habitat integrity of the Little Thukela River has mainly been impacted by the aggradation of sediments due to livestock activities and subsistence farming in the upper catchment. The impact of abstractions and both subsistence and formal agriculture in the riparian zone as well as exotic fauna and flora have also been responsible for significant degradation of both instream and in the riparian zone habitats.

5.4.3 Bushmans River

The presence and operation of the Wagendrift Dam have had a significant impact on the integrity of habitats in the Bushmans River system. As with the other main rivers of the Thukela system, the aggradation of sediments due to livestock activities and subsistence farming in the upper catchment is also applicable here too. Formal farming practices have also been responsible for the degradation of both instream and riparian habitats. The encroachment of reeds and exotic vegetation has resulted in the significant modification of both instream and riparian zone habitats.

5.4.4 Sundays River

The habitat integrity of the Sundays River has also been significantly modified by livestock activities, subsistence farming, unsustainable utilisation of river resources, formal agricultural practices and the devastation by large historical floods. The system is consequently severely aggraded with sediments and the riparian zone is stripped of riparian zone habitat and indigenous vegetation. Large parts of the river are encroached by both reeds and exotic vegetation. The constant pressure of livestock and utilisation of resources by local communities will inevitably ensure that little to no recovery of the system is likely in the long term.

5.4.5 Mooi river

The integrity of habitats in the Mooi river have been impacted mainly by formal agricultural practices such as clearance and farming in the riparian zone, water abstraction, irrigation runoff, weirs and impoundments and formal stock farming. The river has consequently become aggraded with sediments, encroached with both reeds and exotic riparian species as well as exotic fauna, and the water quality has been compromised. Historical large floods have also been responsible for the loss of large areas of the riparian habitat and natural vegetation.

5.4.6 Buffalo River

The upper Buffalo River has been severely impacted by both formal and subsistence farming, livestock activity, unsustainable utilisation of resources mining activities and large historical floods. The integrity of both instream and riparian habitats have been significantly degraded and consequently the river is highly aggraded with sediments, the water quality has been compromised, exotics and reeds have become encroached the riparian zone has been denuded in large areas. The instream and riparian habitats of the lower Buffalo River are, however, in a comparatively good state due to the presence of the gorge and its poor accessibility.

5.4.7 Comparison with previous Habitat Integrity Assessment

The previous assessment of the habitat integrity of the Thukela system was undertaken by Kleynhans (1995). In this assessment only the Thukela River from Spioenkop Dam to just below the Buffalo River confluence was assessed. None of the tributaries apart from the Mooi River (a separate investigation) were assessed.

The current assessment includes a much larger area, from the top of the Thukela to the mouth as well as most of the major tributaries. The only area in common between the two independent assessments appears, however, to be quite similar, particularly from an instream perspective. The current assessment does appear to consider the impact of large historical floods on the riparian zone differently. The current assessment considers the impact of the historical floods as a more significant event under vegetation removal criterion. Consequently, the overall riparian zone assessment is much lower than that of Kleynhans (1995).

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6. QUANTITY RESOURCE UNITS

6.1 APPROACH

In this Chapter:

A general approach was described in DWAF (1999). A specific method was not described and the 1999 approach was refined for use in this study.

If a Reserve determination is required for a whole catchment, it is necessary to break down the catchment into Quantity RUs (referred to hereafter as RUs) which is each significantly different from the other to warrant their own specification of the Reserve, and to clearly delineate the geographic boundaries of each. (DWAF 99, vol 3)

The reason for this is because, for example, it would be inappropriate to set the same numerical Reserve for the headwaters of a river as for the lowland reaches; these sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach.

The breakdown of a catchment into RUs for the purpose of determining the Reserve for rivers is done primarily on a biophysical basis, according to the occurrence of different ecological regions (eco-regions) within the catchment. Since the endpoint of a Reserve determination is an ecological one, the idea is to break down the catchment into units which are relatively homogenous on an ecological basis, to ensure the Reserve is set in appropriate terms. (DWAF 99, vol 3)

The breakdown into RUs via ecoregions and/or geohydrological response units could then be further resolved into smaller RUs which are suited to management requirements. (DWAF 99, vol 3). An example could be where large dams occur in the area and/or transfer schemes. The difference in operation of different river reaches also result in biophysically different river reaches and should be considered.

The process considers all of the above issues, as well as results of the Habitat Integrity assessment (Chapter 5). Overlaying all the data does not necessarily result in a logical and clear delineation and expert judgement, a consultative process and local knowledge are required to determine the RUs. The practicalities of dealing with numerous reaches within one study must also be considered to determine a logical and practical suite of RUs.

The Reserve is determined for each RU by means of either the following:

- An IFR site is selected within the RU representing a critical site within the relevant river section. Results generated for the Resource Unit at the IFR site will then be relevant for the Resource Unit as a whole (Chapter 8).
- No IFR site is selected within the RU and results from adjacent RUs with IFR sites are extrapolated to this RU. The reasons for an IFR site not being selected within the RU can be the following:
  - The characteristics of the river within the RU do not meet the criteria of IFR sites.
  - Due to the amount of RUs within the study area, it could not be practical and/or cost-effective to address IFR sites within each RU.

6.2 ECOREGIONS[1]

The ecoregion typing approach developed in the USA (Omernik 1987) was applied and tested at a preliminary level in South Africa. Ecoregional classification or typing will allow the grouping of rivers according to similarities based on a top-down approach. The purpose of this approach is to simplify and contextualise assessments and statements on ecological water requirements.

The principles and fundamentals of the approach entail the following:

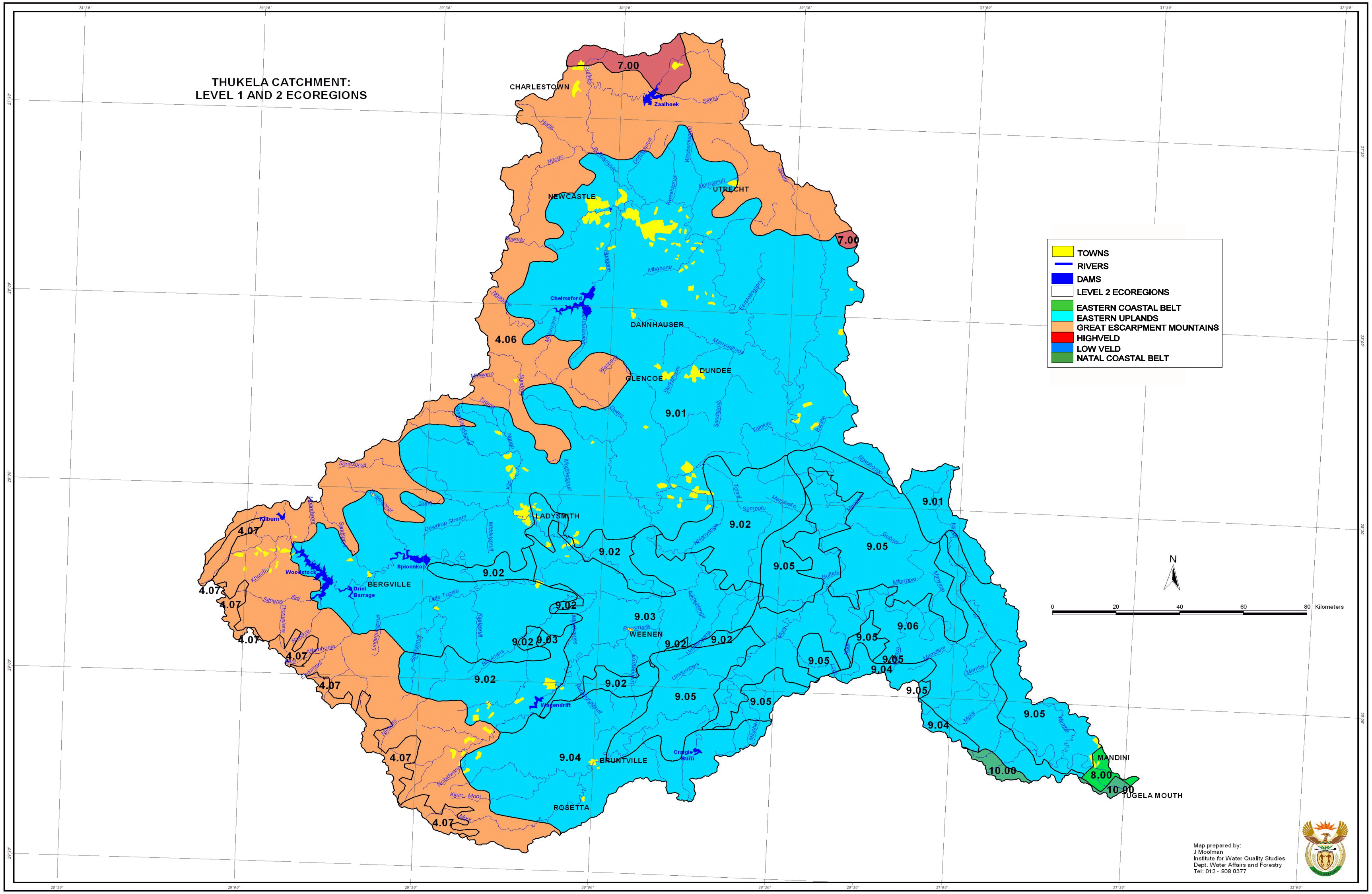
- Ecoregions can be identified or typed according to various levels of detail. The principle of river typing is that rivers or river reaches grouped together at a particular level of the typing hierarchy will be more similar to one another than to rivers in other groups.
- An ecosystems approach recognizes that ecosystem components do not function as independent systems but that they exist only in association with one another.
- Ecosystems and their components display regional patterns that are reflected in spatially variable combinations of causal factors such as climate, mineral availability (soils and geology), vegetation and physiography. These factors interact, but the importance of each factor in determining the character of ecosystems varies from place to place.
- Omernik's approach is based on patterns of terrestrial characteristics and on the premise that relatively homogenous areas exist and that these areas can be defined by simultaneously analysing a combination of causal and integrative factors. In this approach, ecoregions are regions of relative homogeneity in ecological characteristics or in relationships between organisms and their environments.
- Ecoregional classification uses multiple characteristics at each level of a typing hierarchy. Ecological regions are then regions within which there is relative similarity in the mosaic of ecosystems and ecosystem components (biotic and abiotic, aquatic and terrestrial).
- The delineation of ecological regions requires evaluating maps of all geographic phenomena believed to cause or reflect spatial differences in ecosystems. Where combinations of these phenomena coincide spatially, the ecosystems are likely to be similar. The process requires qualitative examination to account for the differences in generality, accuracy, and particular classifications of each map. The regions are essentially sketched, using expert judgement to delineate boundaries.
- Ecoregional classification is a hierarchical procedure that involves the delineation of ecoregions with a progressive increase in detail at each higher level of the hierarchy, i.e. essentially the same characteristics are used at the various levels but with more detail as one moves to a higher level in the hierarchy. In addition, the characteristics that are more or less important can vary from one place to another.

The current effort uses available information to delineate ecoregion boundaries at a very broad scale (i.e. Level I) for South Africa. Attributes such as physiography, climate, rainfall, geology and potential natural vegetation were evaluated in this process and 18 Level I ecoregions were identified. (DWAF 99) The next Level (II) uses the same attributes but in more detail. Physiography can for example, be looked at in more detail by considering terrain morphological classes, slopes, relief, altitude, etc.

The Department of Water Affairs and Forestry (DWAF), Institute of Water Quality Studies (IWQS (Dr Neels Kleynhans and Ms Christa Thirion)) provided the Level I and II ecoregions for the Thukela River. The results are provided in the map below (Figure 6.1).

[1] Note that the ecoregion classification was undertaken by IWQS, DWAF and the results used for this study. Undertaking an ecoregion classification was not part of the TOR.

Fig 6.1 Level II Ecoregions for the Thukela Catchment



6.3 SELECTION OF QUANTITY RESOURCE UNITS

RUs were selected during the IFR planning meeting on 29 July 2001 by the following specialists:
Ms Delana Louw (IFR team leader).
Mr Nigel Kemper (Riparian vegetation and habitat integrity specialist).
Mr Mike Coke (Fish).
Dr Chris Dickens (Aquatic invertebrates).
Dr Neels Kleynhans (Ecoregions and fish)
Ms Christa Thirion (Ecoregions and aquatic invertebrates).
Dr Roy Wadeson (Fluvial gemorphologist).
Dr Drew Birkhead (Hydraulician).

The following were considered when selecting the RU:

- Ecoregions (6.2).
- Geomorphological classification (Chapter 4).
- Operation of the system.
- Hydology.
- Habitat integrity (Chapter 5).
- Local knowledge and expert judgement.

The ecoregion breaks, geomorphological zones and habitat integrity are overlain on a map (Figures 6.2 to 6.6) and discussed below. (NOTE: The colours in these figures only reflect a change in category and do not refer to a specific category)

6.4 RATIONALE FOR AND DESCRIPTION OF RUs

6.4.1 Resource Unit A: Segment 1 - 4 (Rugged Glen to Woodstock Dam) (Figure 6.2)

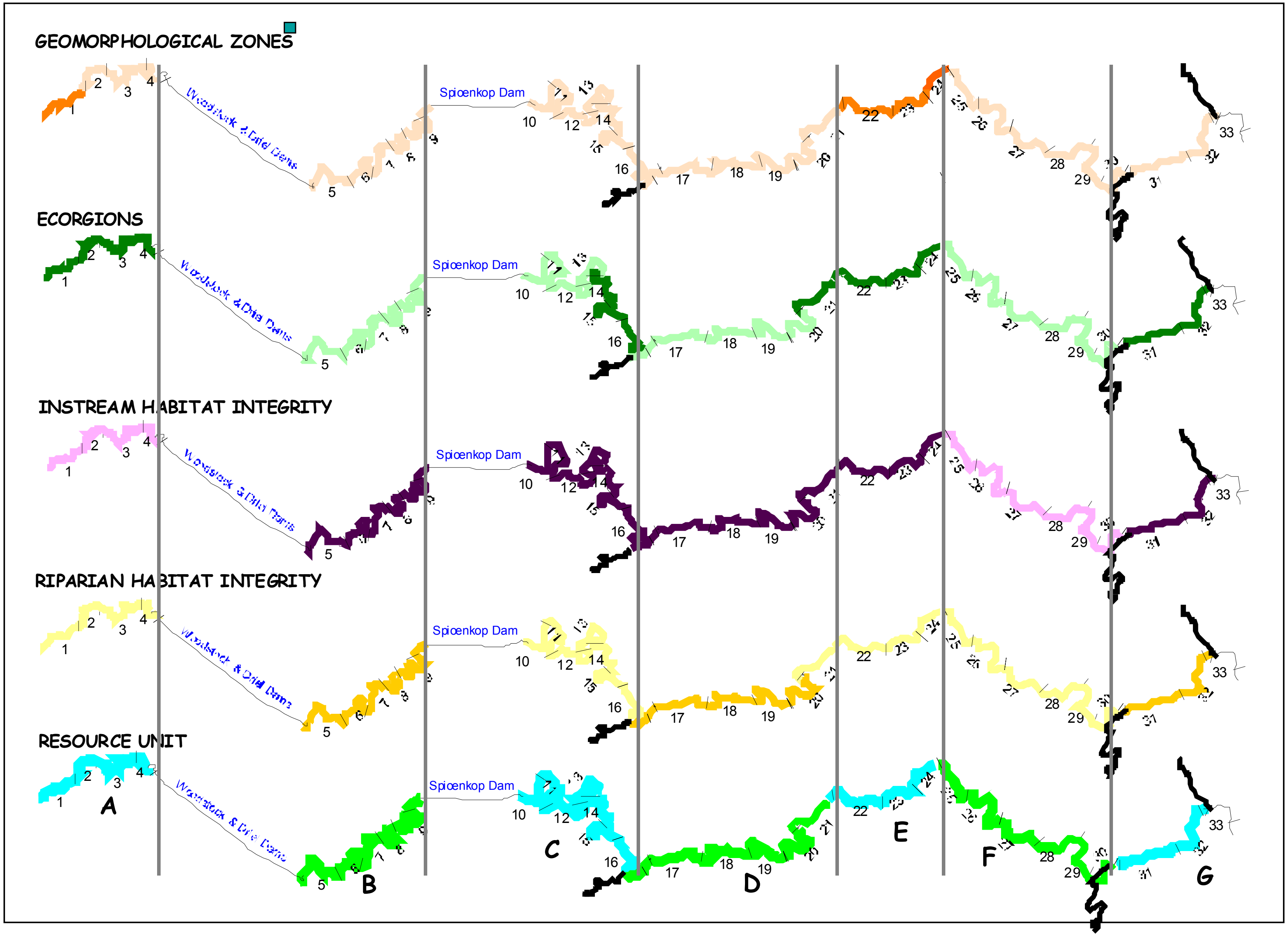
- RU A consists of two geomorphology zones, one of which is one segment long. The geomorphology zone ends at the back up of Woodstock Dam.
- An Ecoregion Level II break occurs at Woodstock Dam
- Habitat Integrity for both instream and the riparian components are homogenous from the start of segment 1 to Woodstock Dam.
- There are no significant operational zones within the study area above Woodstock Dam.

All aspects considered apart from the geomorphological zonation were homogenous in the area upstream of Woodstock Dam. The one segment geomorphological zone which is different from the rest of this section does not warrant a separate Reserve determination (and therefore a separate RU). The 4 segments above Woodstock Dam were therefor classified as RU A with Woodstock Dam as the logical end point.

6.4.2 Resource Unit B: Segment 5 - 9 (Driel Barrage to Spioenkop Dam) (Figure 6.2)

Dams do not form part of the RU and RU B therefore starts at the Driel Barrage. For all the components considered, the stretch of river between Driel Barrage to the back-up of Spioenkop Dam forms a homogenous unit. As Spioenkop Dam forms a significant operational break, the back-up of Spioenkop Dam forms the logical end point of RU B.

Fig 6.2 **Upper Thukela: Comparison between geomorphological zones, ecoregions, instream and riparian Habitat Integrity**



6.4.3 Resource Unit C: Segment 10 - 16 (Spioenkop Dam to Little Thukela confluence) (Figure 6.2)

Dams do not form part of the RU and RU C therefore starts at the Spioenkop Dam wall. For all the components considered, apart from the ecoregions, the stretch of river between Spioenkop Dam to the Little Thukela confluence forms a homogenous unit. Two different ecoregions occur within this zone, but due to the length of river concerned, as well as considering that all the other components are homogenous, it was decided that this RU would incorporate the two ecoregions. The Little Thukela confluence forms the break for the downstream ecoregion as well as a clear hydrological and operational break (attenuation of the Spioenkop Dam operation) and the Klein Thukela confluence therefore forms the logical end point of RU C.

6.4.4 Resource Unit D: Segment 17 - 21 (Little Thukela confluence to end of Lower Foothill Zone) (Figure 6.2)

RU D starts at the end of RU C, i.e. the Little Thukela confluence. Based on a clear break in both geomorphology as well as the ecoregions, this RU ends at segment 21. The riparian habitat integrity change also coincides with this break.

6.4.5 Resource Unit E: Segment 22 - 24 (Start of Rejuvenated Bedrock Falls Zone to Klip confluence) (Figure 6.2)

RU E starts at the end of RU D, i.e. segment 22. The geomorphological zones, ecoregions and the instream habitat integrity change at the confluence of the Klip River. It was also known that the Klip River would change the water quality considerable and the confluence of the Klip River was therefore deemed to be a logical end point for the RU.

6.4.6 Resource Unit F: Segment 25 - 30 (Klip confluence to Bushmans confluence) (Figure 6.2)

RU F starts at the end of RU E, i.e. the confluence of the Klip River. Based on ecoregions and Habitat Integrity (which changed at the confluence of the Bushmans River) as well as considering the change in hydrology and operational implications of the Bushmans River, the Bushmans River confluence was deemed to be a logical end point for RU F.

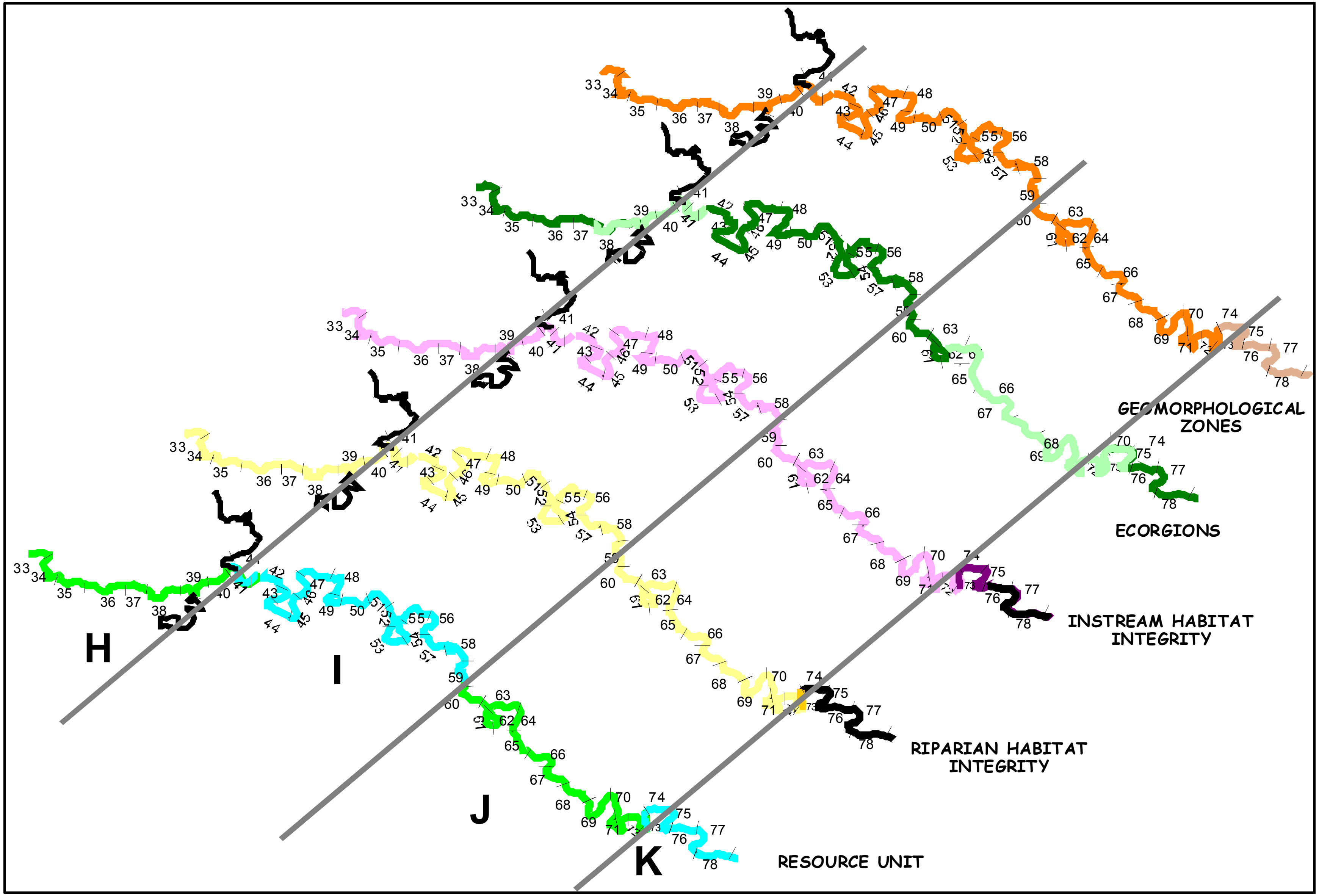
6.4.7 Resource Unit G: Segment 31 - 33 (Bushmans to Sundays confluence) (Figure 6.2)

The RU G starts at the end of RU F, i.e. the confluence of the Bushmans River. The end of the Upper Thukela break is the Sundays confluence and this therefore had to form the logical break of this RU.

6.4.8 Resource Unit H: Segment 34 - 40 (Sundays confluence to Buffalo confluence) (Figure 6.3)

The Lower Thukela starts at the confluence of the Sundays River. The geomorphology, and habitat integrity are homogenous for a significant proportion of the Lower Thukela. As this length of River forms a large part of the study area, it has to be broken down into RUs. The ecoregions, expert judgement and operation therefore played a role in determining these RU breaks. The Buffalo River confluence forms a logical end of the RU considering hydrology and operational units. The Buffalo River confluence also forms the end of an ecoregion. Two ecoregions occur within this RU; however, again the RU is too short a length of River to warrant two RUs. It was therefore decided that the Buffalo River confluence would form the logical end point of the RU.

Fig 6.3 Lower Thukela: Comparison between geomorphological zones, ecoregions, instream and riparian Habitat Integrity



6.4.9 Resource Unit I: Segment 41 - 59 (Buffalo confluence to Middledrift) (Figure 6.3)

The RU I starts at the end of RU H, i.e. the Buffalo confluence. An ecoregion break occurs at approximately segment 61. Middle Drift which forms one of the few access points in this section of River as well as according to the local knowledge illustrates a change in River was selected as the end point of the RU. It was felt that the ecoregion break supported this as the resolution on the ecoregions are such that it cannot be pinpointed to an exact locality. The Middle Drift transfer scheme also provides motivation for this break considering operational units.

6.4.10 Resource Unit J: Segment 60 - 72 (Middledrift to end of Rejuvenated Foothills Zone) (Figure 6.3)

The RU J starts at the end of RU I, i.e. Middle Drift. The end of this RU was located by the change in all the components. It is also in the region of the estuarine River interface and was deemed to be the logical break.

6.4.11 Resource Unit K: Segment 73 - mouth (Start of Lowland River to mouth) (Figure 6.3)

The RU is represented by the estuary and will not be further addressed within the River assessment.

6.4.12 Resource Unit L: Segment 1 - 4 (Wonder Valley base to Eastern Uplands B) (Figure 6.4)

This RU is in the Klein Thukela River. The study area starts at the Wonder Valley base which therefore forms the starting point of RU L. The break in ecoregion (Eastern Uplands B) as well as the change in habitat integrity provides the basis for the end point of this RU.

6.4.13 Resource Unit M: Segment 5 - 12 (Eastern Uplands A to Thukela Confluence) (Figure 6.4)

The RU starts at the end of RU L, i.e. segment 5. Although there are some changes within the rest of the river, it was deemed to be too insignificant to warrant more than one RU. The confluence with the Thukela River therefore forms the logical end point of the RU.

6.4.14 Resource Unit N: Segment 1 - 9 (Elands Park to Wagendrift Dam) (Figure 6.5)

This RU is in the Bushmans River. The study area starts at Elands Park which therefore forms the starting point of RU N. The Wagendrift Dam forms the logical end point of this RU considering hydrology and operational units. This is further supported by the fact that the other components illustrate a mostly homogenous zone upstream of Wagendrift Dam.

6.4.15 Resource Unit O: Segment 10 - 18 (Wagendrift Dam to Upper Foothills) (Figure 6.5)

Dams do not form part of RUs and RU O therefore starts at the Wagendrift Dam wall. No clear indication was provided by the different components on a break within the rest of the Bushmans River. The ecoregion was the only component that provided an indication of a break (Upper Foothills). However, this section is well known by the specialists, especially as two existing IFR sties are located within this section. The change in landuse due to significant irrigation around Weenen as well as the ecoregions provided some indication of a break and the end of the Weenen Nature Reserve was therefore selected as the end point of this RU.

Fig 6.4 Little Thukela and Sundays Rivers: Comparison between geomorphological zones, ecoregions, instream and riparian Habitat Integrity

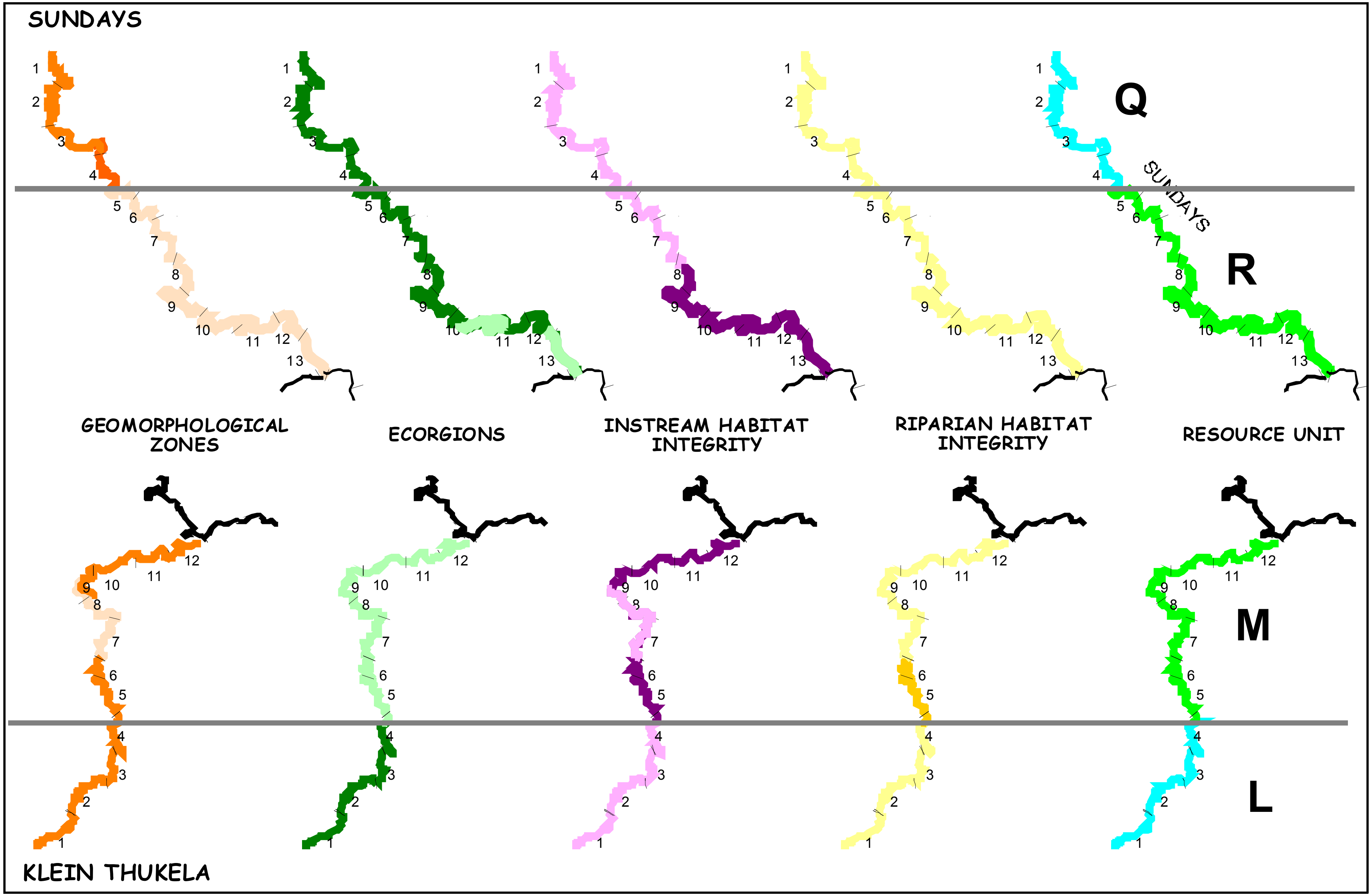
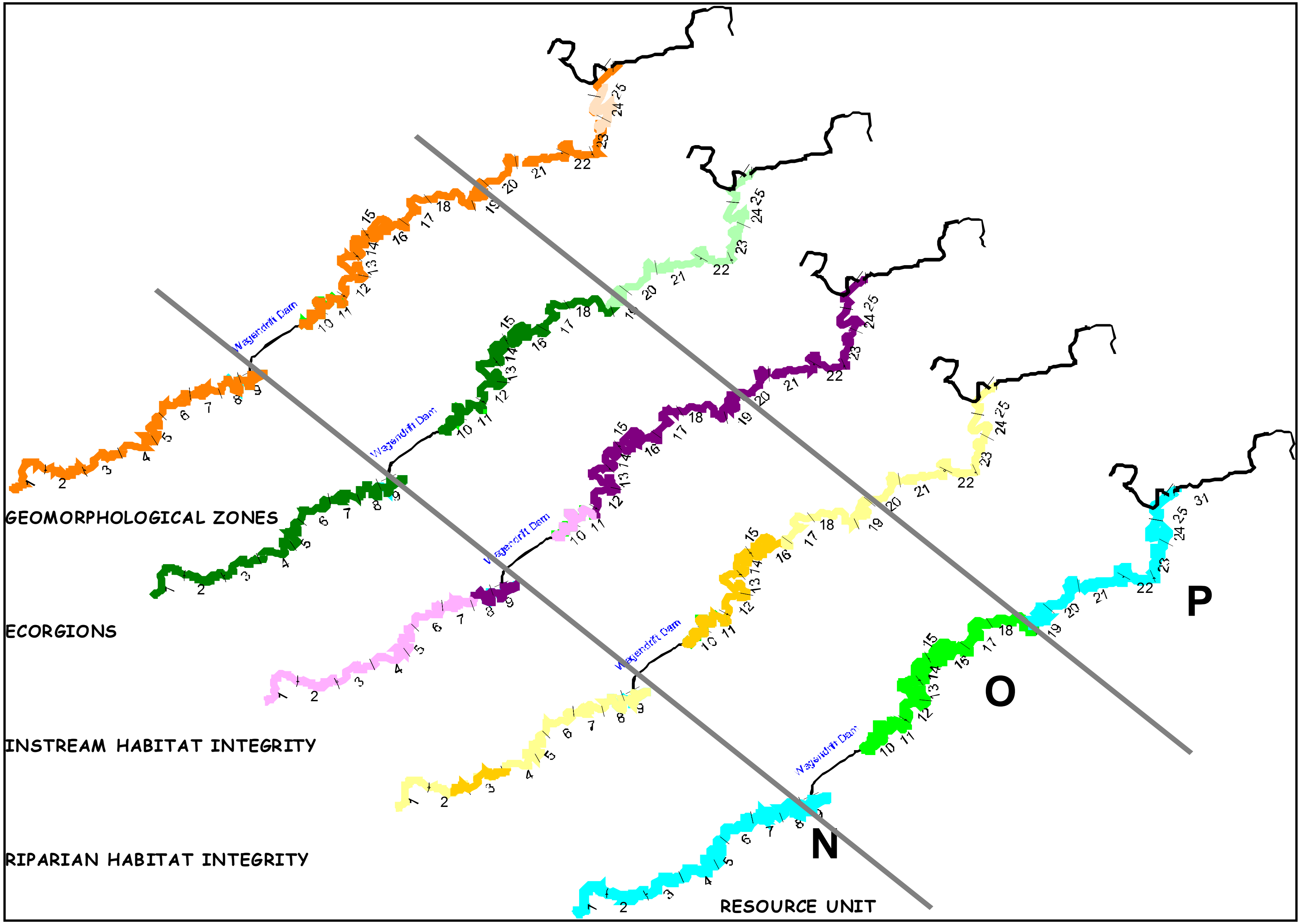


Fig 6.5 Bushmans River: Comparison between geomorphological zones, ecoregions, instream and riparian Habitat Integrity



6.4.16 Resource Unit P: Segment 19 - 25 (Lower Foothills to Thukela confluence) (Figure 6.5)

This RU starts at the end of RU O, i.e. segment 19 and ends at the Thukela confluence. No significant changes in this unit are illustrated by any of the components.

6.4.17 Resource Unit Q: Segment 1 - 4 (Newcastle/Ladysmith Road Bridge to end of Rejuvenated Bedrock Falls) (Figure 6.4)

This RU is in the Sundays River and the start of the study area therefore forms the start of the RU. Apart from the geomorphology, the other components provided no logical break in the Sundays River. The geomorphology was therefore deemed to be logical end point of this RU, i.e. the end of the Rejuvenated Bedrock Falls zone).

6.4.18 Resource Unit R: Segment 5 - 13 (Start of Rejuvenated foothills to Thukela confluence) (Figure 6.4)

The RU R starts at the end of RU Q, i.e. segment 5. The confluence with the Thukela River was the logical end point of this unit. There was some insignificant changes within this unit in the ecoregions (representing a small section of this RU) and the instream habitat integrity. These changes did not warrant separate RUs.

6.4.19 Resource Unit S: Segment 1 - 25 (Little Mooi confluence to the Mooi River Falls) (Figure 6.6)

This RU is in the Mooi River and starts at the Little Mooi and Mooi confluence. The geomorphology, ecoregions and habitat integrity all indicated a logical end point for this RU, the Mooi River Falls.

6.4.20 Resource Unit T: Segment 26 - 38 (Mooi River Falls to Thukela confluence) (Figure 6.6)

The RU T starts at the end of the RU S, i.e. the bottom of the Mooi River Falls. As all the components illustrate a homogenous unit to the confluence with the Thukela, the confluence forms the logical end point of the RU and was selected as such.

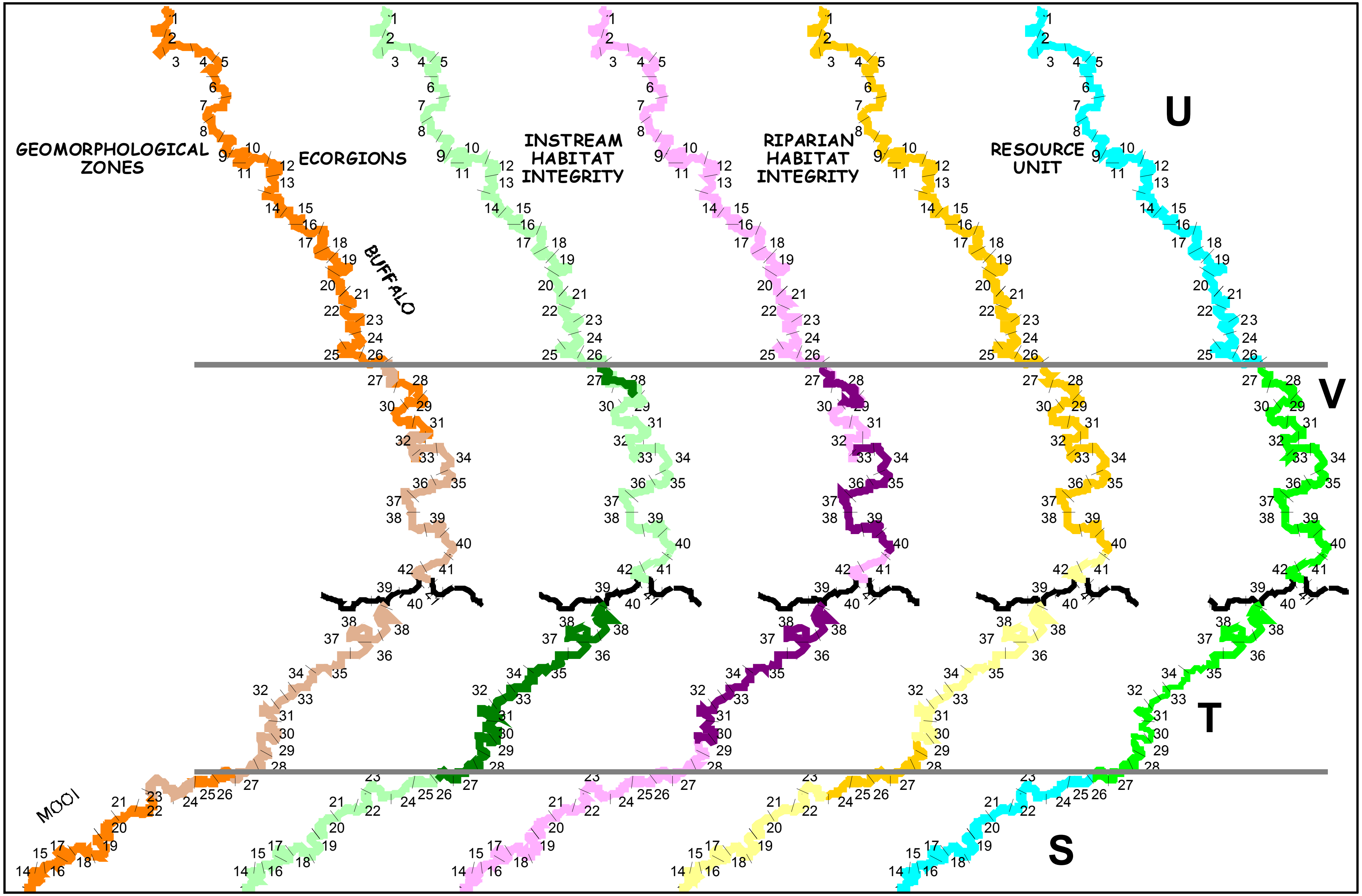
6.4.21 Resource Unit U: Segment 1 - 26 (Utrecht/Ozisweni Road Bridge to end of Lowland River Zone) (Figure 6.6)

This RU is in the Buffalo River and starts at the beginning of the study area, i.e. the Utrecht/Ozisweni Road Bridge. The Buffalo River within the study area is problematic in that access is limited and this had to be taken into account as the selection of IFR sites are closely linked to access. Two IFR sites had to be selected within the Buffalo River and they had to be situated each within its own RU. A change in geomorphology (end of Lowland River) and ecoregions (albeit only for a short section) provided the indication for the end point of this RU.

6.4.22 Resource Unit V: Segment 27 - 42 (Start of Rejuvenated Bedrock Zone to Thukela confluence) (Figure 6.6)

This RU starts at the end of RU U, i.e. the end of the Lowland River Zone and the start of the Rejuvenated Bedrock Zone. Acknowledging the lack of access within the rest of this section of River, it was deemed appropriate to allocate this section of River to one RU and end RU V at the Thukela River.

Fig 6.6 Buffalo River: Comparison between geomorphological zones, ecoregions, instream and riparian Habitat Integrity



7. RIVER: QUALITY RESOURCE UNITS

7.1 INTRODUCTION

> ***In this Chapter:***
> 7.1 Introduction
> 7.2 Data sources and information used to identify quality Rus
> 7.3 Process followed in identifying quality RUs
> 7.4 Final selection of quality RUs

It has been recognized that besides determining the quantity of water needed to maintain a functioning river ecosystem and provide for the uses of a catchment, the quality of water is an integral component of sustaining the river system for its efficient and effective use. Quality and quantity Resource Units are therefore both determined during a Reserve assessment - while these may overlap and sometimes be defined by the same features e.g. a tributary, they are often not the exact same sections of the river. Quality Resource Units are identified for the upper and lower Thukela catchment as areas of homogeneous water quality. This identification is based on water quality monitoring data available for the catchment, as well as land-use activities and any other features which may impact on water quality.

7.2 DATA SOURCES AND INFORMATION USED TO IDENTIFY QUALITY RESOURCE UNITS

The following sources have been accessed for the identification of Quality RUs:

- DWAF monitoring points. Only data of adequate quality in terms of frequency of monitoring and length of data record, are included at this time.
- Data from other sources, e.g. Umgeni Water and Tugela Mill, Sappi.
- Additional water quality data currently being collected for the purposes of this project (named *water quality (WQ) sites 1-6*).
- Limited Polmon data available from IWQS, DWAF.
- 1:50 000 maps of the catchment, depicting land-use activities, point and diffuse sources of pollution, and catchment characteristics, such as towns, tributaries, dams, etc.
- Travelling around the catchment and discussions with residents of the study area, including Mr H Dixon-Paver of DWAF, Durban; Mr K Rothmann and Mr D Perkins of DWAF, Dundee; and Mr J Schlebusch and Mr S Ramkooar of Tugela Mill, Sappi.
- Limited water quality data obtained from Mr Riche at DWAF, Dundee.
- Available water quality reports, e.g. the *Water quality situation assessment: Wasbank River catchment* (DWAF, 1999a).
- The working draft of the *Operating rules report* from the systems modellers on this project (DWAF, 2001).
- Note that information on ecoregions was not available for the selection of Quality RUs.

7.3 PROCESS FOLLOWED IN IDENTIFYING QUALITY RESOURCE UNITS

Method followed for the selection of QRUs was according to the RDM methodology (DWAF, 1999) and additional information included the operating rules from the systems modellers (DWAF, 2001).

7.3.1 Determine the location of DWAF water quality monitoring points, and their proximity to IFR sites

All the DWAF water quality monitoring points in the Thukela catchment study area were identified, including points outside of the study area which may impact on water quality conditions within the study area. Once the IFR sites had been selected for the upper and lower Thukela catchment, the DWAF monitoring points close to the IFR sites could be identified. Only DWAF monitoring points with data of *adequate quality* (see Section 7.3.3) are listed below.

- IFR 1 - V1H058 (outflow of Driel Dam) and V1H026.
- IFR 2 - V1H057 (outflow of Spioenkop Dam).
- IFR 3 - V1H010.
- IFR 4A - no adequate DWAF monitoring point on the Thukela River in this area. Data from additional monitoring (WQ site 5) will be used.
- IFR 5 - no DWAF monitoring point on the Thukela River in this area. Data from DWAF monitoring points on the Little Bushman's River, i.e. V7H012 and V7H018 (segments 10-11) will be used.
- IFR 6 - no DWAF monitoring point on the Bushmans River in this area. Data from additional monitoring (WQ site 4) will be used.
- IFR 7 - V6H004 (segment 2).
- IFR 8 - no DWAF monitoring point on the Sundays River in this area. Data from additional monitoring (WQ site 3) will be used.
- IFR 9 - V6H002 at Tugela Ferry.
- IFR 10 - V2H002 at Mooiriver.
- IFR 11 - V2H004.
- IFR 12 - V2H008 at Keate's Drift.
- IFR 13 - only data from above the study area is available, i.e. V3H009 on the Horn River, and V3H027 on the Ngagane River.
- IFR 14 - no DWAF monitoring point on the Buffalo River in this area. Data from additional monitoring (WQ site 2) will be used.
- IFR 15 - no DWAF monitoring point on the Thukela River in this area. Umgeni Middledrift data and data from additional monitoring (WQ site 1 at Jameson's Drift) will be used.
- IFR 16 - V5H002 upstream of the Mandini / Sundumbili industrial complex.

7.3.2 Determine the availability of water quality data

Water quality data was requested from the DWAF Hydrological Information System (HIS) database for each identified monitoring point. Any other sources of water quality data were accessed, particularly those regions of the study area where DWAF monitoring data was inadequate.

7.3.3 Assess the quality of data (e.g. length of data series)

Only data of adequate quality can be used for determining Reference Condition (RC) and Present Ecological State (PES) per Quality RU. It was therefore necessary to screen all water quality data and select the most reliable data points. In areas where DWAF monitoring data was not available, other data sources were accessed and used.

All data was collected and collated in Microsoft Excel. Data was screened for number of variables analysed, missing data points, the length of the data series (i.e. the date upon which sampling commenced, and the last date of collection), and the frequency of sampling (i.e. weekly, monthly etc.). Monitoring points with a data record of at least 5 years, or 60 data entries, were considered appropriate to assess RC, PES or undertake trend analysis (DWAF, 1999b; DWAF, 2000). Data tables were constructed for each DWAF monitoring point - see Appendix A-2 - and the best points selected for the study, see *Data used in current assessment*. Data points which may be used if absolutely necessary, are presented separately in Appendix A-2 as *Data for possible use*.

7.3.4 Identify sites in the study area requiring additional water quality data collection

Upon screening the water quality data, a number of gaps in the data set became obvious. Six points in the catchment were identified (a budget-dependent selection) for additional data collection. Additional monitoring consists of weekly data for 2 months, as per the requirements of the RDM documents (DWAF, 1999b). Water samples are collected by Mr Tobile Bokwe (mid-August to mid-October) of Umgeni Water, and analysed for a specified list of variables at the Umgeni Water Laboratories. The variables were selected so as to match those monitored by

DWAF - the selection of variables was again budget-dependent. Sites can be identified as follows:

WQ site 1 - on the Thukela River around Jameson's Drift. GPS co-ordinates: 28°46'22.7"S, 30°53'56"E.
WQ site 2 - on the lower Buffalo River, around IFR 14. GPS co-ordinates: 28°26'49"S, 30°36'00.4"E.
WQ site 3 - on the lower Sundays River, around IFR 8. GPS co-ordinates: 28°38'43"S, 30°12'49.5"E.
WQ site 4 - on the Bushmans River between Weenen and the Bushmans River - Thukela River confluence. GPS co-ordinates: 28°46'02.8"S, 30°10'09.6"E.
WQ site 5 - on the Thukela River below the Klip River - Thukela River confluence, and upstream of the Thukela River - Bloukrantz River confluence. GPS co-ordinates: 28°44'47.2"S, 30°08'42.3"E.
WQ site 6 - on the Klip River, below Ladysmith and upstream of the Klip River - Thukela River confluence. GPS co-ordinates: 28°36'43"S, 29°54'12"E.

7.3.5 Identify catchment characteristics e.g. tributaries, dams

Catchment characteristics are identified in Appendix A-1.

7.3.6 Identify catchment activities and potential impacts on water quality

Catchment activities and potential impacts on water quality are listed in Appendix A-1. Except for a few distinct areas - the Horn and Ngagane Rivers, tributaries of the Buffalo River above Newcastle; the Wasbank River which flows into the Sundays River; the Klip River which flows into the Thukela River at Ladysmith; and the Mandini / Sundumbili industrial complex near the Thukela estuary - there are few industrial and economic activities in the catchment. Water abstractions are mostly for irrigation (subsistence crops, some commercial citrus plantations and large-scale fodder crops for cattle), urban / domestic water purposes and to satisfy water transfer requirements.

7.3.7 Access information on the "system operational rules" (e.g. dam management) of the catchment, and identify potential effects on water quality

The working draft of the *Operating rules report* from the systems modellers on this project gives an indication of how dams are operated in the catchment, both for water availability and dilution purposes. This information assists in giving some insight as to whether identified water quality problems are managed by manipulating flows. Although this study advocates the preferential management of point sources of pollution where possible, it is recognized that regional water resource managers do release water from dams for dilution purposes, e.g. the release of water from Spioenkop Dam for the dilution of Sappi Tugela return flows near Mandini, and releases from Ntshingwayo (Chelmsford) Dam to dilute factory spillages.

7.3.8 Assess additional data collection from catchment excursions and evaluate identified Quality RUs

The primary purpose of the two catchment excursions conducted in July and September 2001, was to collect invertebrates for laboratory-based toxicity experiments, and additional data in terms of SASS monitoring, respectively. The toxicity data will be used during the assessment of Ecological Reserve Class per Quality RU for TDS specifically. Available SASS data, from this and previous studies, will be used to confirm the ERCs. Although limited SASS monitoring could be done due to high water levels in the rivers in September, catchment excursions were also used as an opportunity to survey the catchment for land-use activities. This information has been incorporated into Appendix A-1, and assisted in the finalizing of Quality RUs.

7.4 FINAL SELECTION OF QUALITY RUS

The final Quality RUs are listed in Appendix A-1 and illustrated in Figures 7.1 and 7.2. In the figures, the Quantity RUs are also illustrated for reference purposes. The RU letters refer to the Quantity RUs. In the Appendix, the position of the RUs are listed in relation to segment numbers and RUs, as used by the Water Quantity task group. In areas where no water quality data is available, neighbouring Quality RUs may have to be amalgamated.

Fig 7.1 Upper Thukela Quality RUs

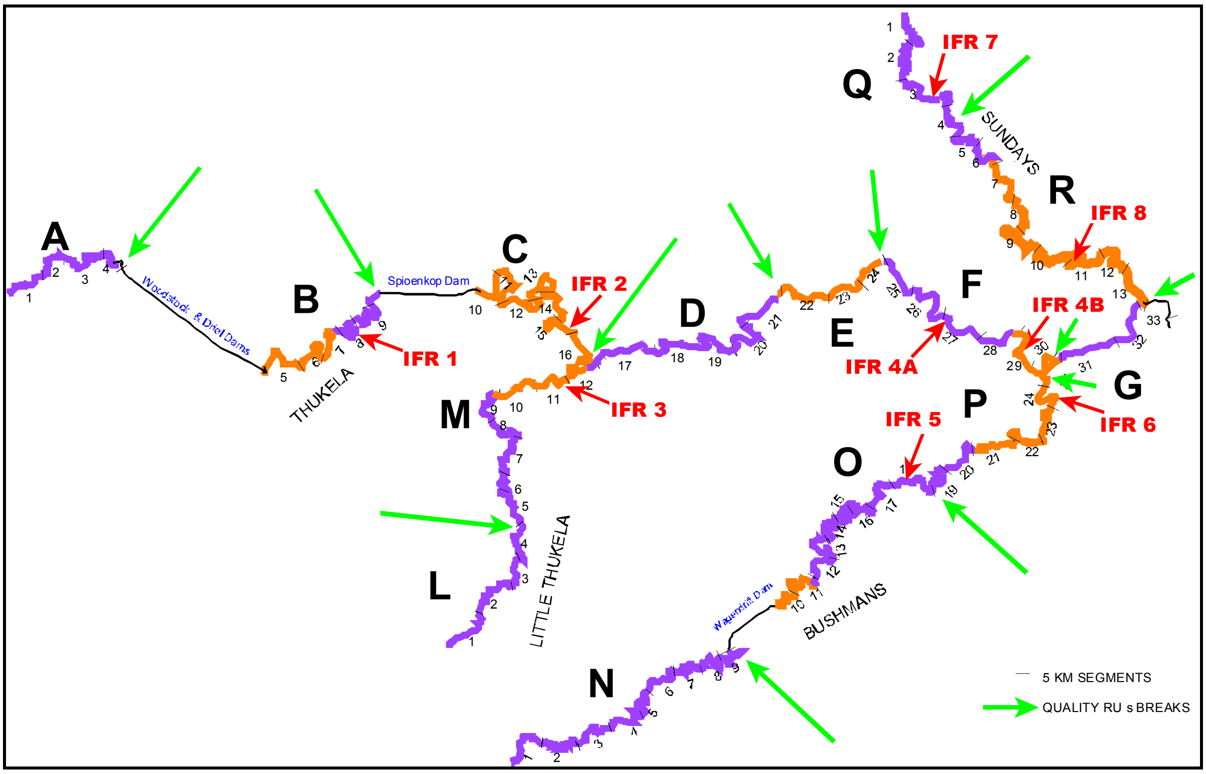
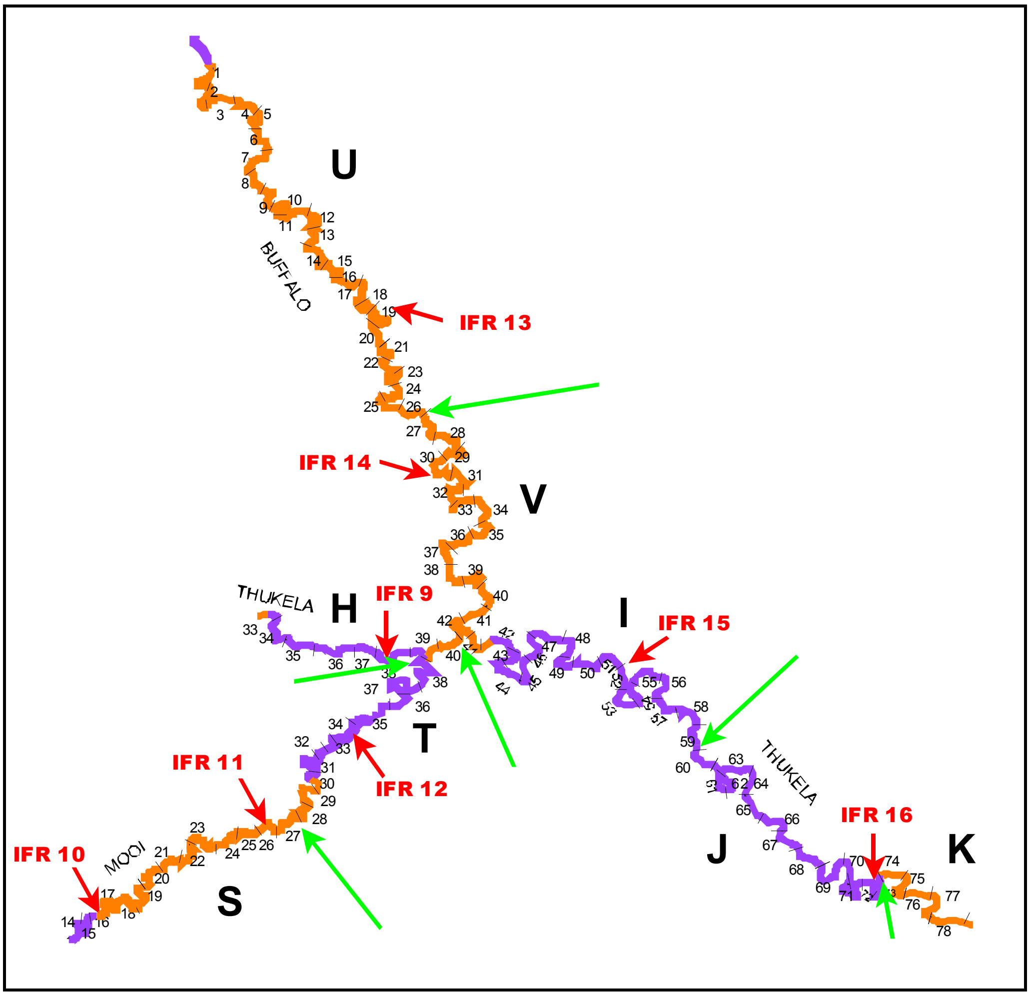


Fig 7.2 Lower Thukela Quantity RUs



7.5 CONFIDENCE IN IDENTIFIED QUALITY RUs, AND ASSOCIATED DATA LIMITATIONS

Data availability in terms of water quality, is relatively low for the Thukela catchment. Even in areas where coal mining and other industrial activity is obvious, no data exists for heavy metals and other toxics. Although extensive croplands are evident in some areas of the catchment, pesticide monitoring is not conducted. Turbidity and TSS is not routinely monitored, even though the Thukela system is relatively turbid. DWAF water quality monitoring data of the Mandini area does not accurately reflect the impact of the industrial activities in the area. Although the Sappi Tugela monitoring points are situated within the industrial zone, and downstream of the zone toward the estuary, data is scattered and limited. Confidence in the identified Quality RUs is maintained due to the land-use activities in the catchment. Crops and cattle farming, which are widely practised in the catchment, result in possible salinisation and nutrient enrichment of the water courses due to agricultural run-off. TDS, electrical conductivity (EC) and nutrients data is available for most Quality RUs.

8. SELECTION OF IFR SITES

The IFR site selection team consisted of the following:

Ms Delana Louw (IFR team leader)
Prof Jay O'Keeffe (IFR facilitator)
Mr Nigel Kemper (Riparian vegetation and habitat integrity specialist)
Mr Mike Coke (Fish)
Dr Chris Dickens (Aquatic invertebrates)
Dr Neels Kleynhans (Ecoregions and fish)
Ms Christa Thirion (Ecoregions and aquatic invertebrates)
Dr Roy Wadeson (Fluvial gemorphologist)
Dr Drew Birkhead (Hydraulician)
Mr Niel van Wyk (Client)
Mr Toriso Thlou (Client)

In this Chapter:

Advantages and disadvantages of the IFR sites (as tabled in this chapter) were provided by the relevant specialists.

8.1 PURPOSE OF IFR SITES

IFRs are determined during a specialist meeting where descriptions of flow in parameters such as depth and water surface level linked to habitat requirements of the various disciplines are stipulated. These parameters, e.g. a 10cm depth, need to be converted to flow by means of a stage discharge curve for a specific cross-section. **The description of flows in depths therefore takes place at a specific cross-section in the river called an IFR site which should represent a variety of habitats.**

The selection of the IFR sites forms the basis of the preparatory work to be undertaken for the IFR specialist meeting and some of the studies (e.g. hydraulics and hydrology) are directly linked and are calculated specifically for the IFR sites.

The IFRs are set for each of the IFR sites, and it is therefore vital that

- the sites are selected to provide as much info as possible about the variety of conditions in a river reach and that the persons that need to use these sites to set IFRs for their discipline can relate to the habitat they represent;
- the persons involved in selecting the sites understand and are experienced with the use of sites in IFR studies.

In order to determine the Instream Flow Requirements (IFRs) of a river system, it is necessary to determine the flow requirements at a number of points within the system.

More than one IFR site is usually selected within the system for a number of reasons:

- Tributaries entering the system may introduce different channel, bank and or habitat conditions which may need to be considered separately.
- The PES and ERC of particular reaches of the river may differ and may therefore require a specific IFR.
- A river system displays biological diversity along its length, and consequently, a single IFR point is unlikely to adequately reflect this range of diversity.
- Various hydrological stage points are required within the system to cater for the inflows of tributaries and losses down the length of the system.

The more IFR sites selected for which IFRs are determined, the better the chance that all the habitat diversity in the system will be covered and therefore, the higher the confidence in the IFR result. The decision as to how many sites are chosen is therefore a function of the length and diversity of the river to be assessed, and a trade-off between the need to characterise the river adequately, and the constrains of time and resources.

8.2 IFR SITE SELECTION PROCESS

The detailed process to select IFR sites is described in the BBM manual (King and Louw,1998). An IFR or Ecological Reserve must be determined for each RU (Chapter 6). Due to the amount of RU's, only some of them will contain IFR sites. Sixteen to eighteen IFR sites were accommodated for in the budget. Existing sites from previous studies will be used.

8.2.1 Helicopter flight to select IFR sites

Determining where possible sites are located in rugged and undisturbed surroundings can be a difficult, frustrating and time-consuming process. It is seldom possible to obtain a comprehensive overview of a river from a ground survey. The process of selecting IFR sites is therefore aided by means of a helicopter flight which is undertaken for the Habitat Integrity analysis (Chapter 5) and capturing the river on video. The Thukela River helicopter flight was undertaken during July 2001.

8.2.2 Use of the river video for the identification of possible IFR sites

From the helicopter survey, a video and a GPS database of latitude and longitudes for every four seconds of the flight was available.

The video was viewed by the Thukela IFR site selection team on 30 July 2001and 10 September 2001 to identify potential IFR sites with potential access. These sites are evaluated and ranked and the most likely potential sites are selected for ground truthing purposes.

8.2.3 Ground truthing - final selection of sites

The selection of IFR sites is guided by a number of considerations such as:

- The locality of gauging weirs with good quality hydrological data.
- The locality of the proposed developments.
- The locality and characteristics of tributaries.
- The habitat integrity/conservation status of the different river reaches.
- The reaches where social communities depend on a healthy river ecosystem.
- The suitability of the sites for follow-up monitoring.
- **The habitat diversity for aquatic organisms, marginal and riparian vegetation.**
- **The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially low flows.**
- **Accessibility of the sites.**
- **An area or site that could be critical for ecosystem functioning. This is often a riffle which will stop flowing during periods of low or no flow. Cessation of flow constitutes a break in the functioning of the river. Those biota dependant on this habitat and/or on continuity of flow will be adversely affected. Pools are not considered as critical since they are still able to function as refuge habitats during periods of no flow.**
- The locality of geomorphological reaches and representative reaches within the geomorphological reaches.

The criteria in bold are the most important and therefore the overriding criteria.

8.3 RESOURCE UNITS AND REQUIRED IFR SITES

The RUs were evaluated to determine whether they contained existing sites, and which of the units warrant additional IFR sites:

Table 8.1 Resource Units and IFR sites

Resource Units	Segments	IFR sites	Motivation
Resource Unit A (Thukela River)	1 - 4	No IFR site	• Upstream of all operational structures. • Small section of river. • Other areas warrant IFR sites more.
Resource Unit B (Thukela River)	5 - 9	IFR 1	• Site required as this section of river functions as an operational unit (upstream of Spioenkop and downstream of Driel Dam). • Existing site with limited information. Site will be accepted unless the video indicates a better site.
Resource Unit C (Thukela River)	10 - 16	IFR 2	• Good existing site.
Resource Unit D (Thukela River)	17 - 21	No IFR site	• Unit badly degraded where accessible and therefore does not warrant a site.
Resource Unit E (Thukela River)	21 - 24	No IFR site	• Short inaccessible section and therefore does not warrant a site.
Resource Unit F (Thukela River)	24 - 30	IFR 4 A & B	• Two good existing sites.
Resource Unit G (Thukela River)	31 - 33	No IFR site	• Short reach. • Existing IFR site in the previous reach and in the next reach and therefore does not warrant an IFR site. • River also similar to the immediate down-and upstream area.
Resource Unit H (Thukela River)	34 - 40	IFR 9	• Existing site with good hydraulics. • Site does not provide good ecological clues as this section of river quite disturbed. • However, no better site exists in this reach.
Resource Unit I (Thukela River)	41 - 59	IFR 15	• Section requires IFR site as large reach and downstream of Buffalo and Mooi tributaries. • Very inaccessible. • Sites with few ecological criteria exists and best site was selected downstream of Jameson's Drift.
Resource Unit J (Thukela River)	60 - 72	IFR 16	• Large section upstream of the estuary. • Requires a site as a link to the estuary. • Existing site with limited information. • Site does not provide good ecological clues, especially riparian vegetation clues which do exist in immediate vicinity (*Ficus sycamores*). • Site immediately in the vicinity was therefore selected. Will link to existing site so information could be used.
Resource Unit K (Thukela River)	73 - mouth	No IFR site	Estuary influence starts so no site warranted.
Resource Unit L (Little Thukela)	1 - 4	Potential for one IFR site	• RU L and RU M can only accommodate one site. • The RU in which it will be situated depends on whether suitable IFR sites occur in the RUs.

Resource Units	Segments	IFR sites	Motivation
Resource Unit M (Little Thukela)	5 - 11	Potential for one IFR site	See above.
Resource Unit N (Bushmans	1 - 9	No IFR site	• Above Wagendrift Dam and operational management of RU therefore limited.
Resource Unit O (Bushmans)	10 - 18	IFR 5	• Good existing IFR site.
Resource Unit P (Bushmans)	19 - 25	IFR 6	• Bad existing IFR site. • From previous studies it is however known that no better IFR sites occur and this site will therefore be used.
Resource Unit Q (Sundays)	1 - 4	IFR 7	• Study has catered for two IFR sites in the Sundays and one in each reach will therefore be selected.
Resource Unit R (Sundays)	5 - 13	IFR 8	• See above. • This site must be as far downstream as possible to ensure that extrapolation between IFR 7 and IFR 8 is of high confidence.
Resource Unit S (Mooi)	1 - 25	IFR 10	• Existing IFR site. • Not a good site - however, no better site exists in the reach.
Resource Unit T (Mooi)	26 - 38	IFR 11 IFR 12	• Good existing IFR site (IFR 11). • Existing IFR site (IFR 12) - not good habitat but best option in this reach.
Resource Unit T (Buffalo)	1 - 26	IFR 13	• The Buffalo is a large system with only two RUs and each one of these therefore warrants an IFR site. • A site must be selected in the lower section of the RU as this section is characterised by more diverse ecological habitats - the upper section is badly degraded and alluvial for large parts.
Resource Unit T (Buffalo)	27 - 42	IFR 14	• See above.

8.4 SELECTION OF THUKELA IFR SITES

Considering the site selection criteria (8.2.3), the following sites were selected:

- *IFR 1, Bergville:* The site selection team evaluated the existing IFR site as well as any other potential sites. The existing IFR site consisted overall of better criteria and was selected.

- *IFR 3, Klein Thukela:* Four potential sites were selected in the Klein Thukela. The three most likely sites were visited; one in the RU L and two in RU M. Although the potential site in the RU L was near a gauging weir and provides good instream habitat, it was situated far upstream from the confluence. IFR results at an IFR site near the confluence would cater more appropriately for the upstream river. The most downstream site answered most of the biological criteria, although the hydraulic accuracy was problematic. Sufficient cross-sections would have to be surveyed to ensure reasonable accuracy.

- *IFR 7, Upper Sundays:* Two potential sites were selected from the video. Access in this area is limited. Only one site was visited due to the time spent finding this site. The site provided excellent biophysical habitats but was complex from a hydraulic viewpoint.

- *IFR 8, Lower Sundays:* Three potential IFR sites were visited, an existing site (1995) for which no usable data existed, as well as two upstream sites. The catchment is in poor condition and riparian conditions illustrated this. The site selected in the end was based on hydraulic criteria as the biophysical habitat was not sufficiently different at the two sites visited to warrant another hydraulically difficult site in the Sundays River to be selected.

- *IFR 13, Upper Buffalo:* Only one potential area with options was identified from the video. This is one of the few areas where it is known that access is available. This section was visited and the first option was not selected due to its hydraulic complexity. A site immediately upstream of this site was selected. The ecological diversity was less than the downstream option, but hydraulically the site was more viable.

- *IFR 14, Lower Buffalo:* Selection of IFR sites in this section is mostly dominated by accessibility and hydraulic complexity. Prior to this site visit, Rorke's Drift was visited as an accessible option but ruled out due to the hydraulic complexity. Fugitives' Drift was also visited by some members prior to the visit and scrutinised on video. It was complex hydraulically especially during high flows and had limited useful riparian vegetation. The Isibindi site where the specialists were staying had a potential riffle upstream of the confluence between the Buffalo and the Sibindi. Even though hydraulically complex, the complexity was less that the other site and the site also answered most of the ecological criteria. Further sites with access were investigated on the video but they were all hydraulically complex and had very limited ecological clues for setting flow requirements, especially for riparian vegetation.

- *IFR 15, Jameson's Drift:* An existing site which formed part of the sediment transport modelling study (Ref) was visited. The benchmarks have however been removed and the site and previous collected data could not be used. The site did not offer sufficient ecological criteria to warrant resurveying the site and potential better sites were investigated from the video. A site downstream from Jameson's Drift was visited and a more complex site with varied instream habitats was selected.

- *IFR 16, Mandini:* This section of river is alluvial with very low gradient. It contains an existing site used for the sediment transport modelling study. This site does not include riparian vegetation indicators as other potential sites immediately upstream. As limited previous information was collected at the existing site, there was no motivation to use the same site. A site was selected which was similar to the previous site but had an important terrace on the right bank with indicator vegetation tree species (*Ficus sycamorus* and *Trichelia emetica* amongst others).

8.5 LOCALITY OF IFR SITES

The locality of the IFR sites is tabled in Table 8.2 and illustrated in Figures 8.1 and 8.2.

Table 8.2 IFR site localities

IFR site	Habitat Integrity Segment	Longitude	Latitude
THUKELA RIVER			
IFR 1, Bergville	8	S28°43,158	E29°23,265
IFR 2, Skietdrift	15	S28°42,98	E29°37,45
IFR 4A, Zingela	27	S28°42,311	E30°03,550
IFR 4B, Tugela Estates	29	S28°44,585	E30°08,369
IFR 9, Thukela Ferry	38	S28°45,350	E30°32,867
IFR 15, Jameson's Drift	52	S28°49,689	E30°54,114
IFR 16, Mandini	72	S29°09,627	E31°20,127
KLEIN THUKELA			
IFR 3, Klein Thukela	11	S28°46,677	E29°37,692
BUSHMANS			
IFR 5, Weenen Nature Reserve	18	S28°53,395	E30 °01,031
IFR 6, Darkest Africa	24	S28°48,01	E30 °10,681
SUNDAYS			
IFR 7, Upper Sundays	3	S28°27,627	E30°02,573
IFR 8, Lower Sundays	11	S28°38,334	E30°12,142
MOOI			
IFR 10, Caravan Park	16	S29°12,28	E30° 00 33
IFR 11, Mooi River Falls	26	S29°03,24	E30°18,04
IFR 12, Gracelands	34	S28°54,13	E30°25,18
IFR 13, Upper Buffalo	19	S28°10,621	E30°29,425
IFR 14, Lower Buffalo	30	S28°25,598	E30°35,701

Fig 8.1 Locality of IFR sites in the Upper Thukela

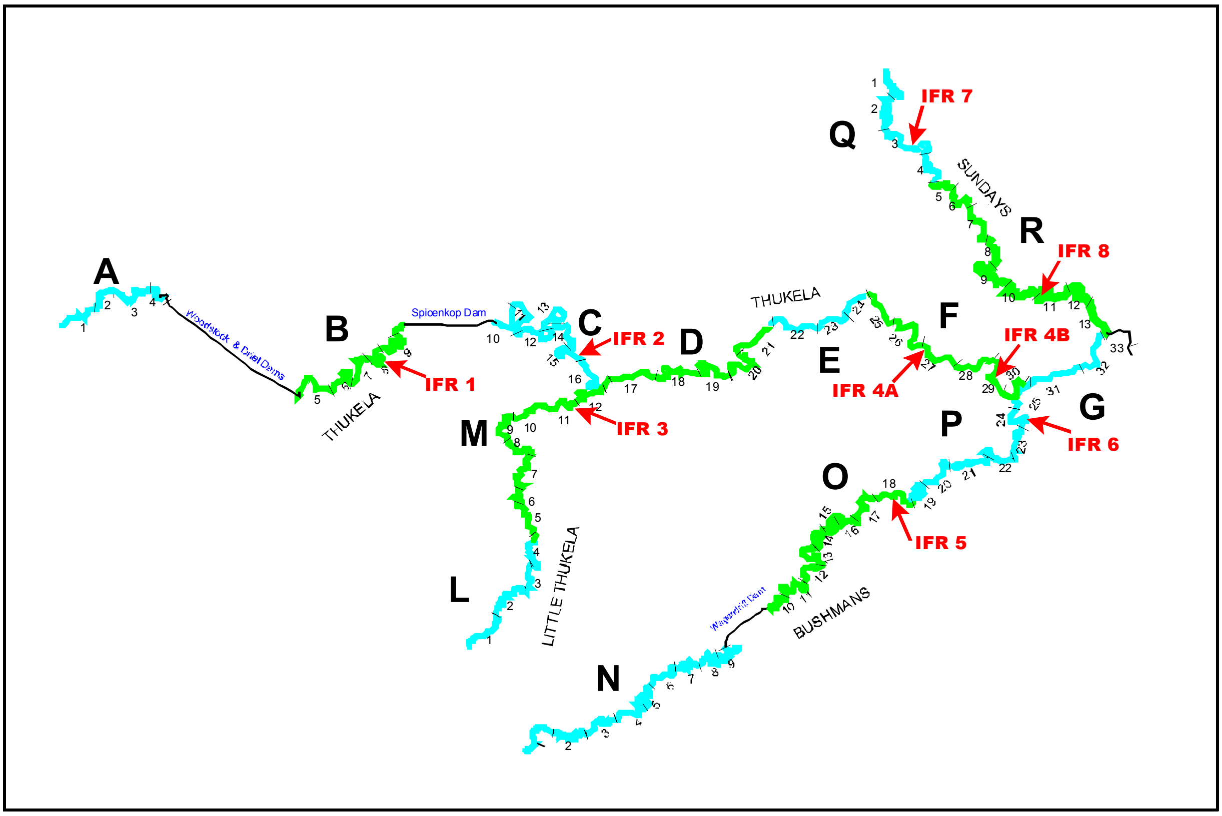
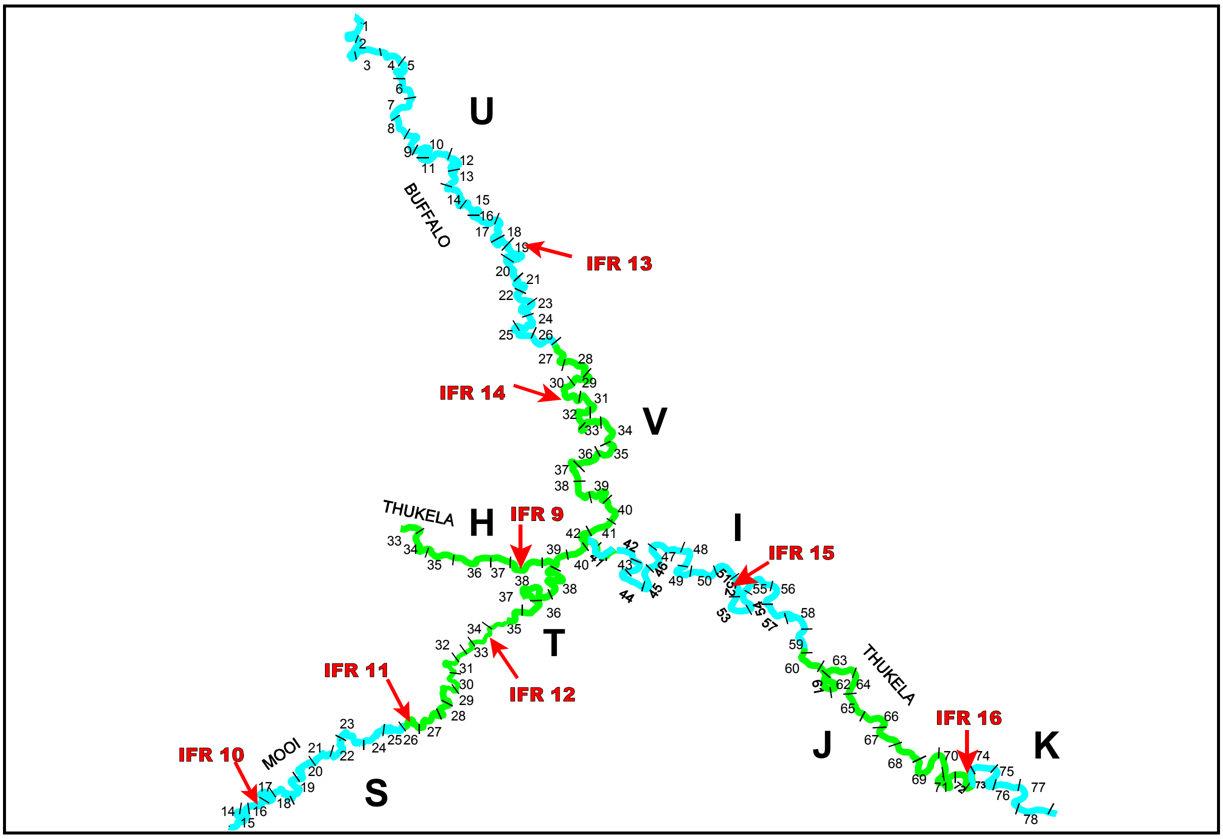


Fig 8.2 Locality of IFR sites in the Lower Thukela



8.6 CHARACTERISTICS, ADVANTAGES AND DISADVANTAGES OF IFR SITES

The sites are described and the advantages and disadvantages of the sites to provide adequate clues to determine the IFRs follow: The IFR sites are illustrated in Figures 8.3 to 8.19.

8.6.1 IFR 1, Bergville

The site is situated at the start of the gorge downstream of Bergville. The left bank is bordered by agricultural lands and forms very steep grassed edge to the instream channel. The right bank is adjacent to a hill where informal grazing takes place. Exotic mixed with indigenous vegetation occurs on this bank. Back waters and a medium flow channel occur on the right side of the channel. The channel is alluvial with pool/riffle morphology. The bed material consists of gravel and cobble.

The site is characterised by unseasonal releases as Driel Dam is often overtopped and unnatural high flows therefore often occurs.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Site located downstream of gauging station V1H026 which may be used for the measurement of discharge, particularly at high flows.	Site consists of a short rapid section characterised by non-uniform flow, multiple channels and backwaters.
Fluvial geomorphology	Straight part of the channel therefore no anomalies associated with sites on a bend. Some distance from tributary inputs. One small flood bench on the LB. Channel morphology is representative for this reach. Bed material is loosely packed - easier to assess velocity requirements for sediment transport. Good hydraulic habitat diversity.	Deeply incised makes it difficult to assess bankfull (but this is typical for this part of the river). No data for sediment from this site (high flows). No flood cues on both sides of the river. Photographic evidence suggests that the channel is getting narrower as vegetation encroaches, therefore suggests an unstable or changing site. Managed flows, so difficult to assess natural condition.
Riparian vegetation	*Salix mucronata* present on all channel bars on waters edge as dominant riparian indicator. *Cirtanthus spp* (fire lily) present on high water level, possibly indicative of regulated flows.	Encroachment of macrochannel floor by *Salix mucronata* is evident due to regulated flows. Diversity of riparian species is low.
Fish	See aquatic invertebrates	See aquatic invertebrates

IFR component	Advantages	Disadvantages
Aquatic invertebrates	Diverse habitats including riffles, pools, backwaters, soft sediments and abundant marginal vegetation. The stones in current that could be reached were surprisingly small and mobile, suggesting a good habitat that was not as dominated by bedrock as appeared. Further stones in current were found flowing into backwater channels, over small cobbles and gravel. Associated with these backwaters were excellent stones out of current and alluvial sediments. Both in these backwaters and also in the main channel, the marginal vegetation was extensive and should provide good habitat.	Habitat inundated regularly from unnatural releases which have negated much of the quality of the site.
General	Access by normal vehicle.	In private farm lands subject to change and access can be fenced off.

8.6.2 IFR 2, Skietdrift

The site is situated approximately 20 km downstream of Spioenkop Dam. The channel is a mixed bed with both bedrock and a combination of fine and coarse material. It is incised within a historic floodplain. A bedrock dyke occurs across the river and mid channel bars with *Phragmites*. Vegetation on the banks is a mixture of indigenous and exotic vegetation. This section of river is subject to unseasonal releases from Spioenkop Dam.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Materially uniform flow conditions at medium and high flows, with existing measured rating data in the range 1.5 to 23.9m^3/s.	IFR site consists of bedrock "pavements" diagonally orientated across the river channel. Although this results in non-uniform flow conditions, these are not significant, except at very low discharges (less than approximately 1 m^3/s). Difficult to measure discharge accurately at low discharges due to flat bottomed channel bed approximately 30m in width containing vegetated bars and isolated boulders.
Fluvial geomorphology	Some distance downstream of Spioenkop dam so more normalised by tributary inputs. Presence of a number of terraces to provide cues for higher flows. Is relatively representative of the morphology that occurs within this zone.	A large dam upstream, managed flows. Historic crossing place so morphology has been affected. Appears to be incised because of the presence of a very high macro channel bank. Unnaturally aggrading reach.

IFR component	Advantages	Disadvantages
Riparian vegetation	*Salix mucronata* (both banks and islands) and *Combretum erythrophyllum* (LB) indicators present. Marginal zones present on both banks and islands.	Large individuals of *C. erythrophyllum* situated above the bank and little value for determining flows. Site severely impacted by grazing and trampling. *Sesbania* present. Indicator species only juveniles and could therefore be indicative of the managed flow regime from Spioenkop Dam. Diversity of indicator species low.
Aquatic invertebrates	A good range of habitats, with riffles, glides, sandy pools, and extensive backwaters. The backwaters were extensive, well vegetated with muddy bottoms. Fairly substantial gravel both in current and out. The gravel was a moderately good habitat as the size was larger than sand, up to 5cm diameter. Vegetation was extensive with both *Phragmites* and *Juncus* in abundance. The former provided only thick bases in the water, while the latter provided habitat even at these moderate flows. During higher flows, vegetation habitat would be extensive.	The type of rock did not provide very good stones, there being very few loose stones/rocks. The stone habitat was dominated by sheet rock which provided poor habitat as there were few cracks and crevices. Most of this was in current.
Fish	Good habitat variety. Two good backwater channels, with marginal vegetation, provide habitat for small barbs and juvenile fish. Natal University has made good supporting collections 1km upstream at Mambasa Bush Camp. Vegetated island and margins facilitate setting of flow requirements.	Not many boulders in the "riffle" area for fish to hide amongst. Disappointing species variety on survey day.
General	Accessible with normal vehicles. Flow manipulation from Spioenkop Dam possible.	Water very turbid and it is difficult to see substrate details under any condition.

8.6.3 IFR 3, Klein Thukela

The site is situated downstream of Winterton approximately 5 km upstream from the confluence with the Thukela. The site is situated in a river valley and consists of a rapid pool section. The cross-section traverses a steep rapid consisting of large boulders, and cobbles. The left bank consist of a floodplain area with sedges. The riparian vegetation consists mostly of exotic vegetation such as black wattles. This is a mixed channel with pool/rapid morphology and bed material consists of bedrock and cobble.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	-	Site characterised by non-uniform flow over a rough bed lying between upstream and downstream pools.
Fluvial geomorphology	Channel morphology is representative for this reach. A flood bench is present on the left bank. The right bank consists of bedrock and is therefore extremely stable.	The site is on a bend so may cause some problems in interpretation of physical clues. The channel is deeply incised and does not provide easy and obvious clues for bankfull. Bed substrate is tightly packed and well embedded - makes an assessment of the velocities required for sediment entrainment very difficult. Poor hydraulic habitat diversity.
Riparian vegetation	Well defined marginal zones present on both banks well colonised by sedges. Riparian zone present on left bank with clear riparian terraces. *Salix mucronata* present on edges of river and marginal zones.	No riparian zone on right bank. Riparian zone on left bank highly eroded. Riparian zone on left bank dominated by a number of exotic species. Fruit trees planted on left bank for bank stabilisation. Low diversity of indigenous riparian species, only a single indicator species (*Salix mucronata*).
Aquatic invertebrates	Moderately diverse habitat, which will improve as flows increase. Vegetation was minimal at this time of the year, but at higher flows more will become inundated (*Juncus* and *Phragmites* in particular) and will then become an important habitat.	The stones in current were extensive but the rocks very impacted, thus providing little habitat underneath stones, normally an important habitat for invertebrates. Stones out of current were abundant in the pool below the riffle, but were covered with slime suggesting some enrichment. There was little alluvial habitat at the site. The confined nature of the channel meant a reduced diversity of habitat with no backwaters.
Fish	Variety of fish habitat present. Good riparian vegetation present providing cover and spawning sites.	Fish habitat armoured. Fairly thick algal slime on rocks. No *Amphilius* present.
General	-	Access not possible by sedan vehicles. Water quality impacts of Winterton is present at the site.

8.6.4 IFR 4A, Zingela

The site is situated downstream of the Klip confluence and the proposed Jana Dam wall. This site is an existing site that was used as a site for habitat modelling and sediment transport modelling during 2000. The channel consists of mixed pool/rapid morphology and bed material consists of bedrock, boulders and cobble. Indigenous vegetation occurs on the banks with *Phragmites*, and sedges on the river edges.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Rapid section reasonably extensive (approx. 100m) in the longitudinal direction (along the length of the river). Flood discharges may be measured at the high-level bridge below IFR Site 4B (Thukela Estates), which has been used to gauge high flows during previous studies on the Thukela River system.	Large resistance elements covering the channel bed, including boulders. This which will result in flow resistance being a function of depth at low to intermediate discharges, requiring a range of flows to be measured for accurate characterisation of stage-discharge and hydraulic relationships. Non-horizontal water surfaces (along the cross-sections) at intermediate flows, with backwater areas on the left-hand side of the channel bed.
Fluvial geomorphology	Channel morphology is representative for this reach. Sediment transport modelling has been carried out for this site (Birkhead). Good habitat diversity and a habitat model is available for this site. Some evidence of the pre-flood morphology on the right bank.	Deeply incised on the left bank makes it difficult to assess bankful (but this is typical for this part of the river). There are limited flood clues on both sides of the river but there are some upstream. Appears as though the right bank is being re-formed therefore suggests an unstable or changing site. The system has been "reset" in terms of geomorphology and is only just starting to recover managed flows from Spioenkop Dam so difficult to assess a natural condition.
Riparian vegetation	Distinct marginal and riparian zones on right bank. *Nuxia oppositifolia* is present on right bank.	The majority of the riparian plants have been removed by large floods. Subsequent recovery of riparian plants has been very slow. Only one useful indicator species present, this being an indicator for elevated flows only. Riparian species diversity is low.
Aquatic invertebrates	A good, large river site, with a variety of depths and velocities, with abundant stones in current, mostly of a large size but some moveable. Smaller amounts of small cobbles in current occur on the left side, out of the main flow of the river. Banks of sandy sediment were found, as were banks of soft mud, both being in the still water sections on the left bank. Marginal vegetation was abundant but not much was submerged at the flows on the day. During high flows, *Juncus* in particular would form an important habitat. Overall, a good, diverse habitat site from an invertebrate point of view.	The stones were generally large, impacted, and slippery probably due to the fine clay suspended sediments in the water. The stones out of current were covered with a thick orange coloured slime which would have a negative impact on invertebrates. Alluvial sediments were also covered with this orange slime.
Fish	Good habitat and fish abundance.	No *Amphilius* collected. Slimy rocks present.
General	-	Access difficult and time consuming even by 4x4; especially when wet.

8.6.5 IFR 4B, Thukela estates

The site is situated in the Thukela River just upstream of the Thukela Estates and the confluence with the Bloukrans River. This is a high confidence site that formed part of the previous IFR studies (ref) and the site will be used as is. The information provided below was therefore obtained from the previous IFR study.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Existing measured rating data in the range 2.2 to 312m^3/s.	IFR site characterised by rapidly varied flow over a rapid composed of large resistance elements, including large boulders. Backwater area alongside the right bank results in elevated stage levels compared with levels in the active (rapid) channel section.
Fluvial geomorphology	Has a well defined flood terrace. Is representative of the morphology found in the lower end of the gorge.	Very coarse bed material so difficult to model sediment movement. Anthropogenic impact confuses expectations for a natural condition (irrigation canal, grazing and browsing).
Riparian vegetation	*Nuxia oppositifolia* present on right bank. Marginal vegetation zone on right bank, mainly comprising *Juncus sp.*	*Nuxia oppositifolia* situated far up the bank and maybe of little value for assessing flows.
Aquatic invertebrates	This site was not surveyed and was only visited briefly. On the margin of the river and in small locations, backwaters etc, good quantities of small cobbles are likely.	The site was not substantially different from site 4a, having large quantities of stones in current, most of which is probably immovable, thus providing limited habitat. Marginal vegetation is only likely to be a significant habitat during higher flows when it becomes inundated.
Fish	Fairly good habitat variety on RB, including backwaters.	Few sandbed areas, but these are available nearby
General	Accessible with a normal vehicle during dry circumstances.	Site disturbed on both banks by roads and canals.

8.6.6 IFR 5, Weenen Nature Reserve, Bushmans River

The site is situated in the Bushmans River just upstream of the border of the downstream border of the Weenen Nature Reserve. This is a mixed channel with pool/riffle morphology and with bed material consisting of cobbles and boulders interspersed with sand and gravel. This is a high confidence site that formed part of the previous IFR studies and the site with the associated habitat modelling that was undertaken as part of the sediment transport modeling (ref) will be used as is.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	IFR site characterised by an extensive riffle (in excess of 100m longitudinally) contained within a straight aligned channel. Flow is materially uniform at medium to high discharges. Existing measured rating data in the range 0.9 to 8.2m^3/s.	Local hydraulic controls formed by the roughness elements constituting the bed (predominantly cobbles and boulders), as well as a side channel/s on the right bank, act to develop non-uniform conditions at low flows.
Fluvial geomorphology	Channel morphology is representative for this reach. Sediment transport modelling has been carried out for this site. Good habitat diversity and a habitat model are available for this site. Bed material is loosely packed - easier to assess velocity requirements for sediment transport. Some distance from tributary inputs. The catchment area immediately upstream is relatively inaccessible and therefore in good condition.	The channel is incised and does not provide easy and obvious clues for bankfull floods on both banks. The channel morphology has been influenced by relatively recent large flood events (ie a changed template). One complicating issue is the fact that the site is a sediment “sink” zone because of a flattened gradient below the gorge.
Riparian vegetation	Riparian vegetation present mainly on left bank, comprising mainly *Combretum erythrophyllum, Schotia brachypetala, Nuxia oppositifolia* and *Salix mucronata*. Marginal zones well developed on both banks and islands, comprising *Arundinella, Miscanthus, Juncus and Cyperus spp.* Clear riparian and marginal zones evident to assess high flows.	Exotic species present comprising *Sesbania punicea* and *Acacia mearnsii*. Some of this has already been removed by Parks board staff in the past.
Aquatic invertebrates	A fair diversity of habitats, including abundant rock (although probably mostly embedded) and marginal vegetation. There is also a diversity of hydraulic habitat, with stones out of current on the margins, and abundant stones in current in the main channel.	This site was not surveyed. Excessive algal growth on the stones due to the high nutrient conditions in the water from upstream activities occurred.
Fish	Good habitat variety, plenty of boulders providing fish-shelter.	Dense algae on rocks - slippery to sample here. Algae may discourage insectovorous fish species [scaly].
General	Reasonable access during dry weather.	During wet weather, access problematic. River difficult to cross to obtain data from RB. Limited place to do flow measurements and no gauge.

8.6.7 IFR 6, Darkest Africa, Bushmans River

The site is situated in the Bushmans River just upstream of the confluence with the Thukela River on a farm named Darkest Africa. The site is downstream of the Bushmans River gorge and waterfall. A mixed channel with pool/rapid morphology occurs with bed material consisting of bedrock, boulders and cobbles. This is a low confidence site that formed part of the previous IFR studies (ref). During the 1997 refinement, it became apparent that a suitable site that would provide better criteria than the existing site does not exist and therefore no other site was selected during the Reserve study. This is also offset by the fact that IFR 5 is known to be a high confidence site.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Existing measured rating data in the range 1.3 to 50m^3/s.	IFR site characterised by rapidly varied flow over bedrock rapids and cobble/boulder riffles that are diagonally aligned across the channel. Accurate discharge measurements at low flows difficult due to the rough channel bed.
Fluvial geomorphology	Representative morphology for the lower Bushmans gorge. Largely natural - limited development. Very diverse hydraulic habitat.	Very coarse bed material so difficult to model sediment movement. Limited confidence in hydraulics because of the complexity of the channel.
Riparian vegetation	-	Site in a gorge with steep hillside on LB and bedrock on RB.
Aquatic invertebrates	Not seen by specialist.	
Fish	-	Dense algal slime - may discourage insectivorous species, and slippery to sample.
General	-	Not easily accessible. In a gorge.

8.6.8 IFR 7, Upper Sundays River

The site is selected upstream of the Enambithi Regional Water Supply in Resource Unit Q. The site is characterised by a mixed channel with pool/riffle morphology. The bed material consists of bedrock and cobbles.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Possibility of using upstream gauging station for the measurement of discharge at high flows.	Site characterised by non-uniform flow over a very rough bed. Active (right bank) and high-flow (left bank) channel separated by large boulder strewn mid-channel bar colonised with trees and shrubs. High-flow channel develops a backwater at low flows.
Fluvial geomorphology	The site is out of the gorge and therefore has a flood bench. The RB provides a very good clue for bankfull level. The channel morphology is representative for this reach. Good hydraulic habitat diversity. Loosely packed substrate - easier to assess velocity requirements for sediment transport. No large impoundments immediately upstream.	The site is complicated by a split channel around an island - are they both naturally active or is one a historical channel? Right bank deeply incised and very unstable.
Riparian vegetation	The site is out of the gorge and therefore has a flood bench. The RB provides a very good clue for bankfull level. The channel morphology is representative for this reach. Good hydraulic habitat diversity. Loosely packed substrate - easier to assess velocity requirements for sediment transport. No large impoundments immediately upstream.	The site is complicated by a split channel around an island - are they both naturally active or is one a historical channel? Right bank deeply incised and very unstable.
Aquatic invertebrates	Good habitat diversity with some moveable stones and cobbles amongst bedrock in the rapid. Beneath the stones was some gravel and even detritus, creating some diversity in habitat. The stone were clean suggesting good water quality.	The stones out of current were large and coated with fine sediment. At low flows, marginal vegetation was not inundated so provided negligible habitat, but at higher flows, would provide an important refuge for inverts. No alluvial sediments were found within the site although were abundant further upstream and downstream. These sediments would not form a very significant part of the habitat for setting flows. The side channel and cobble bar on the left side, would provide a moderate refuge during high flows, although most of the stones were embedded thus providing little habitat beneath.
Fish	See above.	See above.
General		Difficult site to photograph to obtain complete picture. Access problematic for sedan car and for all vehicles during the wet season.

8.6.9 IFR 8, Lower Sundays River

The site is situated near the Veil of Hope in RU R. The site is characterised by a mixed channel with pool/riffle morphology. The bed material consists of cobbles and gravel.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Proximity to road crossings upstream and downstream for the measurement of discharges at high flows.	Non-uniform flow conditions developed by alternating lateral bars, large-scale bed roughness.
Fluvial geomorphology	One of the few areas where the channel is relatively straight. The presence of a small flood bench within the channel. Reasonable hydraulic habitat diversity. No large impoundments immediately upstream. Bed material loosely packed.	A seriously degraded part of the catchment - rural agriculture etc. The channel has been devastated by previous large floods therefore obliterating cues for annual events. The system has been "reset" in terms of geomorphology and is only just starting to recover. The site is heavily utilised by cattle.
Riparian vegetation	Clear marginal zones present on both banks. High flow terraces present on both banks.	No useful riparian tree species present. Only riparian trees present are located high above riparian zone. Diversity of riparian species is low.
Aquatic invertebrates	Outstanding cobble habitat although with poor diversity of depths and flows. Most of the cobbles were of a small size and were moveable, creating good habitat beneath. Pools isolated from the main channel were of a completely different nature, with alluvial sediments and significant depth. These would be important refuges.	Further upstream deeper water was available but was not considered part of the critical habitat of the riffle and so was not included in the survey. Marginal vegetation was also minimal although at higher flows the *Juncus* would be inundated and would then provide habitat. At low flows, the only vegetation habitat was the roots of the *Juncus.* There was also little alluvial habitat. Overall a site with limited diversity of habitat.
Fish	See above.	See above.
General	Accessible by normal vehicle. Good view for photo point monitoring.	Problems with non-flow related activities that could change characteristics of the site - extensive bush clearing.

8.6.10 IFR 9, Tugela Ferry

The site is situated downstream of Tugela Ferry and approximately 5 km upstream of the Mooi River confluence. The site is characterised by a steep boulder rapid with a steep hill side on the right bank and a wide cobble bar on the left bank.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Existing measured rating data in the range 5.7 to 29m^3/s.	IFR site characterised by non-uniform flow over a riffle composed predominantly of cobbles and boulders. Accurate discharge measurements at low flows difficult due to the rough channel bed.
Fluvial geomorphology	Representative morphology for this reach and zone. Reasonable high flow cues - terraces and bars, vegetation zone etc.	Highly disturbed by local inhabitants.
Riparian vegetation	-	No marginal or riparian vegetation indicators present for flow assessments. Exotic species present comprising *Sesbania punicea* and various ruderal species. Grazing and browsing pressure excessive.
Aquatic invertebrates	Not seen by specialist.	
Fish	Fair habitat variety, abundant medium and large fish present but low species diversity, abundant large *Macrobrachium* shrimps.	No backwaters, little instream vegetation.
General	Site easy to photograph. Range of photographs at different flows exist.	Site not accessible by normal vehicle.

8.6.11 IFR 10, Mooi River Caravan Park

The site is situated in the Mooi River Caravan Park, immediately downstream of the town of Mooi River and the confluence with the Little Mooi.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Location of an upstream gauging weir that may be used to obtain accurate measurements of discharge. Limited existing measured rating data in the range 5.3 to 8m^3/s.	Non-uniform flow conditions and potential for non-horizontal water surface levels at low flows.
Fluvial geomorphology	Representative morphology for this geomorphological zone. Good high flow indicators.	-
Riparian vegetation	*Salix mucronata* present on the right bank. Marginal zone present on right bank. Working for Water active in the area and removing exotics.	Diversity of indicator species very low. Left bank cannot be used for setting flows. Exotics presence on left bank and on island (blue gums and willows) Vertical sensitivity poor for medium to high flows. Site highly disturbed.

IFR component	Advantages	Disadvantages
Aquatic invertebrates	A diverse site, with abundant marginal vegetation and diverse stones in current habitat.	Affected by the presence of the large willow trees, which have disturbed the river but have probably increased the habitat diversity. The site is close to the town of Mooi River, and will be receiving negative stress in the form of impaired water quality, which in turn results in abundant filamentous algal growth.
Fish	Fair habitat diversity.	Algal growth on rocks.
General	Accessible by normal vehicle. Upstream of the Mnyamvubu Tributary.	-

8.6.12 IFR 11, Mooi River Falls

The site is situated downstream of the Mooi River Falls in the gorge. The site is characterised by a large long boulder riffle. Indigenous riparian vegetation occurs on the RB and the LB has more terrestrial vegetation on a steep hill side.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Location of an upstream gauging weir that may be used to obtain accurate measurements of discharge. Existing measured rating data in the range 1.1 to 24.2m^3/s.	Small tributary between the IFR site and gauging weir. Influence of rough bed likely to result in residual flow depth/s at the cessation of flow. Potential for non-horizontal water surface levels at low flows.
Fluvial geomorphology	Representative morphology for this geomorphological zone. Good high flow indicators (terraces). Homogeneous, loose, bed material for easier sediment modeling. Good hydraulic habitat diversity, habitat model to be produced. Relatively unspoiled area at base of gorge.	Tends to be a natural sediment sink because of change in gradient as river exits the gorge. Therefore a tendency to overestimate extent of accelerated sedimentation.
Riparian vegetation	Good indicators present on RB. Good marginal zones present on RB. Species on right bank whole range of age classes.	LB mountain slope and therefore little value for setting flows. Terrestrialisation on LB. Present development of recreational area and road could impinge on riparian zones.

IFR component	Advantages	Disadvantages
Aquatic invertebrates	Good habitat diversity, with abundant stones in current, mostly bedrock in size but with some loose stones. Sand and very sparse marginal vegetation occur on the margins of the riffle. Just below the riffle, the river enters a pool section with abundant sand, marginal vegetation and stones out of current. There are also vertical walls of earth undercut by the river. Overall, a suitable site that provides a good representation of the benthic invertebrates	-
Fish	Good habitat variety, plenty of boulders providing fish-shelter.	Mild algal growth on rocks.
General	Accessible by normal vehicle. Upstream of the Mnyamvubu Tributary. Downstream of Mooi Falls.	During flooded times no access to site on right bank.

8.6.13 IFR 12, Gracelands

The site is situated downstream of formal irrigation areas around Muden.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Single channel. Position of a reasonable location for measuring discharge close to the IFR site.	Non-uniform flow conditions at the IFR site, which is characterised by a rough channel bed and occurs at a bend in the river.
Fluvial geomorphology	Not visited.	Not visited.
Riparian vegetation	-	RB covered with Spanish reeds. LB highly disturbed with high grazing pressure. No indigenous species present.
Aquatic invertebrates	A fair diversity of hydraulic habitats dominated by cobbles and stones in current. An upstream rapid provides useful fast current stone habitat. Slow currents with sandy sediments were found on the margins. Overall this site provides a good representation of the river and no doubt of its biota.	Marginal vegetation was abundant on the right bank, although mostly this consisted of the less useful *Phragmites* (less useful in that the immersed parts of the plant are the thick bases of the plant – providing minimal of the fine more protective habitat of fine leaves).
Fish	Presence of some backwaters.	No marginal vegetation. Steep short riffle.
General	Accessible by normal vehicle.	

8.6.14 IFR 13, Upper Buffalo

The site is situated in RU V. The site is characterised by a mixed channel with pool/rapid morphology. The bed material consists of bedrock and boulder with sand.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Flow resistance expected to remain reasonably constant for intermediate and high flows when the effect of the bedrock control is drowned-out (approx. 20-50m^3/s). This improves confidence in the hydraulic modelling at these flows.	IFR site characterised by flow over a narrow (approx. 20m in the longitudinal direction) bedrock section across the channel. Non-horizontal water surfaces at low flows. Difficult to measure low-flows when filamentous algae is present in the river (such as during the site selection in September 2001).
Fluvial geomorphology	Straight part of the channel therefore no anomalies associated with sites on a bend . Some distance from tributary inputs. Flood bench present on the LH bank. Channel morphology is representative for this reach. Limited impact of the large historical floods found in the other sites.	Flood cues on only one side of the river. Local knowledge (farmer) suggests that the channel is getting narrower as vegetation encroaches (*Phragmites*). Poor water quality (algae growth) makes it difficult to assess the sediment condition.
Riparian vegetation	Presence of 3 indicator species. Marginal zones on left bank and islands.	LB and islands useful for flow assessment due to dominance of reeds on RB. High impact of grazing and trampling on LB. Channel appears to be incised.
Aquatic invertebrates	A good site with a variety of flow conditions and biotopes. The vegetation was unusual as stands of *Potomogeton* were found in the slower moving areas, which proved to be an excellent habitat for abundant life.	The disadvantages were linked to the type of rock forming the riffle, which produced only a limited amount of loose cobbles. Most of the site was of bedrock substrate, which even out of current had not been significantly sedimented over, only small banks of sediment (mud underneath sand) being found in a few places and the rest of the surface covered with a thin layer of fine sediment. In the riffle, the smaller stones were completely embedded and mostly immovable, but clean otherwise. There were also abundant filamentous algae, probably *Cladophora*, which had less inhabitants than the former plant. This alga suggests some enrichment of the river from upstream.

IFR component	Advantages	Disadvantages
Fish	Excellent habitat variety - overhanging marginal reeds, some weed beds, some large stones to hide amongst. Good species diversity. Vegetated island and banks facilitate setting of flow requirements.	Somewhat limited amount of riffle habitat between two long pools. Fairly recent fish kill, due to ISCOR toxic spill, has reduced fish populations severely.
General	-	Access with normal care problematic. *Phragmites* on site makes photographing at high flows problematic.

8.6.15 IFR 14, Lower Buffalo

The site is situated upstream of the confluence of the Sibindi River with the Buffalo River. The channel is mixed with pool/riffle morphology. The bed material consists of bedrock, boulder and cobble.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Rapid section reasonably extensive (approx. 80m) in the longitudinal direction (along the length of the river).	IFR site characterised by non-uniform flow over a rapid/riffle composed of large resistance elements, including boulders. Orientation of flow will change with discharge as the local influence of the rapid/riffle becomes drowned-out at high flows (approx. $200m^3/s$). Flow resistance a function of depth at low to intermediate discharges, requiring a large range of flows to be measured for accurate modelling / characterisation of stage-discharge and hydraulic relationships. Non-horizontal water surfaces (along the cross-sections) produced by flow dividing into two channels at low to intermediate flows.
Fluvial geomorphology	Channel morphology is representative for this reach. A new flood bench appears to be present on the RB. Bed material is homogeneous therefore probably easier to assess flow requirements for transport. Bed material is only moderately packed and embedded.	Bankfull is difficult to assess because the banks appear to be re-forming after large historic floods. The present morphology appears to be completely out of equilibrium.
Riparian vegetation	Riparian indicator species present - *Nuxia oppistofolia.* Good marginal zones present on both banks.	Diversity of indicator species confined to *N. oppistifolia*. LB impacted by grazing and trampling.

IFR component	Advantages	Disadvantages
Aquatic invertebrates	Extensive rocky habitat, with large and small stones, mostly clean and clear of sediment. Overall an excellent stone habitat, some areas shallow, and others deep – with good diversity.	Overall a limited site having limited biotope variability. Most of the habitat fairly exposed so that during floods, if the cobbles were moving, things would difficult for invertebrates. The pool below the large upstream rock, also fairly exposed and likely to be a poor habitat in high flows. Vegetation habitat was non-existent, and sand or gravel very limited. In the upstream pool, a bank of sand provided some habitat, but seemed to be sparsely inhabited. In the riffle, small areas of sand and gravel existed between stones. This is an insignificant biotope for this site
Fish	Excellent habitat variety in, below and above large riffle below Isibindi stream confluence. (Similar conditions at IFR transect.)	Disappointing species variety on survey day.
General	Excellent high vantage for photo point monitoring.	Site difficult and time consuming to get to.

8.6.16 IFR 15, Jameson's Drift

The site is situated downstream of Jameson's Drift. Alluvial channel with pool/riffle morphology and a bed consisting of a mixed cobble with gravel and sand matrix.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	Discharge may be accurately measured across the alluvial (sand) channel downstream of the IFR site.	IFR site characterised by flow over a large bedrock outcrop (approx. 60m in the longitudinal direction) across the channel, forming multiple channels and non-horizontal water surfaces at low flows. This results in rapidly-varied flow and different flow directions at low discharges. Difficult to characterise hydraulically using a one dimensional model. This may be addressed by collecting rating data over a range of discharges, particularly at low flows.
Fluvial geomorphology	Channel morphology is representative for this reach - more bedrock and alluvium. Good habitat diversity. Some evidence of the pre-flood morphology on the LB.	There are limited flood clues on both sides of the river. The area is heavily utilised by the local rural population and therefore difficult to assess a "natural" condition. The presence of a contributing gully at the site complicates the geomorphology.

IFR component	Advantages	Disadvantages
Riparian vegetation	Riparian vegetation indicators present on right bank. Marginal zone present on left bank, comprising *Cynodon dactylon*.	Vegetation indicators too high up bank and associated with adjacent tributary and therefore of little to no value for assessing flows. No other vegetation present.
Aquatic invertebrates	Wide range of habitats, from bedrock shutes, to cobble riffles in shallow water, to gravel, sand and mud, with a large patch of trailing *Phragmites*. The diversity of habitats was excellent, although the marginal vegetation was unusual for the RU. The stones in current in particular were excellent, those on the edges of the river being of modest size (20cm diameter, 10cm thick) and completely clear of sediment. This was a good site for invertebrate diversity.	-
Fish	Excellent habitat variety including marginal vegetation and backwater.	None
General	Accessible with normal vehicle	Difficult during high flows to photograph all the channels. Difficult area to measure flows during high flows due to depth in channel.

8.6.17 IFR 16, Mandini

The site is situated about 7 km upstream of the Mandini gauge. The site consists of an alluvial section with large boulder bar on the left bank.

The advantages and disadvantages are provided below:

IFR component	Advantages	Disadvantages
Hydraulics	IFR site characterised by a large (approx. 80-100m wide) alluvial sand channel with isolated bedrock outcrops along the channel bed, but more extensively on the left-bank. Localised influence of bedrock not expected to significantly effect the accuracy of the hydraulic characterisations. Materially uniform flow conditions increasing the confidence in the hydraulic modelling.	Possibility of backup from the Mandini Weir, located approximately 8km downstream. From a purely hydraulics perspective, this can be accounted for by measuring a range of discharges.

IFR component	Advantages	Disadvantages
Fluvial geomorphology	Channel morphology is representative for this reach. Bed material is alluvial therefore easier to assess velocity requirements for sediment transport. Appears to be relatively good flood cues in the form of a terrace on the RH bank.	The channel within this reach is incised and does not provide easy, obvious and consistent clues for bankful floods on both banks. The channel morphology has been influenced by relatively recent large flood events (ie a changed template). One complicating issue is the fact that the site appears to be a sediment storage zone just above the estuary.
Riparian vegetation	RB is of primary value. RB diversity good due to presence of 5 indicator species including *Ficus sycamores, Combretum erythrophyllum* and *Trichelia emetica.* Riparian terrace present on LB. RB : Indicator species of a range of different age classes.	Presence of extensive aliens on RB. Artificial terracing on RB. Marginal zones limited due to return flows. Vertical sensitivity poor.
Aquatic invertebrates	On the left bank, backwater pools were not sampled but would provide some refuge during high flows.	Large amounts of loose sand and little suitable stone. A small pool adjacent to a large rock, on the right bank of the river, contained some signs of life, including filamentous algae, as it provided a more stable habitat than the main river, being deep and out of current (at low flows). The stones in the river were mostly bedrock with the occasional loose stone. Consequently, there was very little life in this biotope. The vegetation was mostly the bases of *Phragmites* and a few leaf tips trailing in the water. The sand substrate, with occasional patches of coarser gravel, is clearly all exposed to current at some stage, and thus is always a poor biotope.
Fish	Moderate habitat variety - but very characteristic of this section of the river. Some overhanging marginal vegetation. Small backwater areas present (at low flow). Fairly gently sloping left bank provides clues for setting flow requirements. Fair historical supporting collections from here and from nearby.	Minimal rocky habitat - all on the far side of the river.
General		Access problematic with a normal car. Photo point monitoring is difficult as limited upstream and downstream views during high flows.

Fig 8.3 IFR 1, 15/9/99, 2.6m^3/s

Fig 8.4 IFR 2, 4/8/01, 1.3m^3/s

Fig 8.5 IFR 3, 31/7/01, 0.37m^3/s

Fig 8.6 IFR 4A, 2/8/01, 5.2m^3/s

Fig 8.7 IFR 4B, 27/7/96, 3.7m^3/s

Fig 8.8 IFR 5, 26/8/96, 0.9m^3/s

Fig 8.9 IFR 6, 27/8/96, 2.4m^3/s

Fig 8.10 IFR 7, 3/8/01, 0.25m^3/s

Fig 8.11 **IFR 8, 06/8/01,0.31m^3/s**

Fig 8.12 **IFR 9, 18/10/96, 12m^3/s**

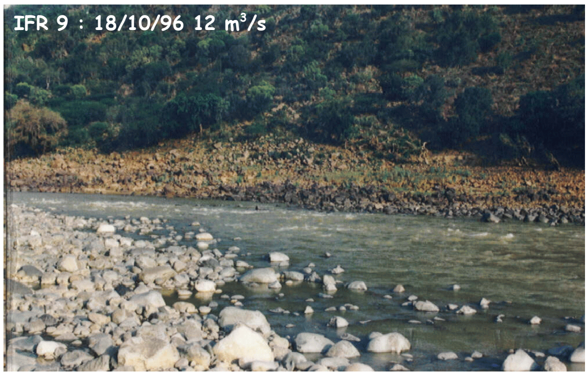


Fig 8.13 **IFR 10, 5/5/98, 5.3m^3/s**

Fig 8.14 **IFR 11, 5/10/01, 2.9m^3/s**

Fig 8.15 **IFR 12, 20/1/98, 13.5m^3/s**

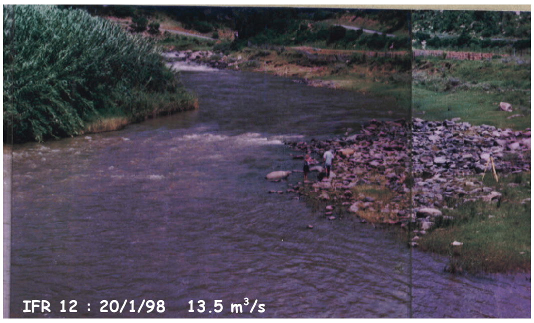


Fig 8.16 **IFR 13, 3/10/01, 1.8m^3/s**

Fig 8.17 **IFR 14, 11/9/01, 0.63m^3/s**

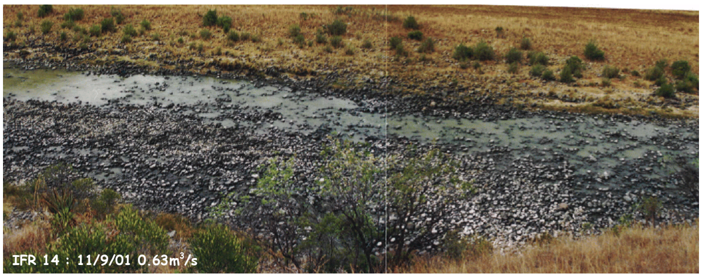


Fig 8.18 IFR 15, 6/1/01, 18.7m^3/s

Fig 8.19 IFR 16, 15/9/01

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APPENDIX A

A-1. QUALITY RUS

Upper Thukela River Catchment: Thukela River				
QRU no.	**Segment no. (RU)**	**Description**	**Monitoring point data to be used**	**Land use activities and implications for water quality**
1	1-4 (A)	Rugged Glen to upstream of Woodstock and Driel Dams.	DWAF mon. points V1H035 and V1H036.	Little land use activity; some cultivated lands. • Water quality conditions good.
2	5-7 (B)	Woodstock and Driel Dams to upstream of Bergville.	DWAF mon. point V1H058.	Water is abstracted for irrigation (cultivated lands) and urban / domestic water purposes, and the water transfer scheme to the Sterkfontein Dam in the Vaal River system from the Woodstock and Driel Dams. • Water quality conditions good.
3	7-9 (B)	Bergville to upstream of Spioenkop Dam.	DWAF mon. points V1H026 and V1H031.	Irrigation (cultivated lands and orchards) and urban / domestic water use. • Water quality conditions good. Water quality at V1H031 (on the Sand Spruit) is poorer than V1H026 (on Thukela), probably due to agricultural return flows - dilution at the confluence expected to improve quality.
4	10-16 (C)	Spioenkop Dam to upstream of Thukela - Little Thukela confluence.	DWAF mon. point V1H057.	Main land use is crop production and cattle farming. • Water quality conditions good.
5	17-20 (D)	Thukela - Little Thukela confluence to upstream of Colenso.	No water quality data. *May have to combine QRUs 5 and 6.*	Main land use is crop production and cattle farming.
6	21-24 (D, E)	Colenso to upstream of Thukela - Klip River confluence near Ladysmith.	DWAF mon. point V1H001 at Colenso.	Urban / domestic water use and limited cultivated lands. • Water quality conditions good. Slightly reduced water quality conditions during winter.

7	25-29 (F)	Thukela - Klip River confluence to upstream of the Thukela - Bloukrantz confluence.	There are no DWAF mon. points in this segment. DWAF data on the Klip River will therefore be used, i.e. V1H038 just upstream of Ladysmith, and Water quality site 6 (*) upstream of Thukela - Klip River confluence. It is important to acknowledge the dilution effects when the Klip and Thukela Rivers join. Water quality site 5 (*) data is also available for the stretch below the Klip confluence and above the Bloukrantz confluence with the Thukela River.	The Klip River brings water of reduced quality to the Thukela River. Urban run-off and discharge from industrial activities associated with Ladysmith drain into the Klip River, and subsequently into the Thukela River. However, quality is expected to be restored to some degree upon dilution at the confluence of the Klip and Thukela Rivers. • Klip River: water quality conditions fair. • Thukela River QRU: effect of Klip River input ameliorated upon dilution.
8	29-30 (F)	Thukela - Bloukrantz confluence to upstream of the Thukela - Bushmans confluence.	No water quality data. *May have to combine QRUs 8, 9 and 10*.	This QRU has been separated from QRU 9 due to the large-scale citrus farming being undertaken at Tugela Estates, just downstream of the Thukela - Bloukrantz confluence.
9	31-33 (G)	Thukela - Bushmans confluence to upstream of Thukela - Sundays confluence.	No water quality data. *May have to combine QRUs 8, 9 and 10*. There is also a significant short tributary called the Sikhehlengeni River in this reach.	Crop farming and some settlements.
Upper Thukela River Catchment: Little Thukela River				
14	1-9 (L, M)	Injasuthi to upstream of Winterton.	No water quality data. *May have to combine QRUs 14 and 15*.	Crop production and irrigation.
15	10-12 (M)	Winterton to the confluence of the Little Thukela and Thukela Rivers.	DWAF mon. point V1H010.	Irrigation of extensive cultivated lands and orchards, and urban / domestic water use. • Water quality conditions fair. In winter some increase in TDS and nutrient levels are evident, which may become problematic.

Upper Thukela River Catchment: Bushmans River				
16	1-9 (N)	Elands Park to upstream of Wagendrift Dam.	DWAF mon. points V7H016 on the Ncibidwane River (a tributary of the Bushmans, joining it at segment 2), and V7H017 on the Bushmans River, at the confluence with the Ncibidwane.	Settlements and subsistence cattle farming. Some cultivated lands and orchards. • Water quality conditions good.
17	10-11 (O)	Wagendrift Dam to upstream of the Little Bushmans River - Bushmans River confluence (including Estcourt).	DWAF mon. points V7H018 and V7H012 (at Escourt) on the Little Bushmans River.	Irrigation and urban / domestic water use. Some industrial activity (e.g. Nestlé, Estcourt meat processing) at Estcourt. • Water quality conditions fair. Quality somewhat reduced at Estcourt (V7H012), probably due to urban run-off and industrial activity.
18	12-20 (O, P)	Little Bushmans River - Bushmans River confluence to upstream of Weenen.	No water quality data. *May have to combine QRUs 18 and 19*.	Crop production and irrigation.
19	21-25 (P)	Weenen to the confluence of the Bushmans and Thukela Rivers.	There are no DWAF monitoring points in this segment. Use Water quality site 4 (*) data.	Crop production, irrigation and urban / domestic water use. • Water quality conditions fair (limited data).
Upper Thukela River Catchment: Sundays River				
20	1-6 (Q, R)	Sundays River from the Ladysmith/Newcastle road to upstream of the Wasbank - Sundays River confluence.	DWAF mon. point V6H006 (above study area) and V6H004 (segment 2).	Informal settlements, subsistence crops and cattle farming. The Newcastle-Platberg Colliery is found in this QRU. • Water quality conditions good above the study area - reduced to fair by segment 2, due to increasing sulphate levels and the presence of the colliery.

21	7-13 (R)	Wasbank - Sundays River confluence to the confluence of the Sundays and Thukela Rivers.	DWAF mon. point V6H003 on the Wasbank River, Water quality site 3 (*) on the lower Sundays River (around IFR 8).	The water quality in this reach is largely affected by input from the Wasbank River. Primary land use in the Wasbank catchment area is agriculture (crop production, cattle and game farming, subsistence farming) and trading. The upper Wasbank River is affected mainly by acid mine drainage from defunct coal mines, and high salt loads are evident. Large informal and semi-formal settlements can be seen in the lower Wasbank catchment. Poor water quality is evident. Some cultivated lands downstream of the Wasbank-Sundays River confluence. • Poor quality water coming in from the Wasbank River (V6H003), with high TDS and sulphate levels. Level still elevated at the monitoring point on the Sundays River, where water quality is poor - fair.
Lower Thukela River Catchment: Thukela River				
10	34-39 (H)	Thukela - Sundays confluence to upstream of Thukela - Mooi River confluence.	DWAF mon. point V6H002 at Tugela Ferry.	This area is rugged and remote, with little activity excluding some settlements and subsistence farming. • Water quality conditions fair. Slightly elevated TDS, particularly in winter. Nutrient levels elevated, potential exists for eutrophication if levels continue increasing.
11	39-41 (H, I)	Thukela - Mooi River confluence to upstream of Thukela - Buffalo River confluence.	No water quality data. *May have to combine QRUs 11and 12*.	This area is rugged and remote, with little activity excluding some settlements and subsistence farming.
12	41-73 (I, J)	Thukela - Buffalo River confluence to upstream of the Mandini / Sundumbili industrial complex.	No DWAF mon. data, therefore use Umgeni Middledrift data and Water quality site 1 (*) at Jameson's Drift.	This area is rugged and remote, with little activity excluding some settlements and subsistence farming. This QRU also includes the Tugela-Mhlathuze transfer scheme abstraction point. • Water quality conditions fair (data confidence low).

13	74 - estuary at 78 (K)	Mandini / Sundumbili industrial complex to the Thukela estuary.	DWAF mon. point V5H002 and water quality data from Sappi Tugela.	Large industrial area, including Sappi Tugela mill, Mandini, Tugela Rail and Sundumbili Sewage Treatment Works. Irrigation by sugar farmers takes places further downstream. Some of the impacts are only evident from the Sappi data, as their monitoring points are at John Ross bridge and further toward the Thukela estuary - however, limited variables are monitored. The DWAF monitoring point is upstream of most of the impacts. Abstraction and discharge takes place in this QRU. • Water quality conditions fair - accessing additional data for verification (data confidence extremely low as a known area of impact).

Lower Thukela River Catchment: Mooi River				
22	1-15 (S)	Beginning of study area to upstream of Mooi River town.	DWAF mon. point V2H006 on the Little Mooi River and V2H005 on the Mooi River.	Cattle farming, stud farms and irrigation. Site of Mooi-Mgeni Transfer Scheme, from the Mooi River to Midmar Dam. • Water quality conditions good.
23	16-30 (S, T)	Mooi River town to upstream of Muden.	DWAF mon. point V2H002 at Mooi River town, and V2H004 on segment 26 (around IFR 11).	Defunct textile mill (closed 1999/2000) in Mooi River town. Extensive nutrient enrichment evident around Mooi River town (July 2001), apparently due to irrigation of fodder crops right down to river's edge. Large cattle breeding (dairy) and citrus farming area. • Water quality conditions fair - good. Elevated TDS levels in winter.
24	30-38 (S, T)	Muden to the confluence of the Mooi and Thukela Rivers.	DWAF mon. point V2H008 at Keate's Drift.	Irrigation and farming activities, particularly the Mooi River Irrigation Scheme before the Mooi-Thukela River confluence. Mostly informal settlements and subsistence farming around Keate's Drift. • Water quality conditions fair. Elevated TDS levels in winter, which may become problematic.

Lower Thukela River Catchment: Buffalo River				
25		Above the study area, including the Newcastle industrial area, the Ncandu and Ngagane tributaries of the Buffalo River, Osizweni and Madendeni.	DWAF mon. points V3H009 on the Horn River, a tributary of the Ngagane River, and V3H027 on the Ngagane River.	Extensive industrial area, including coal mining, Iskor (increasing salt levels significant), 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. Ngagane River therefore heavily affected by pollution. Extensive formal settlements of Newcastle, Madendeni and Osizweni, with associated urban / domestic water usage and discharge impacts. • Water quality poor, particularly in the Horn River. Some amelioration in the Ngagane River.
26	1-42 (U, V)	From the Utrecht - Ozisweni road bridge to the confluence of the Buffalo and Thukela Rivers (area includes IFR 13 and 14).	No DWAF monitoring data is available; use Water quality site 2 (*) - around IFR 14.	Settlements, some farming activities (cultivated lands). • Water quality fair - poor, with high TDS and sulphate levels.

A-2. WATER QUALITY DATA

Data used in current assessment

Upper Thukela River Catchment

QRU1

DWAF Monitoring Point	V1H035Q01
Position	Thukela Canal
Grid Reference	28°40'00"S 29°07'31"E
Number of Samples	406 (with gaps)
Date of first sample	28688
Date of last sample	36304
Predominant sampling frequency	07/1978 to 03/1981 weekly; 04/1981 to 12/1985 monthly; 01/1986 to 03/1989 weekly; 05/1989 to 11/1996 monthly; 12/1996 to 1999 fortnightly
Assessment	Good
Comments	Data for RC and PES

QRU1

DWAF Monitoring Point	V1H036Q01
Position	Jagers Rust Forebay at Jagers Rust Pump Station
Grid Reference	28°36'00"S 29°07'00"E
Number of Samples	215
Date of first sample	28688
Date of last sample	36551
Predominant sampling frequency	*ad hoc* samples in 1978 and 1979; 06/1995 to 08/1999 weekly; 09/1999 to 01/2000 monthly
Assessment	Moderate to good
Comments	Data for RC and PES

QRU2

DWAF Monitoring Point	V1H058Q01
Position	Driel Barrage on Thukela River downstream weir
Grid Reference	28°45'44"S 29°17'33"E
Number of Samples	234
Date of first sample	32580
Date of last sample	36969
Predominant sampling frequency	03/1989 to 08/1999 weekly; 09/1999 to 03/2001 monthly
Assessment	Good
Comments	Good data set for PES (no data prior to 1989)

QRU3

DWAF Monitoring Point	V1H026Q01
Position	Thukela River at Kleine Waterval
Grid Reference	28°43'15"S 29°21'33"E
Number of Samples	941
Date of first sample	25594
Date of last sample	36969
Predominant sampling frequency	Between 1976 and 1994, a combination of weekly and bimonthly sampling; 01/1995 to 03/2001 weekly
Assessment	Moderate to good
Comments	none

QRU3

DWAF Monitoring Point	V1H031Q01
Position	Sand Spruit At Kleine Waterval/Bergville
Grid Reference	28°43'21"S 29°21'05"E
Number of Samples	369 (sample gaps)
Date of first sample	28324
Date of last sample	36549
Predominant sampling frequency	07/1977 to 07/1979 weekly; 12/1979 to 01/1983 monthly; 2 samples in 1983; 01/1984 to 04/1990 bimonthly or less frequent; 05/1990 to 01/2001 monthly but infrequent with many month’s data missing
Assessment	Moderate
Comments	Data for RC and PES

QRU4

DWAF Monitoring Point	V1H057Q01
Position	Spioenkop Dam on Thukela River downstream weir
Grid Reference	28°40'52"S 29°31'00"E
Number of Samples	522
Date of first sample	30437
Date of last sample	36970
Predominant sampling frequency	05/1983 to 09/1985 monthly; 10/1985 to 2001 weekly
Assessment	Good
Comments	Good data for PES assessment

QRU6

DWAF Monitoring Point	V1H001Q01
Position	Thukela River at Thukela Drift/Colenso
Grid Reference	28°44'08"S 29°49'14"E
Number of Samples	913 (with gaps for some Water quality constituents)
Date of first sample	24155
Date of last sample	36954
Predominant sampling frequency	Weekly for EC, but monthly for other Water quality constituents
Assessment	Good
Comments	From 1952-1960 there are measurements for suspended solids, although there are no measurements for suspended solids from 1960 onwards.

QRU7

DWAF Monitoring Point	V1H038Q01
Position	Klip River at Ladysmith Townlands army camp
Grid Reference	28°33'42"S 29°45'09"E
Number of Samples	494 (some data gaps)
Date of first sample	28324
Date of last sample	36535
Predominant sampling frequency	07/1977 to 07/1979 weekly; 11/1979 to 06/1984 monthly; 09/1984 to 11/1988 bimonthly; 12/1988 to 2000 monthly
Assessment	Moderate to good
Comments	None

QRU7

Additional monitoring point	Site 6
Position	Klip River upstream of its confluence with the Thukela River
Grid Reference	28°36'43"S 29°54'12"E
Number of Samples	8
Date of first sample	37116
Date of last sample	37165
Predominant sampling frequency	Weekly
Assessment	Reasonable
Comments	Limited to August and September 2001 sampling

QRU7

Additional monitoring point	Site 5
Position	Thukela River downstream of confluence with Klip River
Grid Reference	28°44'47.2"S 30°08'42.3"E
Number of Samples	8
Date of first sample	37116
Date of last sample	37165
Predominant sampling frequency	Weekly
Assessment	Reasonable
Comments	Limited to August and September 2001 sampling

QRU15

DWAF Monitoring Point	V1H010Q01
Position	Little Thukela River at Winterton
Grid Reference	28°49'05"S 29°32'42"E
Number of Samples	457
Date of first sample	24155
Date of last sample	36968
Predominant sampling frequency	Monthly
Assessment	Moderate to good
Comments	None

QRU16

DWAF Monitoring Point	V7H016Q01
Position	Ncibidwane River at Drakensberg No 1
Grid Reference	29°11'18"S 29°38'21"E
Number of Samples	468
Date of first sample	28163
Date of last sample	36955
Predominant sampling frequency	02/1977 - 04/1978 weekly; 05/1978 - 02/1983 monthly; 04/1983 - 12/1988 bimonthly/less frequent; 02/1089 - 03/2001 monthly
Assessment	Moderate to good
Comments	Data for RC and PES

QRU16

DWAF Monitoring Point	V7H017Q01
Position	Bushmans River at Drakensberg No 1
Grid Reference	29°11'15"S 29°38'13"E
Number of Samples	453
Date of first sample	28323
Date of last sample	36955
Predominant sampling frequency	07/1977 - 07/1979 weekly; 11/1979 - 01/1983 monthly; 03/1983 - 12/1987 bimonthly/less frequent; 01/1988 - 03/2001 monthly
Assessment	Moderate to good
Comments	Data for RC and PES

QRU17

DWAF Monitoring Point	V7H012Q01
Position	Little Bushmans River at Estcourt
Grid Reference	29°00'08"S 29°52'54"E
Number of Samples	439
Date of first sample	24405
Date of last sample	36956
Predominant sampling frequency	10/1966 *ad hoc* sample; 01/1982 - 01/1983 weekly; 03/1983 - 02/1989 monthly to infrequent; 03/1989 - 03/2001 monthly
Assessment	Moderate
Comments	PES data, but data for RC sparse.

QRU17

DWAF Monitoring Point	V7H018Q01
Position	Little Bushmans River at Loch Sloy/Craig
Grid Reference	29°04'05"S 29°44'51"E
Number of Samples	475
Date of first sample	28107
Date of last sample	36809
Predominant sampling frequency	12/1976 - 04/1978 weekly; 05/1978 - 09/1979 monthly; 10/1979 - 02/1981 weekly; 03/1981 - 03/1983 monthly; 04/1983 - 12/1988 bimonthly/less frequent; 02/1989 - 10/2000 monthly
Assessment	Moderate to good
Comments	Data for RC and PES

QRU19

Additional monitoring point	Site 4
Position	Bushmans River upstream of confluence with Thukela River
Grid Reference	28°46'02.8"S 30°10'09.6"E
Number of Samples	8
Date of first sample	37116
Date of last sample	37165
Predominant sampling frequency	Weekly
Assessment	Reasonable
Comments	Limited to August and September 2001 sampling

QRU20

DWAF Monitoring Point	V6H006Q01
Position	Sundays River at Waterfall
Grid Reference	28°14'23"S 29°45'16"E
Number of Samples	349
Date of first sample	28023
Date of last sample	36583
Predominant sampling frequency	09/1976 - 04/1978 weekly; 05/1978 - 01/1984 monthly, with gaps; 02/1984 - 06/1995 no data; 07/1995 - 02/2000 monthly (with gaps)
Assessment	Moderate to good
Comments	Data for RC and PES

QRU20

DWAF Monitoring Point	V6H004Q01
Position	Sundays River at Kleinfontein
Grid Reference	28°24'16"S 30°00'47"E
Number of Samples	446
Date of first sample	24156
Date of last sample	36535
Predominant sampling frequency	02/1966 *ad hoc*; 09/1976 - 04/1978 weekly; 05/1979 - 11/1983 monthly; 01/1984 - 11/1988 bimonthly; 02/1989 - 01/2000 monthly
Assessment	Moderate to good
Comments	Data for RC and PES

QRU21

DWAF Monitoring Point	V6H003Q01
Position	Wasbank River at Kuikvlei
Grid Reference	28°18'34"S 30°08'53"E
Number of Samples	521
Date of first sample	28326
Date of last sample	36590
Predominant sampling frequency	07/1977 - 09/1979 weekly; 11/1979 - 11/1983 monthly; 01/1984 - 12/1989 bimonthly, or less frequent; 01/1990 - 12/1995 monthly; 01/1996 - 03/2000 biweekly, with more than 1 sample on some days
Assessment	Moderate to good
Comments	Data for RC and PES

QRU21

Additional monitoring point	Site 3
Position	Sundays River above confluence with Thukela River
Grid Reference	28°38'43"S 30°12'49.5"E
Number of Samples	8
Date of first sample	37116
Date of last sample	37165
Predominant sampling frequency	Weekly
Assessment	Reasonable
Comments	Limited to August and September 2001 sampling

Lower Thukela River Catchment

QRU10

DWAF Monitoring Point	V6H002Q01
Position	Thukela River at Thugela Ferry
Grid Reference	28°45'00"S 30°26'34"E
Number of Samples	861
Date of first sample	28326
Date of last sample	36929
Predominant sampling frequency	07/1977 - 07/1979 weekly; 12/1979 - 12/1983 monthly; 01/1984 - 12/1988 bimonthly, or less frequent; 03/1989 - 02/2001 monthly, with intermittent more frequent sampling
Assessment	Moderate to good
Comments	Data for RC and PES

QRU12

Additional monitoring point	Site 1
Position	Thukela River at Jameson's Drift
Grid Reference	28°46'22.7"S 30°53'56"E
Number of Samples	8
Date of first sample	37116
Date of last sample	37165
Predominant sampling frequency	Weekly
Assessment	Reasonable
Comments	Limited to August and September 2001 sampling

QRU12

Umgeni Water	Middledrift
Position	Thukela River at Middledrift
Grid Reference	
Number of Samples	24
Date of first sample	35607
Date of last sample	37104
Predominant sampling frequency	Monthly
Assessment	Fair
Comments	A sparse data set

QRU13

Sappi Thukela Data	Havelock Farm
Position	Thukela River downstream of Mandini
Grid Reference	
Number of Samples	55
Date of first sample	01/1997
Date of last sample	08/2001
Predominant sampling frequency	Monthly
Assessment	Poor
Comments	Limited water quality constituents measured

QRU13

DWAF Monitoring Point	V5H002Q01
Position	Thukela River at Mandini
Grid Reference	29°08'26"S 31°23'31"E
Number of Samples	1135 (with data gaps dates with no records)
Date of first sample	28316
Date of last sample	36978
Predominant sampling frequency	07/1977 to 07/1979 weekly; 11/1979 to 10/1984 monthly; 10/1984 to 09/1994 weekly and monthly; 10/1994 to 03/2001 monthly
Assessment	Moderate to good
Comments	None

QRU13

Sappi Thukela Data	John Ross Bridge
Position	Thukela River downstream of Mandini
Grid Reference	
Number of Samples	55
Date of first sample	01/1997
Date of last sample	08/2001
Predominant sampling frequency	Monthly
Assessment	Poor
Comments	Limited water quality constituents measured

QRU22

DWAF Monitoring Point	V2H006Q01
Position	Little Mooi River at Dartington
Grid Reference	29°15'29"S 29°52'09"E
Number of Samples	495
Date of first sample	28023
Date of last sample	36585
Predominant sampling frequency	09/1976 to 04/1978 weekly; 05/1978 to 10/1979 monthly; 11/1979 to 03/1981 weekly; 04/1981 to 02/1983 monthly; no data from 03/1983 to 05/1995; 06/1995 to 03/2000 weekly
Assessment	Moderate to good
Comments	None

QRU22

DWAF Monitoring Point	V2H005Q01
Position	Mooi River at the Bend/Avon
Grid Reference	29°21'34"S 29°52'52"E
Number of Samples	467
Date of first sample	28323
Date of last sample	36585
Predominant sampling frequency	07/1977 - 03/1981 weekly;04/1981 - 02/1983 monthly; 03/1983 - 05/1995 no data; 06/1995 - 03/2000 weekly
Assessment	Moderate to good
Comments	Apart from the data gap from 1983 to 1995, this data set is good with predominantly weekly sampling

QRU23

DWAF Monitoring Point	V2H002Q01
Position	Mooi River at Mooiriver
Grid Reference	29°13'10S 29°59'37"E
Number of Samples	549
Date of first sample	27939
Date of last sample	36585
Predominant sampling frequency	06/1976 to 04/1978 weekly; 05/1978 to 08/1979 monthly; 10/1979 to 07/1981 weekly; 08/1981 to 03/2000 monthly
Assessment	Moderate to good
Comments	01/1970 to 12/1975 only have suspended solids data

QRU23

DWAF Monitoring Point	V2H004Q01
Position	Mooi River at Doornkloof
Grid Reference	29°04'15"S 30°14'45"E
Number of Samples	432
Date of first sample	28326
Date of last sample	36558
Predominant sampling frequency	07/1977 - 02/1981 weekly; 03/1981 - 02/1983 monthly; poor data record from 04/1983 - 12/1988; 02/1989 - 02/2000 monthly
Assessment	Moderate to good
Comments	None

QRU24

DWAF Monitoring Point	V2H008Q01
Position	Mooi River at Keate's Drift
Grid Reference	28°51'34"S 30°30'00"E
Number of Samples	118
Date of first sample	30069
Date of last sample	36593
Predominant sampling frequency	04/1982 - 07/1983 monthly; 08/1983 - 12/1994 no data; 05/1995 - 03/2000 monthly
Assessment	Moderate (for PES)
Comments	Only recent data, therefore no RC

QRU25

DWAF Monitoring Point	V3H009Q01
Position	Horn River at Ballengeich
Grid Reference	27 °53'45"S 29 °57'05"E
Number of Samples	1039
Date of first sample	24155
Date of last sample	36556
Predominant sampling frequency	02/1966 - 01/1967 *ad hoc*; 01/1967 - 08/1975 no data; 09/1975 - 04/1978 weekly; 05/1978 - 12/1978 monthly; 01/1979 - 11/1979 *ad hoc*; 12/1979 - 03/1981 weekly; 04/1981 - 03/1982 monthly; 08/1982 - 07/1988 bimonthly; 10/1988 - 02/2000 weekly
Assessment	Moderate to good
Comments	None

QRU25

DWAF Monitoring Point	V3H027Q01
Position	Chelmsforddam on Ngagane River downstream weir
Grid Reference	27°57'11"S 29°56'53"E
Number of Samples	107
Date of first sample	30117
Date of last sample	36556
Predominant sampling frequency	06/1982 - 07/1987 *ad hoc*; 09/1987 - 05/1988 weekly; 06/1988 - 01/1989 no data; 02/1989 - 01/1990 weekly; 02/1990 - 10/1996 no data; 11/1996 - 02/2000 monthly
Assessment	Moderate
Comments	No historical data record (for RC, or adequate trend analysis), but suitable for PES

QRU26

Additional monitoring point	Site 2
Position	Buffalo River upstream of confluence with Thukela River
Grid Reference	28°26'49"S 30°36'00.4"E
Number of Samples	8
Date of first sample	37116
Date of last sample	37165
Predominant sampling frequency	Weekly
Assessment	Reasonable
Comments	Limited to August and September 2001 sampling

Data for possible use

Upper Thukela River Catchment

QRU1

DWAF Monitoring Point	V1H003Q01
Position	Ndumeni Tributary 2 at Cathedral Peak
Grid Reference	28°59'23"S 29°13'36"E
Number of Samples	119
Date of first sample	30748
Date of last sample	36094
Predominant sampling frequency	Weekly from 1984 to 1985; monthly from 1986 to 1990; one sample in 1998
Assessment	Fair (not for present state)
Comments	May be useful for trend analysis and RC

QRU1

DWAF Monitoring Point	V1H005Q01
Position	Masongwane Tributary 4 at Cathedral Peak
Grid Reference	28°59'26"S 29°14'38"E
Number of Samples	225
Date of first sample	29908
Date of last sample	33150
Predominant sampling frequency	1981 - 1985 weekly to fortnightly; 1986 - 1990 monthly
Assessment	Moderate
Comments	Trend analysis

QRU1

DWAF Monitoring Point	V1H007Q01
Position	Masongwane Tributary 3 at Cathedral Peak
Grid Reference	28°59'23"S 29°14'18"E
Number of Samples	224
Date of first sample	29901
Date of last sample	35540
Predominant sampling frequency	1981 to 07/1985 weekly/fortnightly; 08/1985 to 1990 monthly; 1 sample in each of 1992, 1995, 1997
Assessment	Fair
Comments	Trend analysis

QRU1

DWAF Monitoring Point	V1H021Q01
Position	Masongwane Tributary 7 at Cathedral Peak
Grid Reference	28°59'13"S 29°15'13"E
Number of Samples	222
Date of first sample	29915
Date of last sample	33029
Predominant sampling frequency	11/1981 to 07/1985 weekly; 08/1985 to 06/1990 monthly
Assessment	Moderate
Comments	Trend analysis

QRU1

DWAF Monitoring Point	V1H022Q01
Position	Masongwane Tributary 6 at Cathedral Peak
Grid Reference	28°59'15"S 29°15'07"E
Number of Samples	221
Date of first sample	29908
Date of last sample	33029
Predominant sampling frequency	11/1981 to 07/1985 weekly; 08/1985 to 06/1990 monthly
Assessment	Moderate
Comments	Trend analysis

QRU1

DWAF Monitoring Point	V1H023Q01
Position	Mhlwazini Tributary 9 at Cathedral Peak
Grid Reference	28°59'29"S 29°16'25"E
Number of Samples	222
Date of first sample	29908
Date of last sample	34016
Predominant sampling frequency	11/1981 to 07/1985 weekly; 08/1985 to 06/1990 monthly; single sample in 1993
Assessment	Moderate
Comments	Trend analysis

QRU1

DWAF Monitoring Point	V1H033Q01
Position	Thukela River at Wan Hoop/Clifford Chambers
Grid Reference	28°39'10"S 29°02'40"E
Number of Samples	187
Date of first sample	28674
Date of last sample	35089
Predominant sampling frequency	07/1978 to 02/1981 weekly; 03/1981 to 02/1983 monthly; single sample in 1996
Assessment	Poor to fair
Comments	May be suitable for RC and trend analysis

QRU1

DWAF Monitoring Point	V1H034Q01
Position	Kombe River at Grootgeluk
Grid Reference	28°40'23"S 29°05'09"E
Number of Samples	188
Date of first sample	28681
Date of last sample	35100
Predominant sampling frequency	1978 to 1981 weekly sampling; from 03/1981, sampling for all constituents but EC and temperature are monthly to sporadic
Assessment	Fair
Comments	May be suitable for RC and trend analysis

QRU1

DWAF Monitoring Point	V1H040Q01
Position	Tuva Canal at Woodstock
Grid Reference	28°43'39"S 29°14'33"E
Number of Samples	478 (with few data gaps)
Date of first sample	30469
Date of last sample	35964
Predominant sampling frequency	06/1983 to 03/1984 weekly; 04/1984 to 09/1985 monthly; 10/1985 to 06/1995 weekly; 07/95 to 06/1998 *ad hoc*/fortnightly
Assessment	Moderate to good
Comments	Good data record for PES assessment and trend analysis

QRU2

DWAF Monitoring Point	V1H029Q01
Position	Geluksburg Spruit at Schoonspruit
Grid Reference	28°30'28"S 29°20'54"E
Number of Samples	241
Date of first sample	28138
Date of last sample	33783
Predominant sampling frequency	1977 - March 1981 weekly/fortnightly sampling; 04/1981 onwards monthly to sporadic
Assessment	Fair
Comments	Potential use for RC and trend analysis

QRU2

DWAF Monitoring Point	V1H030Q01
Position	Njongola River at Strydhoek
Grid Reference	28°30'50"S 29°20'13"E
Number of Samples	221
Date of first sample	28138
Date of last sample	33888
Predominant sampling frequency	1977 - March 1981 weekly/fortnightly sampling; 04/1981 onwards monthly to sporadic
Assessment	Fair
Comments	Potential use for RC but not PES

QRU2

DWAF Monitoring Point	V1H050Q01
Position	Venter Spruit at Klipplaatsfontein/Action Valley
Grid Reference	28°37'15"S 29°24'44"E
Number of Samples	172
Date of first sample	31333
Date of last sample	34883
Predominant sampling frequency	Weekly to fortnightly from 1985 to 05/1988; then sampling becomes predominantly monthly/sporadic
Assessment	Poor to fair
Comments	Trend analysis

QRU7

DWAF Monitoring Point	V1H009Q01
Position	Bloukrans River at Frere
Grid Reference	28°53'29"S 29°46'14"E
Number of Samples	439
Date of first sample	24155
Date of last sample	36548
Predominant sampling frequency	Single sample in 1966; 06/1976 to 04/1978 weekly; 05/1978 to 1983 monthly; 1984 to 2000 bimonthly to *ad hoc*
Assessment	Moderate
Comments	Potential use for RC and trend analysis

QRU14

DWAF Monitoring Point	V1H039Q01
Position	Little Thukela River at Drakensberg 2
Grid Reference	29°03'29"S 29°31'44"E
Number of Samples	227
Date of first sample	28324
Date of last sample	36066
Predominant sampling frequency	07/1977 to 03/1983 weekly; 04/1981 to 02/1983 monthly; single sample in 1998
Assessment	Poor to fair
Comments	Potential use for RC and trend analysis

QRU21

DWAF Monitoring Point	V6H012Q01
Position	Uithoek Spruit at Uithoek- Wasbank confluence
Grid Reference	-28.204444S 30.132222E
Number of Samples	44
Date of first sample	35046
Date of last sample	36590
Predominant sampling frequency	12/1995 - 03/2000 monthly
Assessment	Poor
Comments	Insufficient data record (as per RDM requirement) but potential use for trend analysis

QRU21

DWAF Monitoring Point	V6H016Q01
Position	Mkomazanariver at Wasbank confluence
Grid Reference	-28.317222S 30.127778E
Number of Samples	35
Date of first sample	35046
Date of last sample	36590
Predominant sampling frequency	12/1995 - 03/2000 monthly
Assessment	Poor
Comments	Insufficient data record (as per RDM requirement) but potential use for trend analysis

QRU21

DWAF Monitoring Point	V6H017Q01
Position	Blinkwater River at Lynwood - upstream of Wasbank confluence
Grid Reference	-28.333333S 30.173333E
Number of Samples	41
Date of first sample	35046
Date of last sample	36590
Predominant sampling frequency	12/1995 - 03/2000 monthly
Assessment	Poor
Comments	Insufficient data record (as per RDM requirement) but potential use for trend analysis

QRU21

DWAF Monitoring Point	V6H018Q01
Position	Tholeni River at Vaalkop Asbank confluence
Grid Reference	-28.452778S 30.174167E
Number of Samples	40
Date of first sample	35046
Date of last sample	36561
Predominant sampling frequency	12/1995 - 02/2000 monthly
Assessment	Poor
Comments	Insufficient data record (as per RDM requirement) but potential use for trend analysis

QRU21

DWAF Monitoring Point	V6H019Q01
Position	Wasbank River at Vaalkop Holeni confluence
Grid Reference	-28.458611S 30.179167E
Number of Samples	42
Date of first sample	35046
Date of last sample	36560
Predominant sampling frequency	12/1995 - 02/2000 monthly
Assessment	Poor
Comments	Insufficient data record (as per RDM requirement) but potential use for trend analysis

QRU21

DWAF Monitoring Point	V6H020Q01
Position	Wasbank River at Asynkraal - Upstream of Sundays River confluence
Grid Reference	-28.531111S 30.781667E
Number of Samples	35
Date of first sample	35046
Date of last sample	36430
Predominant sampling frequency	12/1995 - 09/1999 monthly
Assessment	Poor
Comments	Insufficient data record (as per RDM requirement) but potential use for trend analysis

Lower Thukela River Catchment

QRU23

DWAF Monitoring Point	V2H010Q01
Position	Mnyamvubu River atRietvlei/Caigie Burn Dam
Grid Reference	29°10'57"S 30°16'00"E
Number of Samples	121
Date of first sample	31321
Date of last sample	33933
Predominant sampling frequency	10/1985 - 05/1988 weekly; followed by 2 *ad hoc* samples
Assessment	Fair
Comments	Trend analysis

QRU25

DWAF Monitoring Point	V3H005Q01
Position	Slang River at Vlakdrift
Grid Reference	27°26'08"S 29°58'34"E
Number of Samples	341
Date of first sample	28325
Date of last sample	34058
Predominant sampling frequency	07/1977 - 07/1979 weekly; 11/1979 - 11/1983 monthly; 01/1984- 04/1985 bimonthly; 05/1985 - 03/1993 monthly (with gaps)
Assessment	Moderate (for RC)
Comments	Potential use for RC and trend analysis

QRU25

DWAF Monitoring Point	V3H012Q01
Position	Fourie Spruit at Sleutelpoort
Grid Reference	28°04'16"S 29°52'00"E
Number of Samples	70
Date of first sample	31334
Date of last sample	33267
Predominant sampling frequency	10/1985 - 01/1991 biweekly
Assessment	Fair
Comments	Trend analysis

QRU25

DWAF Monitoring Point	V3H023Q01
Position	Ngagane River at Parklands/Buffalo River Confluence
Grid Reference	27°43'19"S 30°04'49"E
Number of Samples	310
Date of first sample	31868
Date of last sample	34856
Predominant sampling frequency	04/1987 - 12/1988 biweekly; 03/1989 - 06/1995 monthly
Assessment	Fair
Comments	Trend analysis

QRU25

DWAF Monitoring Point	V3H028Q01
Position	Zaaihoek Dam downstream weir
Grid Reference	27°26'15"S 30°03'40"E
Number of Samples	113
Date of first sample	32603
Date of last sample	36585
Predominant sampling frequency	04/1989 - 12/1989 *ad hoc*; 01/1990 - 03/2000 monthly, with intermittent more frequent samples, but also gaps in data record
Assessment	Moderate
Comments	Trend analysis

QRU26

DWAF Monitoring Point	V3H011Q01
Position	Bloed River at Rietvlei/Bembaskop
Grid Reference	27°53'52"S 30°34'53"E
Number of Samples	451
Date of first sample	24063
Date of last sample	33688
Predominant sampling frequency	11/1965 *ad hoc* sample; 09/1975 - 04/1978 weekly; 05/1978 - 12/1983 monthly; 01/1984 - 07/1989 bimonthly (or less frequent); 08/1989 - 03/1992 monthly
Assessment	Moderate
Comments	Potential use for RC and trend analysis

QRU26

DWAF Monitoring Point	V3H015Q01
Position	Buffalo River at Vaalbank/rail bridge
Grid Reference	27°44'15"S 30°12'14"E
Number of Samples	146
Date of first sample	30158
Date of last sample	34611
Predominant sampling frequency	07/1982 - 12/1991 predominantly monthly, with intermittent more frequent samples taken with no particular pattern; 10/1994 single *ad hoc* sample
Assessment	Fair
Comments	Trend analysis