EASTERN CAPE RIVER HEALTH PROGRAMME

TECHNICAL REPORT:
MTHATHA RIVER MONITORING, 2004 - 2006

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The **ECRHP biomonitoring team** responsible for data collection and specialist workshops for the Mthatha River, was comprised of the following team members. The aerial video and data curation teams are also listed. All input is gratefully acknowledged. A special acknowledgement to Dr Kleynhans and Ms Thirion of Resource Quality Services, DWAF, for their tireless contributions to the EcoStatus workshop held in January 2006.

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Specialist	Task
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EXECUTIVE SUMMARY

The National Aquatic Ecosystem Biomonitoring Programme was set up in South Africa in 1994. The aim of this programme was to monitor the health of aquatic ecosystems using biological organisms. The first focus of the programme was on rivers, with the River Health Programme (RHP) adopted on a national level and framework documents for implementation being produced in 1996. The programme aims to promote standardised and continuous monitoring and reporting on river health, and is operated at both national and provincial level.

This report provides the technical input which will underlie the State-of-Rivers Report to be produced for the Mthatha River, Eastern Cape, in 2006. This forms a product of Phase II of the Eastern Cape River Health Programme (ECRHP), initiated in July 2002.

The report provides results and recommendations for three monitoring surveys (March, July and October 2005) of 9 Assessment Units (AU) and 10 sites spread throughout the upper, middle and lower Mthatha River catchment, including selected tributaries. Field indices used for data collection included the South African Scoring System version 5.0 (SASS5) for macroinvertebrates, the Fish Assemblage Integrity Index for fish (FAII), the Integrated Riparian Vegetation Index (IRVI) developed during the Buffalo River programme of the ECRHP, the Geomorphology Assessment Index (GAI) and a water quality assessment using information from DWAF gauging weirs and data collected during field surveys. Habitat integrity was assessed using a video produced for the Mthatha River and the Index of Habitat Integrity (IHI; both instream and riparian assessments were conducted). All data were analysed through the use of associated EcoStatus models per index, to arrive at an integrated EcoStatus per Assessment Unit. The output of the EcoStatus assessments are shown below:

ASSESSMENT UNIT	DESCRIPTION OF LOCATION	ECOSTATUS CATEGORY	RIVER HEALTH CLASS
1	Upper catchment to the confluence of the Qelana and Mthatha rivers	C (68.40)	Fair
2	Below the Qelana tributary to the Langeni sawmills	C – C/D (62.01)	Fair
3	Langeni sawmills to Mthatha Dam (but excluding Mthatha Dam)	C (62.69)	Fair
4	Downstream Mthatha Dam to Mthatha town (no data; qualitative assessment based on aerial video only)	C (69.69)	Fair
5	Below Mthatha town to First Falls Dam	E (38.23)	Poor
6	Below First Falls Dam to Ngqungqu River confluence	D – D/E (52.74)	
7	Ngqungqu River confluence to Mthatha estuary	C (69.43)	Fair
8	Cicira River	D (43.74)	Fair
9	Ngqungqu River	C (66.19)	Fair

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ABBREVIATIONS AND ACRONYMS

ASPT	Average Score Per Taxon
DO	Dissolved Oxygen
DSS	Decision Support System
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
ECRHP	Eastern Cape River Health Programme
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
EVC	Extent of Vegetation Cover
FAII	Fish Assemblage Integrity Index
FRAI	Fish Response Assessment Index
GAI	Geomorphological Assessment Index
HAI	Hydrological Driver Assessment Index
IHAS	Integrated Habitat Assessment System
IAP	Invasive Alien Plants
IHI	Index of Habitat Integrity
IRVI	Integrated Riparian Vegetation Index
MAR	Mean Annual Runoff
MIRAI	Macroinvertebrate Response Assessment Index
NAEBP	National Aquatic Ecosystem Biomonitoring Programme
NRHP	National River Health Programme
PAI	Physico-chemical Assessment Index
PCIRS	Percentage Cover of Riparian species
PES	Present Ecological State
PGS	Present Geomorphological State
RDM	Resource Directed Measures
RHP	River Health Programme
RIP	RIPARI-MAN (vegetation index)
RIRS	Recruitment of Riparian Species
RQO	Resource Quality Objectives
RVI	Riparian Vegetation Index
SAIAB	South African Institute of Aquatic Biodiversity
SASS5	South African Scoring System Version 5
SI	Structural Intactness
SoR	Sate of Rivers
TDS	Total Dissolved Salts
TIN	Total Inorganic Nitrogen
TSS	Total Suspended Solids
VEGRAI	Vegetation Response Assessment Index
WRC	Water Research Commission

CHAPTER 1

RIVER HEALTH AND BIOLOGICAL MONITORING

1.1 INTRODUCTION: SOUTH AFRICAN RIVER HEALTH PROGRAMME

Biological monitoring, or biomonitoring, is a method for determining the present state or ecological health of a system by assessing the health status of the organisms living in and around that system. It is based on the recognition that monitoring of physico-chemical water variables only is not sufficient to achieve integrated ecosystem monitoring, but that the additional monitoring of biological communities offers a more holistic approach. A range of communities are assessed, e.g. in-stream communities such as fish, macroinvertebrates, algal forms such as diatoms, and in-stream, fringing and riparian vegetation, as well as the physical template upon which the biota depend. Physical parameters include the hydrology and water quality of the system, as well as the geomorphological shape and form of the river channel. If information on all these physical indicators is not available, a habitat integrity assessment can be conducted as it provides qualitative information on all physical indicators used in the RHP. This index primarily assesses the impact of human disturbances on riparian and in-stream habitats.

Biomonitoring is therefore an *effects or response-oriented* approach which measures various indicators, and from these measurements, makes an assessment about the health of the aquatic ecosystem. The focus of this approach is therefore the resource, specifically the status of that resource (Uys et al., 1996; Roux, 2003). Biological indicators are therefore able to provide early warning of deterioration of the system or of unsustainable use of its resources, and act as *red flags* indicating that deterioration may be taking place, but without providing any causal links. The biomonitoring technique is usually favoured for its speed, simplicity, effective results and ease of interpretation as well as for recognizing that a freshwater ecosystem is made up of many mutually dependent parts.

The South African National River Health Programme (NRHP) involves the evaluation of the present state of the country's riverine ecosystems relative to their natural state, and projection of long-term trends in river health. It therefore aims to provide information so as to support the effective management of the country's rivers. At a national level, the programme focuses on "state-of-environment" reporting, and aims to achieve the following objectives:

- Measure, assess and report on the ecological state of aquatic ecosystems
- Detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems
- Identify and report on emerging problems regarding aquatic ecosystems
- Ensure that all aquatic ecosystem health report provide scientifically relevant information for the management of aquatic ecosystems

In addition to the aims of national monitoring, provincial monitoring can incorporate the following additional aims:

- To identify where impacts are occurring
- To assess the extent of impacts (pre- and post-impact monitoring)

- To audit compliance with regulatory standards or objectives
- To provide additional information for Resource Directed Measures (RDM). RDM aim to protect aquatic resources through activities such as determining the Ecological Water Requirements (EWR) or Ecological Reserve for a water resource, and setting Resource Quality Objectives (RQO) for effective management of a system. More information can be seen in Chapter 8 regarding the links between the RHP and EWR assessments.

The sections below are modified from the Buffalo River Technical Report, produced for the ECRHP in 2004 (CES, 2004), as the information is fundamental to the RHP. Links between indices and EcoStatus models are indicated in Section 1.3, as the use of EcoStatus models for the interpretation of data collected by the RHP is a relatively new initiative. Details of the EcoClassification and EcoStatus process can be found in Kleynhans et al., 2005.

1.2 RIVER HEALTH CLASSIFICATION

When interpreting results from biomonitoring surveys, it is necessary to know what changes are considered part of the natural variation of the river, i.e. distinguishing between natural and unnatural (rates of) change. A method by which this distinction can be made is to establish a natural benchmark or reference condition, or identify reference sites, with which conditions at monitoring sites can be compared. The RHP relies on this comparison of conditions at monitoring sites vs. reference sites or condition within the same ecoregion, for the interpretation of monitoring data. Ecoregions are areas of broad ecological similarity in terms of physiography, climate, geology, soils and potential natural vegetation. It is assumed that rivers occurring in a particular ecoregion will have certain similarities (DWAF, 2006). Ecoregion boundaries are therefore identified before the site selection process is initiated.

Due to the absence of pristine areas in most catchments and river systems in the country, *miminally impacted sites* are used as surrogates for reference sites. Dallas (2000) has provided guidance regarding the establishment of reference conditions, with her work conducted in Mpumalanga during the pilot-scale phase of the NRHP.

In order to standardize the output of the different indices, to allow comparisons between different rivers and areas of the country, and relate these outputs to river condition categories, the following river health classification system has been developed, along with the associated ecological and management perspectives per River Health Category (Table 1.1).

Table 1.1 The river health classification system used in the NRHP (adapted from Roux, 2003)

RIVER HEALTH CATEGORY	ECOLOGICAL PERSPECTIVE	MANAGEMENT PERSPECTIVE
Natural (N)	No or negligible modification of in-stream and riparian habitats and biota.	Protected rivers; relatively untouched by human hands; no discharges or impoundments allowed.
Good (G)	Ecosystem essentially in good state; biodiversity largely intact.	Some human-related disturbance, but mostly of low impact potential.
Fair (F)	A few sensitive species may be lost; lower diversity and abundances of biological populations are likely to occur: or sometimes, higher abundances of tolerant or opportunistic species occur.	Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation.
Poor (P)	Habitat diversity and availability have declined; mostly only tolerant species present; species present are often diseased; population dynamics have been disrupted (e.g. biota can no longer reproduce or alien species have invaded the ecosystem).	Often characterized by high human densities or extensive resource exploitation. Management intervention is needed to improve river health, e.g. to restore flow patterns, river habitats or water quality.
Artificial	Transformed to such an extent that their habitat types, biological communities and ecosystem processes bear little or no resemblance to those that would occur under natural conditions.	Modified beyond rehabilitation to anything approaching a natural condition. Example: canalized rivers in urban environments.

1.3 INDICATORS AND ECOSTATUS MODELS USED IN THE RHP

1.3.1 Data collection in the field

As the goal of monitoring for the RHP is state-of-environment reporting, monitoring constitutes rapid monitoring of a large number of sites distributed over a wide area, with the concept of an *ecological indicator* or *indicator species* being fundamental to the monitoring process. Organisms used as indicators of change to the instream environment include fish, birds, macroinvertebrates, protozoa, algae, yeasts, fungi, bacteria, and viruses (Uys et al., 1996; Roux, 2003), with fish and macroinvertebrates being the most common instream indicators. Riparian and instream vegetation is also considered a biological response indicator, although vegetation also forms instream and marginal habitat. The RHP therefore focuses primarily on biological responses as an indicator of ecosystem health, with only a general assessment of the cause-and-effect relationship between *drivers* or *physical indicators*, and *biological responses*. The drivers include the following parameters:

- Flow
- Geomorphology
- Water quality or a physico-chemical assessment
- Habitat integrity assessment if no specific driver information is available

The inclusion of data on these parameters therefore assist with the interpretation of changes seen in the biological indicators. Additional information regarding each index, and the recommended spatial scale and frequency of monitoring (*according to the guidelines of the NRHP*) are shown in Tables 1.2 - 1.4 below.

Table 1.2 Biological and physical indicators used during biomonitoring (Murray, 1999)

ECOSYSTEM COMPONENT	RELEVANCE TO BIOMONITORING
Fish	Fish comprise one of the main biological components of aquatic ecosystems. Because they are relatively long-lived and mobile, they can indicate long-term influences (years) and general habitat conditions in a river reach. They represent a variety of trophic levels and hence integrate effects of environmental changes.
Macroinvertebrates	Invertebrate communities respond relatively quickly to localized conditions in a river, especially water quality, though their existence also depends on habitat diversity. They are common, have a wide range of sensitivities, and have a suitable life-cycle duration that indicate short- to medium-term impacts of water quality.
Riparian vegetation	Healthy riparian zones maintain channel form and serve as important filters for light, nutrients and sediment. Riparian vegetation regulates river flow, improves water quality, provide habitats for faunal species and corridors for their movement, controls river temperatures, provides nutrients and maintains bank stability. Changes in riparian vegetation, structure and function are commonly associated with changes in river flow, exploitation for firewood or changing use of the riparian zone (e.g. grazing or ploughing).
Habitat	Habitat availability and diversity determine aquatic community structure. Habitat degradation adversely affects biological communities.
Flow / Hydrology	Flow conditions in a river affect the distribution and abundance of biota by creating dynamic habitats characterized by current speed, water depth, and (in the longer term) substratum characteristics.
Water quality	Aquatic ecosystems and their biota are affected by turbidity, suspended solids, temperature, pH, salinity, concentrations of dissolved ions, nutrients, oxygen, biocides and trace metals. Changes in these due to pollution, geomorphological or hydrological factors can have detrimental or even lethal effects on aquatic organisms.
Geomorphology	Geomorphological processes determine river channel morphology which provides the physical environment within which stream biota live. Changes to channel form occurs both naturally and as a result of man-made changes to rivers or their catchments (e.g. impoundments, water transfers, agriculture).

Table 1.3 Summary of the main indices, associated ecosystem components and typical spatial scale (Murray, 1999)

INDEX	COMPONENT	SPATIAL SCALE
Biological indicators		
SASS5	Macroinvertebrates	Up to 20 m
FAII	Fish	Homogeneous fish segments, typically kms
RVI / IRVI	Riparian vegetation	10s of metres
Physical indicators		
IHI	Habitat	5 km
IHAS	In-stream habitat (invertebrates)	Up to 20 m
GAI	Geomorphology	10s of metres

Table 1.4 Typical sampling frequencies for various biomonitoring indices (Murray, 1999)

INDEX	FREQUENCY	COMMENTS
SASS5 and IHAS	2-3 times per year	Preferably during dry season, end of dry season, and at end of wet season
FAII	Every 3 years	
RVI / IRVI	Every 3 years	To coincide with fish monitoring
IHI	Every 3-5 years	Depending on rate of developments within the catchment.
GAI	Annually during low flow period	Baseline assessment done initially for all rivers; then after major hydrological events or upstream disturbances such as a forest fire or major change in land use.

1.3.2 EcoStatus models

The endpoint of river health or Ecological Reserve (or compliance) monitoring is to determine the Ecological Status, or EcoStatus, of the river. This process is called Ecological Classification, or EcoClassification. EcoStatus therefore represents an ecologically integrated state representing both the drivers (hydrology, geomorphology, physico-chemical) and biological responses (fish, aquatic macroinvertebrates and riparian vegetation). Once the field data has been collected following the methods of the NRHP-approved indices, i.e. SASS5, FAII and RVI/IRVI, the data is interrogated using the following models, so as to arrive at an integrated EcoStatus:

- Hydrological Driver Assessment Index (HAI): not undertaken during this study
- Geomorphology Driver Assessment Index (GAI)
- Physico-chemical Driver Assessment Index (PAI): not undertaken during this study
- Fish Response Assessment Index (FRAI)
- Macroinvertebrate Response Assessment Index (MIRAI)
- Vegetation Response Assessment Index (VEGRAI): currently in development

1.4 THE EASTERN CAPE RIVER HEALTH PROGRAMME: MTHATHA RIVER

The Mthatha River is the second river to be monitored as part of the Eastern Cape RHP (ECRHP), primarily due to the importance of this system in the section of the Eastern Cape known as the former-Transkei. Note that this report focuses only on river sites. Methods used for data collection were developed for flowing-water systems only, and dams, wetlands, and the Mthatha Estuary were not assessed during this study.

The main objectives of the ECRHP at the initiation of this study were as follows:

- Conduct three monitoring surveys of the Mthatha River using selected indices - March, July and October 2005. Note that an aerial video of the river system was produced as part of the Mthatha River programme. The video was viewed in February 2005 to aid in desktop site selection.
- Assess the habitat integrity of the system through a specialist workshop – December 2005
- Conduct an EcoStatus workshop – January 2006
- Produce a Technical Report for the Mthatha River
- Train DWAF and selected staff of Walter Sisulu University and the University of Fort Hare in biomonitoring methods, so as to produce a functioning and effective team.

This report therefore fulfils the objectives of Task 5, namely the production of a Technical Report for the Mthatha River. The State-of-Rivers report will be produced by the end of 2006.

1.4.1 Biological monitoring of the Mthatha River

Ten sites in nine Assessment Units of the Mthatha River and Cicira and Ngqungqu tributaries were selected for biological monitoring. The catchment and biomonitoring sites are described in Chapter 2 and Appendix 1. The following indices were selected for monitoring – selection was based on importance and available expertise within the Eastern Cape:

- Macroinvertebrates (SASS5) and IHAS – Chapter 3 and Appendix 2
- Fish - Chapter 4 and Appendix 3
- Riparian vegetation – Chapter 5 and Appendix 4
- Geomorphology – Chapter 6 and Appendix 5
- Water quality – Chapter 7

Each chapter will provide background, methods, results, discussion and recommendations for future monitoring. Chapter 8 is a chapter on determining habitat integrity and the interrogation of field data using the EcoStatus models and derivation of EcoStatus per Assessment Unit, with Chapter 9 being the final discussion and conclusion of the report.

CHAPTER 2

THE MTHATHA RIVER CATCHMENT AND STUDY SITES

2.1 GENERAL DESCRIPTION

The Mthatha River catchment lies within the former-Transkei area of the Eastern Cape Province, situated between the Mzimvubu River catchment to the north and the Mbashe River catchment to the south. Three secondary catchments make up the Mthatha River catchment area, namely the Mthatha River catchment (T20), the Mngazi River catchment (T70) and the Xhora River catchment (T80). Together these three secondary catchments have a total catchment area of approximately 5 500 km^2 (DWAF, 2004a).

The Mthatha River has an average natural mean annual runoff (MAR) of 382 million m^3 and is the major river draining the T20 catchment. It is 100 km in length, stretching from its headwaters in the Drakensberg Mountains to the Indian Ocean, north of Coffee Bay. The Mngazi River, in the T70 catchment, has an average natural MAR of 292 million m^3, while the Xhora River (draining the T80 catchment) has an average natural MAR of 152 million m^3.

The Mthatha River has two large tributaries, namely the Cicira River, which enters the Mthatha River below Mthatha Dam, and the Ngqungqu River which is located in the lower catchment.

2.1.1 Climate

The area experiences a temperate to subtropical climate, with rainfall occurring predominantly in summer. Average rainfall is relatively high along the coast (1 000 to 1 300 mm per annum), decreasing towards the interior (700 mm per annum) and finally increasing in the upper catchment areas of the escarpment (up to 1 500 mm per annum).

2.1.2 Geology

The Mthatha River catchment is hilly with deep valleys and incised gorges (Plate 2.1). The dominant geological formations in the region are the Dwyka Foundation and the Beaufort Group. The Dwyka Foundation is fine-grained and compact, and thus forms a poor aquifer, with boreholes yielding less than 0.7 L/s. The Beaufort Group is mostly sandstone, and although the water quality is generally adequate for human consumption, the average yield of boreholes in this rock type is 0.5 L/s (DWAF, 2004a).

2.1.3 Vegetation

Both exotic (due to afforestation in the upper catchment area) and indigenous (in the central and lower catchment areas towards the coast) vegetation occurs in the Mthatha River catchment area. Of the indigenous vegetation, coastal and riparian forests make up 10% of the total area, while inland forests contribute to less than 1% (DWAF, 2004a). The Mthatha River runs through two primary ecoregions, namely the South Eastern Uplands and the Eastern Coastal Belt. Primary vegetation types within these ecoregions consist of Afromontane Forest, Valley Thicket, Eastern Thorn Bushveld, Moist Upland Grassland and Coastal Scarp

Forest (Low and Robelo, 1998). Riparian vegetation in the study area has been heavily impacted by human activities.

Plate 2.1 Mthatha River at Mpindweni showing the gorges and valleys of the lower catchment

2.1.4 Land and water use

Veld and grazing for livestock occupies 70% of the total catchment area, while settlements and subsistence agriculture take up 15%. Approximately 4% of the Mthatha River catchment area is under commercial afforestation, e.g. Langeni plantations. Only 0.05% of the total area is under irrigation, mostly in the Mngazi River catchment (DWAF, 2004a). Land use is shown in Figure 2.1.

Major reservoirs in the Mthatha River catchment are the Mthatha Dam (on the Mthatha River), the Mabeleni Dam (on the Mhlahlane tributary, in the upper catchment of the Mthatha Dam) and the Mhlanga Dam (on the Mhlanga River, a tributary of the Mngazi River). The Mthatha Dam has a catchment area of 886 km^2, with a gross holding capacity of 254 million m^3, yielding 145 million m^3 water per annum (1:50 year). This dam supplies Mthatha and surrounding towns with domestic water, and also serves as storage for the hydropower balancing dams (DWAF, 2004a), although its yield is impacted by alien vegetation upstream of the dam (DWAF, 2004b). Mabeleni and Mhlanga dams have catchment sizes of 10 and 15 km^2, respectively, both yielding less than 2 million m^3 per annum (DWAF, 2004a). The Corona Dam is found on an upstream tributary of the Mthatha River (DWAF, 2001).

Groundwater resources have not been fully developed in the region, but a hydrological map of Queenstown indicates that borehole yields range between 0.5 and 2 L/s throughout the catchment (DWAF, 2004a).

Irrigation, based on water abstraction directly from the rivers using pumping systems, is mainly for subsistence agriculture. The majority of irrigation practices are small-scale, producing mainly vegetables and grain crops. There is a lack of metering for irrigation systems however, resulting in estimates of water requirements for irrigation being inaccurate (DWAF, 2004a). The largest water user in the area is commercial forestry, followed by urban and rural water use (50% for stock-watering) (DWAF, 2004b).

The water quality state of the Mthatha River is very poor, with impacts being raw sewage, wastewater return flows and stormwater runoff from the town of Mthatha and other dense informal settlements downstream. The poor water quality is a major problem in the Mthatha River as communities live alongside the riverbanks, particularly in the region immediately downstream of the city. These communities rely on the Mthatha River as a source of domestic water supply without any form of treatment (DWAF, 2004a).

There are relatively few urban and industrial water users in the Mthatha River catchment, other than forestry-related industries, e.g. the sawmills at Langeni and KwaBhaca (DWAF, 2004b). The primary water requirements are for rural villages and the few small towns that exist, namely Mthatha, Port St. Johns and Mqanduli. There is little urban development in the area with low levels of economic activity (DWAF, 2004b).

Another major user of water on the Mthatha River is ESKOM. ESKOM has two hydro-electricity generation stations at First and Second Falls. Plate 2.2 is a photograph of First Falls Dam taken in March 2005. An average of 170 million m^3 water per annum is utilised, but since the water is returned to the river, this use is non-consumptive (DWAF, 2004a).

Plate 2.2 Hydropower plant at First Falls Dam on the Mthatha River

Hydropower generation generally takes place during the week with a shut down of the turbines over weekends (should Mthatha Dam not be spilling), unless there is a power shortage in the area (DWAF, 2001). Power generation will then be continued without warning or consultation. It was not possible to ascertain the pattern of releases during this study as records were not available and conflicting information was reported. It did however appear as if releases were being made for most of the survey periods, including the weeks preceding field trips (Kama, DWAF Mthatha, pers. comm.).

Hydropower releases are problematic for the ecological functioning of the river systems and particularly the Mthatha Estuary, as freshwater inflows to the estuary are too high and regular.

Additionally, there is one interbasin transfer scheme from the Mngazi River catchment to Port St. Johns in the Mzimvubu River catchment. This scheme transfers approximately 500 m^3 per day. According to DWAF (2004a), the total water requirements (including the environmental requirements) vary from approximately 46% of the MAR for the Mthatha River catchment to 84% in the Mngazi River catchment and 89% in the Xhora River catchment.

2.1.5 Ecological Water Requirements

An Ecological Reserve assessment was conducted for the stretch of the Mthatha River below Mthatha Dam and above the estuary at a Reduced Intermediate Level as part of the Mthatha River Basin Study of 1999-2000 (DWAF, 2001). The study was regarded as incomplete as cross-sectional surveys were not undertaken despite three attempts due to high flows. These high flows were associated with hydropower releases from Mthatha Dam, as well as exceptionally high summer rainfall in 1999-2000 (DWAF, 2001). Ecological surveys were also not completed due to high flows. Two study sites were selected for the Reserve study, i.e. Mthatha Site 1 in quaternary cathment T20E (31º46’54”S, 28º53’6”E) and Mthatha Site 2 (31º55’57”S, 29º08’24”E) in quaternary catchment T20G. The sites were situated above and below the confluence with the Ngqungqu River as this tributary is regarded as a major hydrological input into the system. Information from the study is shown in Table 2.1 below.

Table 2.1 Output of the Ecological Reserve study conducted for the Mthatha River in 2000 (DWAF, 2001)

OUTPUT + INFORMATION	MTHATHA SITE 1	MTHATHA SITE 2
Range of instream habitats	Restricted	Good
Condition of riparian habitat	Degraded	Poor
PES	D/E	C/D
Factors governing PES	Invertebrates: D Fish: E Disrupted flow regime; catchment degradation	Invertebrates: C Fish: C Disrupted flow regime but improved instream condition
Attainable EC	C	C
Long term mean annual Instream Flow Requirement (IFR) as % MAR (DSS model)	13.5%	13.79%

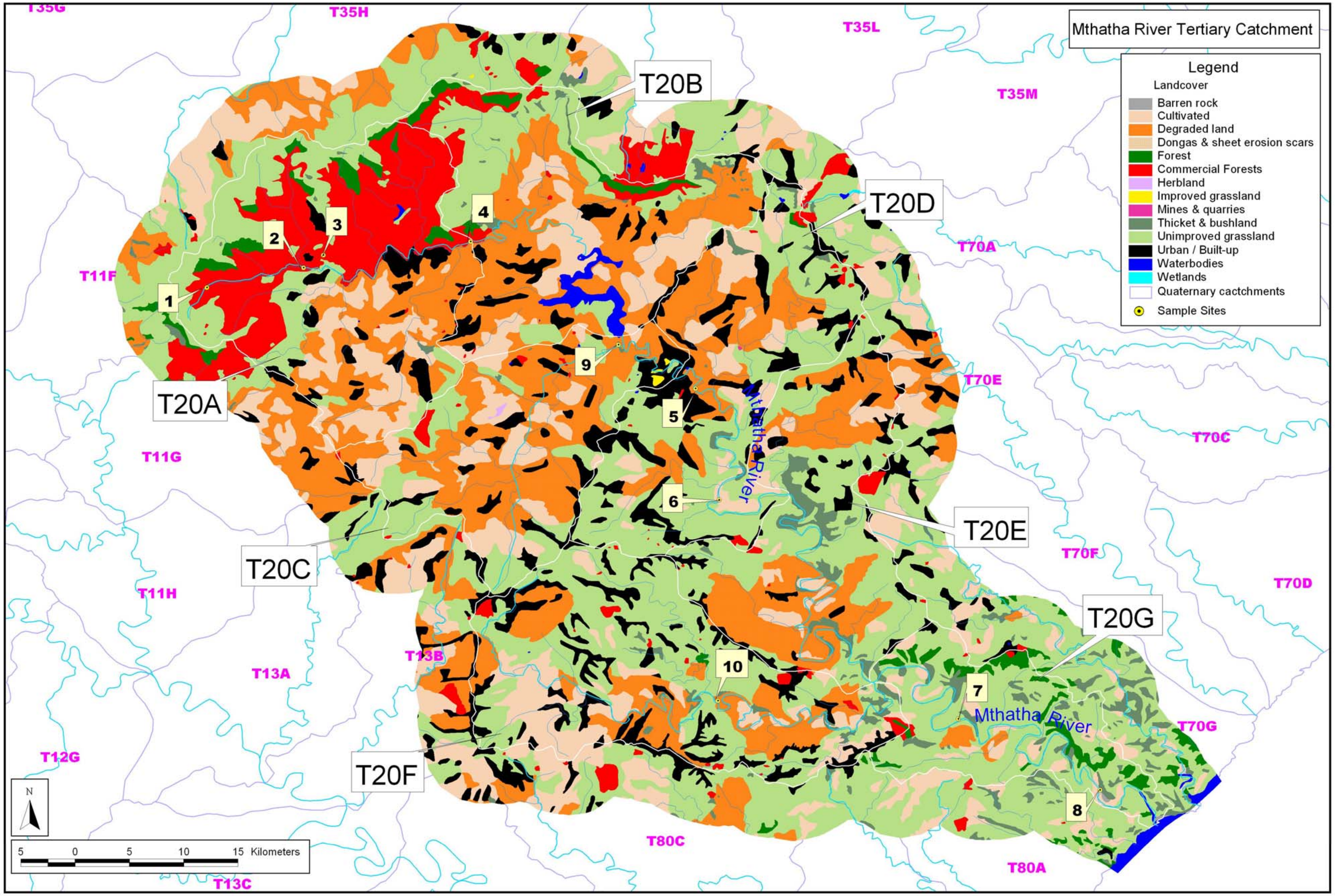

Figure 2.1 Land use in the Mthatha River catchment

The recommendation of the study was the generation of a Reserve assessment for flow management based on the DSS model (now referred to as the Desktop Reserve Model). This recommendation was based on the fact that the flow regime of the Mthatha River downstream of Mthatha Dam precluded the use of Intermediate Reserve methods to relate flows to natural conditions. The assessment should use discharge patterns from the Mthatha Dam and First and Second Falls dams, include the requirements for power generation, the structural limitations of the impoundments for releases, and the difficulties in using "normal" Reserve assessment protocols in this highly modified system (DWAF, 2001).

2.2 SITE SELECTION FOR BIOMONITORING OF THE MTHATHA RIVER

Site selection for monitoring surveys was based on the following information:

- Ecoregion Level II delineation of the catchment, produced by RQS, DWAF (Figure 2.2).

- Aerial video of the catchment and major tributaries flown in March 2004 by Dr Anton Bok and Dr Neels Kleynhans
- Planning workshop and desktop site selection workshop of February 2005 where Assessment Units were selected, i.e. the units for which river health was assessed. These units were selected on the basis of ecoregion and therefore ecological homogeneity, a well as usefulness for management purposes.

2.2.1 Assessment Units and monitoring sites

Table 2.2 is a summary of the delineated reaches, or Assessment Units (AU), for which EcoStatus assessments were conducted. Sites used as indicator sites per AU are also shown on Table 2.2 and Figure 2.2. A photographic record of each site can be seen in Appendix 1.

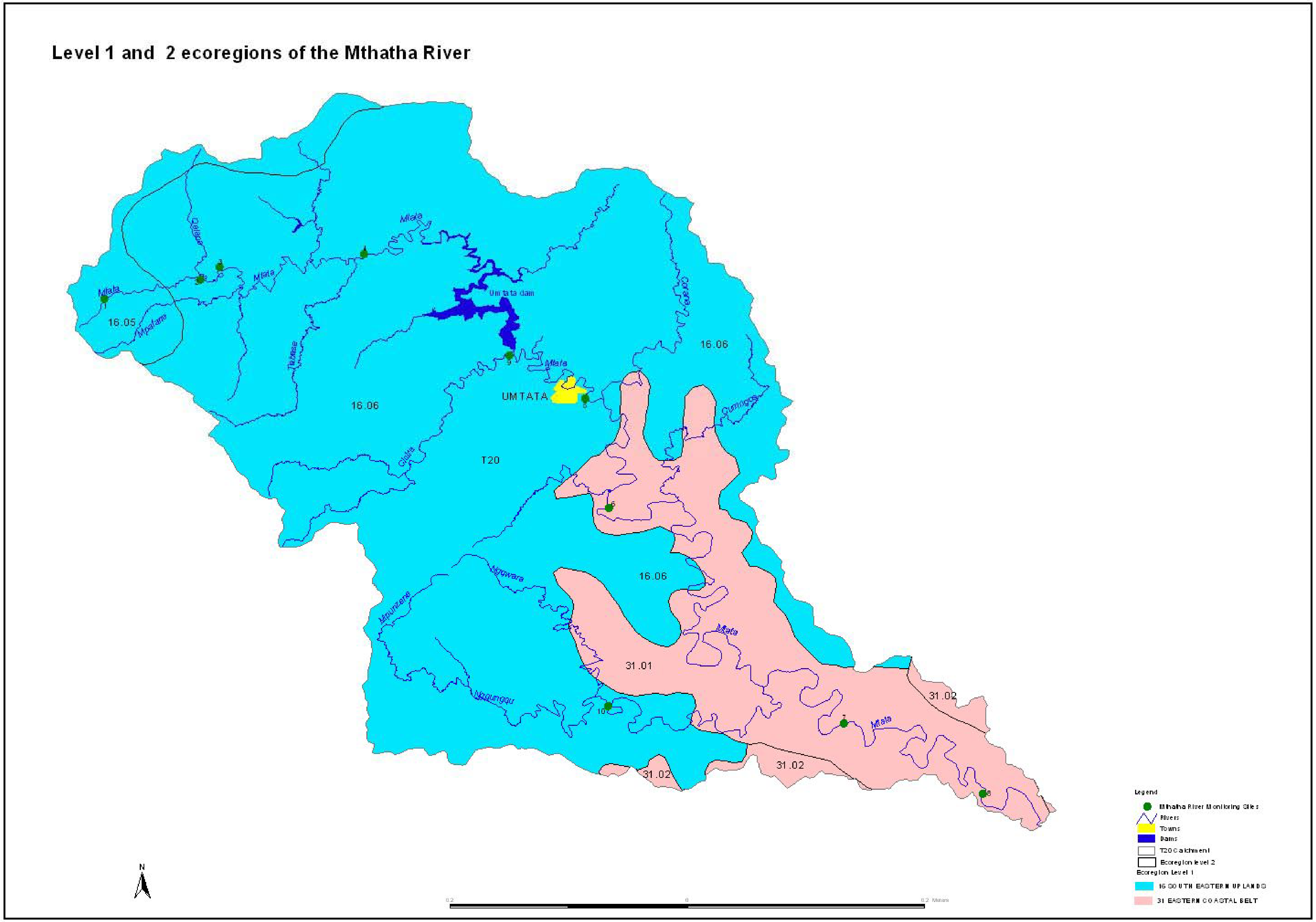

Figure 2.2 Level 1 and 2 ecoregions of the Mthatha River catchment

Table 2.2 Description of AU and associated sites used to describe the EcoStatus for the Mthatha River and major tributaries

ASSESSMENT UNIT	DESCRIPTION OF LOCATION	SITE NUMBER + GPS CO-ORDINATES
1	Upper catchment to the confluence of the Qelana and Mthatha rivers (least impacted site at source of Mthatha River)	1: 31º30’32.5 S; 28º28’47.8 E
2	Below the Qelana tributary to the Langeni sawmills	2: 31º29’34.1S; 28º28’37.0 E (above Langeni sawmills)
3	Langeni sawmills to Mthatha Dam (but excluding Mthatha Dam)	3: 31º28’57.0 S; 28º29’35.8 E (below Langeni sawmills) 4: 31º28’16.6 S; 28º36’54.4 E (Kambi forest)
4	Downstream Mthatha Dam to Mthatha town	no site-specific data; qualitative assessment based on aerial video only
5	Below Mthatha town to First Falls Dam	5: 31º35’35.3 S; 28º48’4.6 E (below Mthatha town)
6	Below First Falls Dam to Ngqungqu River confluence	6: 31º41’07.3 S; 28º49’15.0 E (Takata)
7	Ngqungqu River confluence to Mthatha estuary	7: 31º52’00.2 S; 29º01’07.7 E (Mpindweni) 8: 31º55’32.9 S; 29º08’10.0 E (Mdumbi)
8	Cicira River (joins Mthatha River below Mthatha Dam)	9: 31º33’23.6 S; 28º44’15.1 E
9	Ngqungqu River (tributary in lower part of catchment)	10: 31º51’06.5 S; 28º49’11.5 E

CHAPTER 3

MACROINVERTEBRATES

3.1 INTRODUCTION

Aquatic macroinvertebrates have been successfully used worldwide to assess the biological integrity of riverine ecosystems and are considered to be a good reflection of a river's prevalent environmental water quality (Rosenberg and Resh, 1993).

Chutter (1998) developed the South African Scoring System (SASS) which has become the standard accepted method for rapid assessment for river water quality in South Africa using aquatic macroinvertebrates and is currently in version 5 (Dickens and Graham, 2002), accredited to ISO 18025. In the SASS method, invertebrate taxa are allocated a score between 1 (tolerant) and 15 (sensitive), depending on their known sensitivities to water quality. These scores are added to give a sample score (SASS score) and the number of taxa is used to calculate the Average Score Per Taxon (ASPT). The ASPT provides an indication of the average sensitivity of invertebrates to water quality at a particular site. SASS has been used in most of the River Health Programme (RHP) assessments to date.

The SASS method is now complemented by an additional data assessment step for assessing the integrity of macroinvertebrate communities in rivers, specifically for use in Ecological Water Requirements (EWR) determinations. The Macroinvertebrate Response Assessment Index (MIRAI) is designed to provide insights into the causes and sources of any deviation of a macroinvertebrate community structure from a natural or reference condition to its present ecological state (Kleynhans et al., 2005). Although SASS is a good indicator of water quality, it was not designed to have a strong cause effect basis and instead relies on the Integrated Habitat Assessment System (IHAS) (McMillan, 1998) to interpret SASS results in terms of habitat change. Although the MIRAI was developed specifically for EWR determinations it is recommended for use in RHP assessment too, specifically to provide insights into the causes and sources of any deviation of a macroinvertebrate community from a natural or reference condition and to contribute to the EcoStatus assessment for a site. MIRAI has recently been utilized in the State-of-Rivers Report for the Crocodile (West) Marico Water Management Area (RHP, 2005).

The philosophy behind the development of the MIRAI is based on the theory that under natural conditions, a specific reach of river will support a particular assemblage of species forming a functional community. The species that make up the community are adapted to the prevailing conditions found within the river, or in other words, the life history stages of these aquatic organisms have been formed on a specific habitat template (De Anglelis and Curnutt, 2002). Habitat can be defined as any combination of the following factors: flow regime (velocity and magnitude of flow, and seasonal variations thereof), physical habitat structure (channel form and substrate – cobble, bedrock, vegetation, sand, gravel, mud), physico-chemical water quality (water chemistry, temperature, pH and dissolved oxygen), and biological features (food source, predation, and nutrient and organic inputs from the catchment) (Milhous and Bartholow, 2004). Because a variety of the above-mentioned habitat attributes are required to meet the life history requirements of a species, the success of a species can be limited by a single factor or combination of factors (Hardy, 2000). Thus, a change to one of these factors will lead to changes in community structure through the loss of certain species, providing conditions for the potential increase in abundance of other species and/or the establishment of a range of new species (Kleynhans et al., 2005).

This chapter details, in terms of macroinvertebrate responses, the findings of a study to determine the ecological integrity of the Mthatha River.

3.2 METHODS

3.2.1 SASS

Macroinvertebrates were sampled using SASS5 at each of the selected sites (Chapter 2; Appendix 1) during three seasons (summer, winter and spring) in 2005. Considering SASS5 is designed for low to moderate flows (Dickens and Graham, 2002), and high flows were observed during the summer sampling occasion, results obtained on this occasion should be interpreted accordingly.

At each of the sites, all available biotopes were sampled using the SASS5 collecting protocol (Dickens and Graham, 2002) (Appendix 2, Figure 2-1). In addition, water quality parameters (temperature, pH, dissolved oxygen and conductivity) were measured, and a habitat assessment was undertaken using IHAS (McMillan, 1998) (Appendix 2, Figure 2-2). As ASPT is considered to be the least variable of the SASS5 scores (Dickens and Graham, 2002), it was utilized to determine river health class for each site using default benchmark values (Table 3.1).

Table 3.1 Default benchmark river health class boundaries for SASS5

CLASS BOUNDARY	RANGE OF ASPT SCORES
Natural	7
Good	6
Fair	5
Poor	< 5

Site 1 was chosen as a reference for sites occurring within the South Eastern Uplands Level II Ecoregion, and Site 10 as a reference for sites occurring in the Eastern Coastal Belt Level II Ecoregion (Figure 2.2).

3.2.2 MIRAI

The determination of the Ecological Category (EC) for aquatic invertebrates using the MIRAI is detailed in Kleynhans et al. (2005). Briefly, the index is composed of three different metric groups that measure the deviation of the current invertebrate assemblage from the reference (or expected) assemblage for each Assessment Unit (AU) in terms of:

- Flow modification
- Habitat modification (physical substrate)
- Water quality modification

Within each of these group metrics are a number of other specific metrics. These specific metrics were ranked and weighted according to which metric was considered to be the most important in determining the present state of the invertebrate community. There was a fourth metric designed to assess any changes in the presence and abundance of migratory taxa. This metric was not considered relevant for AUs 1-5, 8 and 9 and was therefore not ranked and left blank during the assessment. Examples of the MIRAI spreadsheets can be found in Appendix D of Kleynhans et al. (2005).

The information needed to complete the metrics was placed in the "Data" sheet of the MIRAI spreadsheet model and included the *abundances* of different invertebrate taxa under natural (reference) conditions, as well as the abundances and *frequency of occurrence* (if data existed – note that this only occurred when there was more than one sampling site within an AU) of the invertebrate taxa currently present. An increase or decrease in abundance and/or frequency of occurrence was seen as an impact or change from natural. Following the MIRAI protocol, the information needed to determine the expected taxa for the Reference Condition (RC) for each AU was either obtained by sampling a reference site within the same ecoregion, utilizing historical data or consulting with macroinvertebrate specialists. As the Mthatha River runs through two Level I ecoregions, i.e. the South Eastern Uplands and Eastern Coastal Belt (Figure 2.2), two reference sites were utilized, i.e. Sites 1 and Site 10 respectively. In addition, reference conditions for AUs 1-3 were also determined using an aquatic biomonitoring report produced for the SINGISI Matiwane plantations based on surveys within the upper catchment of the Mthatha River in July 2004 (Graham, 2005). Lastly, expert knowledge of local macroinvertebrate fauna was used to determine the reference condition for all sites (Thirion, RQS DWAF, pers. comm.). The field-based determination of taxa currently present at each site was undertaken using the standard SASS5 methodology (Dickens and Graham, 2002). The habitat assessments, IHAS and Index of Habitat Integrity (IHI) (Kleynhans, 1999), were consulted when completing the MIRAI spreadsheets.

The three metric groups (flow, habitat and water quality modification) were then combined to derive the Ecological Category (EC) for aquatic invertebrates. For AU6 and AU7 the *connectivity* and *seasonality metric* was included. This is done by ranking the metric groups according to the method described earlier. The model automatically calculated the EC based on a percentage of reference. By investigating the metrics groups (and the metrics they contain) that produced the EC, the impacts most likely to have caused the change in invertebrate community composition were revealed.

No sampling was undertaken in AU4; consequently a river health class for macroinvertebrates for this part of the Mthatha River was not determined.

3.3 RESULTS

In terms of the ASPT score of 7.2 (Table 3.2), it appears that Site 1 was suitably chosen as a reference site for the South Eastern Uplands ecoregion. However, this score should be interpreted with caution as the site was only sampled in spring, and at the time no vegetation biotope was available. The proposed reference site for the Eastern Coastal Belt ecoregion was determined to have ASPT scores of 6.9 in winter and 6.1 in spring, corresponding to a **Good** river health class, suggesting it was not suitable as a designated reference site for the lower Mthatha River (Appendix 2, Table 2-1).

There were marked seasonal variations in SASS score, number of families sampled and ASPT at individual sites (Appendix 2, Table 2-1). This could however be a natural occurrence. Dallas (2004) undertook a study on the variability of macroinvertebrate assemblages at a number of reference sites in the Western Cape, and found significantly different seasonal ASPT scores and number of taxa.

A geometric mean of ASPT scores from each season were used to generate river health classes based on macroinvertebrate assemblages, using Table 3.1, for each of the sites sampled (Table 3.2 – unshaded area). Despite the MIRAI being developed for use in EWR studies, ECs can be converted into river health classes (Table 3.2 – shaded area) using the method detailed in Table 3.3. Consequently, the MIRAI-derived river health classes are discussed and interpreted on a site-by-site basis using the information provided by the IHI, IHAS and ASPT-derived health classes where appropriate.

Table 3.2 A comparison of river health classes per site as determined using ASPT scores, and river health classes per Assessment Unit as determined using the MIRAI

SITE	MEAN ASPT	ASPT DETERMINED RIVER HEALTH CLASS	MIRAI DETERMINED RIVER HEALTH CLASS	ECOLOGICAL CATEGORY	ASSESSMENT UNIT
1	7.2	Natural	Fair	C	1
2	6.6	Good	Good	B	2
3	5.7	Fair	Fair	C	3
4	6.7	Good			
			No sampling site		4
5	3.7	Poor	Fair	D	5
6	5.3	Fair	Fair	C/D	6
7	7.0	Natural	Fair	C	7
8	6.3	Good			
9	4.5	Poor	Fair	C	8
10	6.5	Good	Good	B	9

Table 3.3 Method for converting EC obtained from MIRAI to river health class

EC	EC SCORE	RIVER HEALTH CLASS
A	> 89	Natural
A/B	88-92	Good
B	80-89	
B/C	78-82	
C	60-79	Fair
C/D	58-62	
D	40-59	
E	20-39	Poor
F	< 20	

3.3.1 Assessment Unit 1

The EC for AU1 is a 'C', which equates to a **Fair** river health class. Inspecting the individual metric groups within the MIRAI reveals that the habitat modification metric scored considerably lower than the other two metrics, suggesting habitat alteration is the primary cause of the changes in macroinvertebrate assemblage from the reference condition (Table 3.4). Observations at Site 1 suggest that boulders and rocks may have been introduced into the river bed, and flow modification may be occurring as a result of the surrounding commercial pine forests. However, despite these aspects, the IHI instream was classed as **Natural**, although the IHAS score was only 70.

Assessment Unit 1; incorporates Site 1 on the upper Mthatha River, above the confluence with the Qelana tributary

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
1	70	7.2	Natural	Fair	C	1	Natural

The ASPT determined for Site 1 was 7.2, reflecting a **Natural** health class. This value should be treated with caution, however, as Site 1 was only sampled in Spring, and no vegetation biotope was available (Appendix 2, Table 2-1). Furthermore, the total SASS score was only 101 (Appendix 2, Table 2-1). Thus, although the stones biotope scored a high ASPT of 8.6, suggesting a number of sensitive macroinvertebrate species were present, the lack of vegetation biotope reduces the ecological integrity of this site.

Table 3.4 Breakdown of metric group scores of the MIRAI for AU1

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	79.8	*0.345*	27.5223	1	100
HABITAT	H	66.7	*0.345*	22.9885	1	100
WATER QUALITY	WQ	80.1	*0.310*	24.8669	2	90
CONNECTIVITY & SEASONALITY	CS	80.0	*0.000*	0		0
						290
INVERTEBRATE EC				75.3777		
INVERTEBRATE EC CATEGORY				C		

3.3.2 Assessment Unit 2

The EC for AU2 is a 'B', equating to a river health class of **Good**. The water quality metric group scored the lowest (Table 3.5), mainly impacted by the lower than expected SASS and ASPT scores (Appendix 2, Table 2-1). The ASPT determined river health class for Site 2 is also a **Good**, corresponding well with the MIRAI determined river health class, and the instream IHI.

Assessment Unit 2; incorporates Site 2 on the upper Mthatha River, stretching from the Qelana tributary to the Langeni sawmills

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
2	72	6.6	Good	Good	B	2	Good

A biomonitoring assessment of the Qelana tributary, entering the Mthatha River immeadiately upstream of AU2, revealed water quality problems associated with the Langeni informal settlement and associated village's sewage plant (Graham, 2005). However, these water quality problems appear to have a limited impact at Site 2. Emphemeroptera and Odonata were well represented in samples, but Hemiptera were not as frequently sampled (Appendix 2, Table 2-2).

Table 3.5 Breakdown of metric group scores of the MIRAI for AU2

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	87.3	*0.351*	30.6469	1	100
HABITAT	**H**	83.1	*0.351*	29.1538	1	100
WATER QUALITY	**WQ**	80.5	*0.298*	24.0233	2	85
CONNECTIVITY & SEASONALITY	**CS**	80.0	*0.000*	0		
						285
INVERTEBRATE EC				83.824		
INVERTEBRATE EC CATEGORY				**B**		

3.3.3 Assessment Unit 3

The EC for AU3 is a 'C', equating to a river health class of **Fair**. The water quality metric group again scored the lowest (Table 3.6), mainly impacted by the lower than expected SASS and ASPT scores measured at Sites 3 and 4 (Appendix 2, Table 2-1). Fewer Ephemeroptera, Hemiptera and Coleoptera were sampled at Site 3 compared to Site 4 (Appendix 2, Table 2-2). The ASPT determined river health class for Site 3 was **Fair**, reflecting the impact of Langeni sawmills on water quality. Extensive algal growth on rocks was observed on each sampling occasion, as well as during an independent biomonitoring study undertaken at this site in 2004 (Graham, 2005). By Site 4 the ASPT determined health class had increased to **Good**, reflecting the natural cleaning processes within the river. Despite improved water quality (lack of algae on rocks) at Site 4, the IHAS was slightly lower reflecting evidence of moderate erosion upstream and the absence of vegetation biotope at Site 4 during Spring. The instream IHI class was determined to be **Good**.

Assessment Unit 3; incorporates Sites 3 and 4, stretching from Langeni sawmills to the Mthatha Dam

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
3	63	5.7	Fair	Fair	C	3	Good
4	58	6.7	Good				

Table 3.6 Breakdown of metric group scores of the MIRAI for AU3

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	80.9	*0.345*	27.8835	1	100
HABITAT	H	77.5	*0.345*	26.7241	1	100
WATER QUALITY	WQ	73.7	*0.310*	22.8651	2	90
CONNECTIVITY & SEASONALITY	CS	80.0	*0.000*	0		
						290
INVERTEBRATE EC				77.4727		
INVERTEBRATE EC CATEGORY				C		

3.3.4 Assessment Unit 5

The EC for AU5 is a 'D', equating to a river health class of **Fair**. Although all metric groups within the MIRAI were low scoring, the water quality metric scored particularly low (Table 3.7). The poor macroinvertebrate assemblage sampled at Site 5 was the main contributing factor to the low scores within the water quality metric (Appendix 2, Table 2-1). Only a few hardy taxa were sampled (Appendix 2, Table 2-2), reflecting the poor water quality associated with Mthatha town and sewage works. There was a strong sewage odour present when sampling was undertaken, and the rocks present were covered with a slimy silt layer.

Assessment Unit 5; incorporates Site 5, stretching from below Mthatha town to First Falls Dam

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
5	62	3.7	Poor	Fair	D	5	Fair

The main impact on flow modification metric was the regulated releases from Mthatha Dam for hydroelectric scheme at First Falls Dam. The lack of suitable habitat, particularly cobbles and boulders and to a lesser extent gravel, sand and mud impacted on the habitat metric score. In general however, although the water quality was highly impacted, the physical habitat available within the river reflected the **Fair** health class.

The ASPT determined health class was **Poor**, reflecting the tendency of the SASS5 protocol to assess the sensitivities of macroinvertebrates to water quality conditions, while focusing less on any flow or habitat modifications.

Table 3.7 Breakdown of metric group scores of the MIRAI for AU5

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	56.3	*0.345*	19.4105	1	100
HABITAT	**H**	50.8	*0.345*	17.5108	1	100
WATER QUALITY	**WQ**	26.6	*0.310*	8.24019	2	90
CONNECTIVITY & SEASONALITY	**CS**	80.0	*0.000*	0		
						290
INVERTEBRATE EC				45.1614		
INVERTEBRATE EC CATEGORY				**D**		

3.3.5 Assessment Unit 6

The EC for AU6 is a 'C/D', equating to a river health class of **Fair**, corresponding well with the ASPT determined river health class of **Fair**. The water quality metric was the lowest scored, suggesting impacts from Mthatha town are still affecting the macroinvertebrate assemblage (Table 3.8). Only a few families within each of the orders were sampled (Appendix 2, Table 2-2). Habitat modification also appears to be a significant contributing factor with fewer taxa associated with cobbles, and gravel, sand and mud being sampled compared to those expected for the reference condition. The instream IHI was classed as **Fair** with one of the main impacts identified being bed modification. This was supported by observations of erosion within the AU. Flow modification is still an affect within this AU, and was identified as a major impact within the instream IHI assessment.

Assessment Unit 6; incorporates Site 6, stretching from below First Falls Dam to the confluence with the Ngqungqu River

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
6	66	5.3	Fair	Fair	C/D	6	Fair

The connectivity and seasonality metric was used in the assessment of this AU (Table 3.8), as the migratory swimming prawn was listed as an expected taxa within the reference condition, albeit in small numbers. None were sampled however.

Table 3.8 Breakdown of metric group scores of the MIRAI for AU6

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	65.5	*0.313*	20.4637	1	100
HABITAT	**H**	52.8	*0.313*	16.4885	1	100
WATER QUALITY	**WQ**	48.7	*0.313*	15.2299	1	100
CONNECTIVITY & SEASONALITY	**CS**	90.0	*0.063*	5.625	2	20
						320
INVERTEBRATE EC				57.8071		
INVERTEBRATE EC CATEGORY				**D**		

3.3.6 Assessment Unit 7

The EC for AU7 is a 'C', equating to a river health class of **Fair**. This is considerably lower than the ASPT determined health classes of **Natural** and **Good** determined for Sites 7 and 8. However, Site 7 was not sampled in summer due to high flows, and the gravel, sand and mud biotope was unavailable in spring due to high flows, consequently the health class of **Natural** should be interpreted with caution. Furthermore, in the case of both sites, total SASS scores were fairly low (Appendix 2, Table 2-1), as were the number of taxa sampled, suggesting that although there were a number of sensitive taxa present, a number of expected taxa were not sampled. Families from the orders Odonata, Hemiptera and Coleoptera were poorly represented (Appendix 2, Table 2-2).

Assessment Unit 7; incorporates Sites 7 and 8, stretching from below the confluence with the Ngqungqu River to the estuary

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
7	68	7.0	Natural	Fair	C	7	Good
8	74	6.3	Good				

It is difficult to identify possible negative impacts within this AU, as the instream IHI was classed **Good**, and reasonably high IHAS score was determined. There appear to be few impacts from settlements and the effect of flow modification from First Falls Dam should have dissipated. In addition, the input from the Ngqungqu tributary should have improved water quality.

The connectivity and seasonality metric was again used in assessment of this AU (Table 3.9) as the migratory swimming prawn was listed as an expected taxa within the reference condition. The high score reflects that individuals were sampled in summer at Site 8 (Appendix 2, Table 2-2).

Table 3.9 Breakdown of metric group scores of the MIRAI for AU7

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	70.5	*0.313*	22.017	1	100
HABITAT	**H**	70.6	*0.313*	22.0644	1	100
WATER QUALITY	**WQ**	66.5	*0.313*	20.7708	1	100
CONNECTIVITY & SEASONALITY	**CS**	95.0	*0.063*	5.9375	2	20
						320
INVERTEBRATE EC				70.7898		
INVERTEBRATE EC CATEGORY				C		

3.3.7 Assessment Unit 8

The EC for AU8 is a 'C', equating to a river health class of **Fair**. The water quality metric scored considerably lower than either flow modification or habitat, affected mainly by the low SASS and ASPT scores compared to the expected reference condition (Table 3.10). The low SASS score and fairly high number of taxa sampled suggests that few sensitive taxa inhabit this river and instead a greater proliferation of tolerant taxa dominate (Appendix 2, Table 2-1). Table 2-2 of Appendix 2 reveals that no single order was absent, but only a few families from each order were sampled.

Assessment Unit 8; incorporates Site 9 on the Cicira River, a tributary entering the Mthatha River within AU4

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
9	67	4.5	Poor	Fair	C	8	Fair

The poor water quality is reflected in the ASPT determined river health class which scored a **Poor**. There was extensive algal growth on the rocks and the river was inundated with litter and solid waste. Although water quality in this AU is significantly affected by surrounding informal settlements, the habitat structure and flow regime of this river remains intact, reflected in the **Fair** instream IHI, and the IHAS score of 67.

Table 3.10 Breakdown of metric group scores of the MIRAI for AU8

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	78.3	*0.357*	27.9661	1	100
HABITAT	**H**	71.6	*0.357*	25.576	1	100
WATER QUALITY	**WQ**	46.0	*0.286*	13.1467	2	80
CONNECTIVITY & SEASONALITY	**CS**	80.0	*0.000*	0		0
						280
INVERTEBRATE EC				66.6889		
INVERTEBRATE EC CATEGORY				C		

3.3.8 Assessment Unit 9

The EC for AU is a 'B', equating to a river health class of **Good**. This corresponds well with the ASPT derived river health class. The water quality metric scored lowest (Table 3.11), again affected by the lower than expected SASS and ASPT scores at Site 10 (Appendix 2, Table 2-1), suggesting some sensitive species were missing. No order was unrepresented, with a number of families sampled within each order (Appendix 2, Table 2-2). The low SASS score could be ascribed to the limited vegetation available for sampling at Site 10.

No obvious land use was observed negatively impacting Site 10, which is reflected in the instream IHI classed as **Natural**, and the IHAS score of 75.

Assessment Unit 9; incorporates Site 10 on the Ngqungqu River, a tributary entering the Mthatha River between AU6 and AU7

Site	Mean IHAS	Mean ASPT	ASPT determined river health class	MIRAI determined river health class	EC	AU	IHI instream
10	75	6.5	Good	Good	B	9	Nautral

Table 3.11 Breakdown of metric group scores of the MIRAI for AU9

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	88.4	*0.351*	31.0307	1	100
HABITAT	**H**	88.7	*0.351*	31.1111	1	100
WATER QUALITY	**WQ**	79.1	*0.298*	23.6012	2	85
CONNECTIVITY & SEASONALITY	**CS**	80.0	*0.000*	0		0
						285
INVERTEBRATE EC				85.743		
INVERTEBRATE EC CATEGORY				**B**		

3.4 CONCLUSIONS AND RECOMMENDATIONS

The MIRAI was used to assess changes in the macroinvertebrate assemblage for 7 Assessment Units along the length of the Mthatha River, and for one AU on each of the Cicira and Ngqungqu tributaries.

Generally, the macroinvertebrate assemblages of the Mthatha River indicate that the river is in a **Fair** to **Good** condition. Habitat alteration is a concern within the upper catchment (manipulation of the river substrate) and for some distance below Mthatha town (mainly caused by the high silt loads). Flow modification (releases from Mthatha Dam for hydropower generation at First Falls Dam) impacts the river downstream of Mthatha town, however this effect is ameliorated by AU7. Water quality is compromised locally within AU3 immediately below the Langeni saw mill, extensively within AU5 by activities associated with Mthatha town and the sewage works, and improves slowly down the length of the river to the estuary. The water quality within the Cicira tributary is extensively affected by surrounding settlements.

The MIRAI provides useful insight into the possible causes of the modifications to macroinvertebrate assemblages and should be encouraged for further RHP assessments. However, this method relies on good information concerning instream habitat within AUs, which can only be effectively gathered by spending more time at each of the biomonitoring sites than is presently allocated for SASS sampling. Thus, an extra 0.5-1 hour spent assessing available instream habitat will greatly improve understanding of the impacts affecting the riverine biota.

The poor water quality situation associated with the Langeni saw mill warrants further investigation to determine the exact sources of pollution. The very poor water quality downstream of Mthatha town should be addressed as the impact on the aquatic invertebrates is extensive and continues a considerable distance downstream. General land management within the catchment should be assessed in order to identify the sources of the high silt loads within the river, and actions initiated to address this issue. The poor water quality within the Cicira River also warrants further investigation and improved management.

CHAPTER 4

ASSESSMENT OF FISH ASSEMBLAGE INTEGRITY

4.1 INTRODUCTION

The hydrology of the Mthatha River system has been modified by the construction of at least 2 dams along its length; including the Mthatha Dam upstream of the town of Mthatha, and the First Falls Dam from which water is released daily (during large parts of the year) for power generation (Collins, ESKOM, pers. comm.). The ichthyofauna of this system, like that of other systems in the Eastern Cape, were not of primary consideration in the planning of these developments and it can be expected that the dams have impacted negatively on fish movements and habitat availability. Furthermore, through the introduction of alien angling fish species in the Eastern Cape in the 1950s by agencies such as the trout hatchery at Pirie (on the upper Buffalo system), many alien species were established. Trout and other predaceous angling species such as bass continue to have had a marked effect on indigenous fish species today (Jackson, 1982).

The integrity and composition of the native fish assemblage found within the Mthatha River has been used as one of the biological indicator groups, which together with macroinvertebrates and riparian vegetation, were used to assess the biological integrity of the river system as a whole. As part of the River Health Programme, indices were originally developed for each of these groups (Uys et al., 1996). The assemblage health of fish was measured using the Fish Assemblage Integrity Index (FAII), which utilized the available and measurable fish assemblage parameters as judged sensitive to human-induced environmental impacts (Kleynhans, 1999). However, the fish assemblage class ratings, derived for RHP, highlighted potential problems with the FAII index itself. FAII was found to underestimate fish assemblage integrity at sites (Chapter 4 of Buffalo River Technical Report; CES, 2004) due to the following factors:

- The paucity or non existence of historical data
- The reliance on expert knowledge to construct a likely fish assemblage. Here the derived assemblage in turn has the potential to inflate the expected catch, thereby reducing the realized FAII score.
- Also problematic were the low species diversities found in the former-Transkei rivers, a characteristic not compatible with the FAII index as it does not effectively assess the fish assemblage integrity under low species diversity scenarios.

Although the Fish Response Assessment Index (FRAI) (Kleynhans et al., 2005) utilizes the same information base as FAII, it further explores details of the habitat drivers of fish assemblages on a cause-effect basis. FRAI therefore has the potential to provide fuller estimates of fish assemblage integrity in areas of low species diversity and determine the factors responsible for the deviation of the fish assemblage from reference condition. This contrasts with FAII's broad or synoptic assessment requirements aimed at the RHP, which were not particularly strong on cause-effect interpretations (Kleynhans et al., 2005).

4.2 MATERIAL AND METHODS

4.2.1 Study sites and sampling regime

Ten study sites were selected that categorised and explored the Mthatha tertiary catchment – see Chapter 2 and Appendix 1 for more detail on the study sites and Assessment Units.

Sampling was undertaken both upstream and downstream of each study site identified for biomonitoring. Due to time constraints, this generally entailed fishing a single site per habitat segment and only one site per habitat. Sampling was conducted over three surveys; Survey 1-March 2005, Survey 2-July 2005 and Survey 3-October 2005. Results from all three surveys were combined for the fish assessment. Fish caught were preserved in 10% formalin in the field and transported back for identification and cataloguing at the South African Institute for Aquatic Biodiversity (SAIAB) in Grahamstown. Specimen identification was confirmed by resident experts. Fish specimens have been transferred into 60% propanol for storage.

4.2.2 Equipment

Fish sampling was undertaken primarily using an electroshocker (SAMUS - 725G; 650 watts of output power), as well as a small seine net (5m by 1.5m, mesh size of approximately 0.5cm). The seine was only utilized where seineable conditions prevailed, as most sites were often rocky and debris-littered which limited seine use. The use of larger seine nets was attempted, but was not successful due to the rocky nature of the river system. Water quality parameters were recorded (see Chapter 7).

4.2.3 Data analysis

Fish Assemblage Integrity Index (FAII)
The FAII index is the recognised method of assessing fish assemblage integrity for the River Health Programme, which has been revised and modified as the programme has developed. Limitations identified resulted in alternate methods of analysis being compared for the Buffalo River (CES, 2004), but the FAII protocol (Kleynhans, 1999) remained the input data source for this study (see Appendix 3, Figure 3-1, for an example of an FAII datasheet). These results were then used in the ecosystem determination protocol of river ecoclassification for fish, known as the FRAI (Fish Response Assessment Index) (Kleynhans et al., 2005).

The calculation of the FRAI
The components requirements for the calculation of the FRAI include the following (Kleynhans et al., 2005):

- Running the Fish Intolerance and Habitat Preference Database
- Analysing metrics as nested within metric groups
- Exploring the potential interaction of these metric groups, effectively the drivers, on the resultant fish assemblage

This process is fine-tuned through experts or field ecologists who rate and weigh the effective levels of metric groups or drivers. Ultimately the integration of the individual metric group assessments into an overall index value, is the EC that represents the fish assemblage at any river delineation.

Ecostatus determination using fish assemblages
The fish assessment forms part of the ecoclassification of the river where the determination of the Present Ecological State (PES; health or integrity) of the different biophysical attributes of the rivers are compared to the natural/close to natural reference conditions (Kleynhans et al., 2005). In this process the state of the river is appraised in terms of its measurable biophysical components. The drivers are the physico-chemical, geomorphological and hydrological state, which together underpin the habitat template (Southwood, 1977). It is the habitat template itself that catalyses the biological responses of target organisms such as fish, riparian vegetation or aquatic invertebrates. The fish ecostatus, or EC as defined by the fish assemblages present in each Assessment Unit, is therefore measured through the use of the Fish Response Assessment Index protocols (FRAI).

4.3 RESULTS

The Mtahtha River has not been extensively sampled to date (Skelton, 2001) and thus this survey is one of the only collections catalogued in the national fish collection at SAIAB. Only 13 species were recorded during this study, which included 9 indigenous and 4 aliens species (Table 4.1). Aliens included two introduced North American species, the Rainbow Trout *Oncorhychus mykiss* and the Smallmouth Bass *Micropterus dolomieu*, and two indigenous but translocated species, i.e. the Sharptooth Catfish *Clarius gariepinus* and the Banded Tilapia *Tilapia sparrmanii.* Of the indigenous species 6 have marine/estuarine origins, and only 3 are primarily freshwater species, of which only *Barbus anoplus* occurred originally.

Present day species reflect a marine oribion with marine/estuarine related species making up 46% of the catch. Of interest was the record of the Baldy, *Caffrogobius natalensis,* previously known as *Gobius melancophephalus,* an indo-pacific species that was recorded at Mpindweni (Site 7). It is considered rare in our seas having been recorded as far south as Durban (Smith, 1977). Another marine/estuarine species sampled the lowest site was the widespread pipefish *Syngnathus temmincki,,* previously *Syngnathus acus* (Mwale, unpublished thesis). The other 4 estuarine-related species included the Flathead Mullet *Mugil cephalus,* the Freshwater Mullet *Myxus capensis,* the Cape Mooney *Monodactylus falciformis*te, and the ubiquitous Longfin Eel *Anguilla mossambica*.

Table 4.1 Fish species recorded in the Mthatha River system during the River Health Programme surveys

SPECIES NAME	COMMON NAME	INDIGENOUS (I) OR ALIEN (A)	INDIGENOUS MARINE (M) /FRESHWATER (F) RELATED SPP
Anguilla mossambica	Longfin Eels	I	M /F
Barbus anoplus	Chubbyhead Barb	I	F
Caffrogobius natalensis	Baldy	I	M
Clarius gariepinus	Sharptooth Catfish	A	-
Glossogobius callidus	River Goby	I	F
Micropterus dolomieu	Smallmouth Bass	A	-
Monodactylus falciformis	Cape Moony	I	M
Mugil cephalus	Flathead Mullet	I	M
Myxus capensis	Freshwater Mullet	I	M
Oncorhychus mykiss	Rainbow Trout	A	-
Oreochromis mossambicus	Mozambique Tilapia	I	F
Tilapia sparrmanii	Banded Tilapia	A	-
Sygnathus temmincki	Pipefish	I	M

The only primarily freshwater fish in the system was *Barbus anoplus*, highlighting what is know by ichthyologists as the "Transkei Gap" as referenced in Bok (2002). This highlights the naturally low numbers of freshwater fish encountered in the well-watered hinterland of eastern South Africa, the former-Transkei, probably due to biogeographical factors and the evolutionary history of South Africa. It appears that there are a number of undescribed species related to *Barbus anoplus* that have been collected in this area (Bok, 2002). These form part of a PhD thesis currently underway by Luis da Costa through SAIAB, insights of which may prove invaluable to DWAF efforts in the region.

In the final EC assessment process the fish sampled were grouped by sites within defined Assessment Units (Tables 2.2 and 4.2). AUs 1-7 trace the Mthatha River from headwater to estuary, while AU8 and AU9 represent the Cicira and Nqgunqgu tributaries respectively. Note that no records are present for AU4 as surveys could not be undertaken in this AU due to inaccessibility. The results of the FRAI assessment are discussed below; sheets per AU can be found in the tables of Appendix 3.

Table 4.2 Fishes as recorded at field sites during the Mthatha River RHP surveys of 2005, and grouped within Assessment Units

FISH SPECIES RECORDED IN MTHATHA RIVER SURVEYS	**ASSESSMENT UNITS & FIELD STATIONS SURVEYED WITHIN THE MTHATHA RIVER SYSTEM**										
	AUs	**AU1**	**AU2**	**AU3**		**AU4**	**AU5**	**AU6**	**AU7**		**AU8**	**AU9**
SPECIES	**SITES**	**1**	**2**	**3**	**4**		**5**	**6**	**7**	**8**	**9**	**10**
Anguilla mossambica										*		*
Barbus anoplus								*				*
Caffrogobius natalensis										*		
Clarius gariepinus							*	*		*	*	
Glossogobius callidus									*	*		
Micropterus dolomieu			*	*	*							
Monodactylus falciformis										*		
Mugil cephalus										*		
Myxus capensis										*		
Oncorhynchus mykiss			*									
Oreochromis mossambicus										*	*	
Tilapia sparrmanii							*	*		*	*	*
Sygnathus temmincki										*		

The FRAI percentage, Ecological Category and corresponding river health class is summarised for all Assessment Units in Table 4.3.

Table 4.3 FRAI percentage, EC and corresponding River Health Class based on fish assemblages for AUs of the Mthatha River system

INDICATORS	**ASSESSMENT UNITS**								
	AU1	**AU2**	**AU3**	**AU4**	**AU5**	**AU6**	**AU7**	**AU8**	**AU9**
FRAI %	43.10	41.18	32.20	43.10	30.36	75.14	88.77	36.81	72.82
EC: FRAI	D	D	E	D	E	C	B	E	C
River Health Class	**Fair**	**Fair**	**Poor**	**Fair**	**Poor**	**Fair**	**Good**	**Poor**	**Fair**

River health class within the upper AUs (1-2) is **Fair** dropping to **Poor** at AU3, i.e. the unit above Mthatha Dam. AU4 was assessed to be **Fair** (based on video only), but conditions in AU5 are **Poor** due to the influence of the developments in the environs of Mthatha town. From here the state of the river is seen to improve from **Fair** (AU6) to **Good** (AU7). Likewise the tributary close to Mthatha town at AU8 (Cicira River) was classed as **Poor** while the rural Nqgunqgu River (AU9) was rated as **Fair**.

Section 4.3.1 shows some detail of the fish results per AU.

4.3.1 Summary of fish sampling effort per AU

AU1: EC D / Fair
No fish were sampled at this site. This seems surprising especially as the fish habitat appears ideal. *Barbus anoplus* is the most likely species lost due to alien introductions downstream. Trout scales were found on the bank suggesting that trout may well be present in the stream.

AU2: EC D / Fair
Likewise this AU had good cover and flow ratings. Unfortunately the only fish sampled were the highly predaceous Smallmouth Bass *Micropterus dolomie* and the Rainbow Trout *Oncorhynchus mykiss.* Again *Barbus anoplus* was unexpectedly absent.

AU3: EC E / Poor
This AU upstream of the Mthatha Dam, showed reduced velocity and cover metric groups, with Instream sediment deposition. As at the upstream sections, no indigenous fish species were recorded, with only *Micropterus dolomieu* present sheltering in the rocky runs and with numerous young in backwaters revealing active breeding.

AU5: EC E / Poor
This unit directly below Mthatha town to First Falls Dam was assessed as **Poor** due to reduced water quality and cover availability. Both species collected, i.e. the predaceous *Clarius* gariepinus and the omnivorous *Tilapia sparrmanii*, are aliens to the system originating from other catchments in South Africa.

AU6: EC C / Fair
This unit has again resets itself downstream of First Falls Dam to the Nqgunqgu River confluence. The first indigenous fish, *Barbus anoplus*, is recorded as well as regional aliens *Clarius gariepinus* and *Tilapia sparrmanii.* Cover is reduced due to inputs of excessive sediment into the channel and habitat are further reduced due to flushing flows from daily water release from First Falls Dam.

AU7: EC B / Good
This Assessment Unit, stretching from the Ngqungqu River confluence to above the estuary at Mdumbi, was categorised as **Good** and the best stretch of the river seen. Some records were unusual, e.g. *Caffogobius natalensis* and *Syngnathus temmincki*. The two species alien to the system, *Tilapia sparrmanii* and *Clarius gariepinus*, were recorded but *Barbus anoplus,* the catchment's only indigenous species was not, probably related to its cool water requirements. Many of the remaining species showed a marine origin, e.g. *Glossogobius callidus and Oreochromis mossambicus*, or an estuarine affiliation namely, *Anguilla mossambica, Monodactylus falciformis, Mugil cephalus* and *Myxus capensis.*

AU8: EC E / Poor
As with AU5, this AU was impacted by the development of Mthatha town with poor habitat and water quality conditions evident. All three fish species sampled, i.e. *Clarius gariepinus* and the cichlids *Oreochromis mossambicus* and *Tilapia sparrmanii*, are alien to the system if indigenous to South Africa.

AU9: EC C / Fair
This Assessment Unit, on the largest tributary of the Mthatha River, was categorized as **Fair** and still records the only indigenous species in the catchment to date, i.e. *Barbus anoplus.*

The Banded Tilapia *Tilapia sparrmanii* and the Longfin Eel *Anguilla mossambica* were also recorded.

4.4 CONCLUSIONS AND RECOMMENDATIONS

The ecological status of the Mthatha River was assessed as **Fair** to **Good** despite the low fish diversity in this river system. This low diversity is reflective of the region's biogeographic isolation and development and is commonly termed the "Transkei Gap" as quoted in Bok (2002).

Barbus anoplus is an indigenous and widespread South African cool water minnow, which is still found in many streams draining the former-Transkei. Although displaced in reaches due to the invasion of alien trout and bass, this species or group may prove to be a useful biomonitoring indicator organism. A number of collections have been made locally and regionally (Bok, 2002), but some disparity still remains as to whether there are a number of distinct taxa closely related to *Barbus anoplus*, or whether all collections are a single species. The distribution and evolutionary history of this species or species group is currently being researched by Luis da Costa through SAIAB for his PhD. This study will assist in understanding the life-history of the *Barbus* species and develop the basis for future monitoring using *Barbus anoplus* as an indictor species.

The following recommendations can be made for future biological monitoring using fish assemblages and future management strategies:

- Focussed regional fish collections from the cooler water sub-catchments would add support to current studies focused on developing an understanding of the ichthyology of former-Transkei rivers and thus filling the Transkei data gap.
- Implement controls to stop the spread of alien fish species in the region's rivers, especially the predaceous species. The FRAI model input spreadsheets shown below for AU3 (as an example) demonstrate the impact of alien fish species (and the presence of dams) on the fish assessment and overall EC for this Assessment Unit. Metric scoring relates to the following Ecological Categories under the following conditions:

  - A (**Natural**): when the river is not dammed or populated with alien fish species

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	32.43	3	60
COVER METRICS	100.00	40.54	2	75
FLOW MODIFICATION METRICS	100.00	5.41	5	10
MIGRATION METRICS	100.00	0.00	4	0
PHYSICO-CHEMICAL METRICS	90.00	19.46	4	40
IMPACT OF INTRODUCED SPP (NEGATIVE)	0.00	0.00	1	0
	5.00			185.00
FRAI (%)			97.84	
EC: FRAI			A	
BOUNDARY EC				

- B (**Good**): when the river is well dammed but remains free of alien fish species

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	26.67	3	60
COVER METRICS	100.00	33.33	2	75
FLOW MODIFICATION METRICS	100.00	4.44	5	10
MIGRATION METRICS	15.00	2.67	4	40
PHYSICO-CHEMICAL METRICS	90.00	16.00	4	40
IMPACT OF INTRODUCED SPP (NEGATIVE)	0.00	0.00	1	0
	5.00			225.00
FRAI (%)			83.11	
EC: FRAI			B	
BOUNDARY EC				

- E (**Poor**); present state of the AU: where the effects of both alien fish and dams together reduce the EC

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	21.05	3	60
COVER METRICS	100.00	26.32	2	75
FLOW MODIFICATION METRICS	100.00	3.51	5	10
MIGRATION METRICS	100.00	0.00	4	0
PHYSICO-CHEMICAL METRICS	90.00	12.63	4	40
IMPACT OF INTRODUCED SPP (NEGATIVE)	82.35	-28.90	1	100
	6.00			285.00
FRAI (%)			34.61	
EC: FRAI			E	
BOUNDARY EC				

- Control measures should therefore be put in place to prevent alien fish species moving into rivers in the region. The impact of alien fish populations can however only be seen through gaps in present day distributions. Management measures could include conservation initiatives grounded on a clear understanding of remnant genetically identifiable populations, e.g. through the work currently taking place around the genetics of the *Barbus anoplus* fish complex.

CHAPTER 5

RIPARIAN VEGETATION ASSESSMENT

5.1 INTRODUCTION

Riparian vegetation is the flora which occurs in the riparian zone near to, or on the banks of, rivers and streams. Riparian zones are those areas which are influenced by the river. They are often visually distinguishable from areas further away from the river or stream by virtue of their different physical appearance and vegetation composition. Riparian vegetation is often specifically adapted to the mesic zones and occasional periods of inundation that occur in the riparian area, as well as the specific soil and microclimate conditions associated with rivers. It is usually characterized by having a higher biodiversity, both in terms of flora and fauna, than that of surrounding areas and is important in the ecological functioning of rivers.

A functional riparian zone consists of structurally intact indigenous vegetation which improves water quality by trapping sediment and reducing erosion and the suspended sediment load carried in the water. It offers resistance to high flows and reduces the impact of floods through attenuation. In terms of fauna, it provides essential habitat to species which are often very specific to the riparian zone, and contributes to in-channel habitats for organisms through its influences on river morphology and nutrient cycling. It also provides a migratory corridor for those species which do not necessarily function only in riparian zones. These migratory corridors are particularly important where the river runs through, or near to, residential or other built-up areas (Kemper, 2001; Kotze et al., 1997).

Intact riparian areas are a source of direct social benefits in terms of recreational use and use of natural resources for food, fuel and medicine. However, these areas are also favoured for agriculture and often become degraded due to unsustainable land use and other anthropogenic influences. As the health of the riparian vegetation has a direct impact on river health, it is beneficial for biomonitoring programmes to assess riparian vegetation concurrently with other indicators such as habitat integrity, fish and aquatic invertebrates. Once the status quo for riparian vegetation is established, steps for the appropriate management of anthropogenic influences on riparian vegetation can be taken.

The Mthatha River lies within two Level I ecoregions, namely the South Eastern Uplands and the Eastern Coastal Belt. Primary vegetation types within these ecoregions consist of Afromontane Forest, Valley Thicket, Eastern Thorn Bushveld, Moist Upland Grassland and Coastal Scarp Forest (Low and Rebelo, 1998). Riparian vegetation in the study area has been heavily impacted by human activities. The land use map (Figure 2.1) indicates that most of the upper regions (Sites 1-4) lie within areas of commercial forestry. In the middle reaches riparian vegetation has been transformed by urban and peri-urban activities and falls under the description of degraded land. Along other areas of the Mthatha River riparian vegetation is described as unimproved grassland, cultivated land or degraded land.

5.2 MATERIALS AND METHODS

5.2.1 Sampling sites and Assessment Units

Sampling was undertaken at 10 sites along the length of the Mthatha River, which were chosen for biomonitoring purposes because of the variety of habitat types they represented as well as other factors such as accessibility and compatibility for sampling by other specialist fields. The position of sites are shown in Chapter 2.

Sites 1-4 represent the upper reaches of the river; Sites 5, 6 and 9 represent the middle reaches of the river, whilst Sites 7, 8 and 10 represented the lower reaches of the river. Sampling for riparian vegetation was undertaken in two different seasonal phases, i.e. from 28th February 2005 to the 3rd March 2005 and again from 25th to 27th October 2005. Two sites (Site 1 and Site 3) were not sampled during the February sampling session. Site 1 was only located after this survey (so only sampled once for all indices), and Site 3 was not surveyed due to its similarity to Site 2. GPS co-ordinates, photographic records and selected plant samples were taken at each site. Plant samples are housed at the herbarium at Walter Sisulu University in Mthatha. For the purposes of obtaining EcoStatus scores, Assessment Units were assigned for the length of the river – the detail and locations of these AUs is shown in Table 2.2. There was no representative sampling site in AU4 and scores were assigned on the basis of observations of an aerial video of the area as well as assessors' limited local knowledge of the area.

5.2.2 Indicators and data collection

At the time of commencement of field studies, the riparian vegetation assessment method for the NRHP was being updated and standardised national guidelines were still in development and not yet available (Dallas, 2005). For this study, a modified version (hereafter referred to as the Integrated Riparian Vegetation Index (IRVI); see CES, 2004 for development information) of the RVI index (Kemper, 2001), which incorporates elements of the RIPARI-MAN index (Kotze et al., 1997), was used in the riparian vegetation assessment at 10 sites along the Mthatha River. The IRVI (see blank forms in Appendix 4, Section 4-1a), as discussed in the Buffalo River Technical Report (CES, 2004), incorporates the characteristics of the RVI required for the generation of scores which are compatible with the Ecological Reserve assessment classes, in their entirety. In addition, it incorporates the capturing of some additional data, which was originally required by RIPARI-MAN, pertaining to channel profiles and extent of meander characteristics and the assignment of % assessments of various human influences such as littering and channelisation.

The riparian vegetation sampling under the IRVI method consists of three stages. The first of these is compiling a plant species list, whilst doing a site walkabout. The riparian zone is inspected for a distance of between 50 and 100 m above and below the midpoint of the sampling site (usually determined as the position where SASS sampling is done), on both left and right banks where accessibility is possible within the specified time period. The intent is primarily to record the dominant woody species and any species of special concern that are noted. Significant recruitment is to be noted and if time permits an estimate of cover for each species is assigned according to a table supplied in the RIPARI-MAN field manual. The 5 cover classes coincide roughly with 4 of the classes (1, 2, 3 & 4 combined, 5) of the Braun-Blanquet rating system. Selected samples that cannot be identified in the field should be collected for later identification in the herbarium. This task was undertaken during the Mthatha River vegetation surveys.

Secondly, from a suitable vantage point, the IRVI questionnaire is filled in. This records data on land use in the area, physical attributes of the reach, disturbance and invasive alien vegetation. The answers on this sheet are not scored and do not contribute directly to the formula for the assessment class. However, it does assist the assessor to formulate a more holistic impression of the site and further provides basic information for the national database which may prove useful for queries at a later stage.

Lastly the RVI scoring sheet is filled in. This requires the assessors to assign values based on what is observed on the site relative to a perceived reference state of what one could be expected to observe prior to recent anthropogenic influences. Scores are assigned to the following characteristics:

- Extent of vegetation cover (EVC)
- Structural intactness of trees, shrubs, reeds, sedges and grasses (SI)
- % cover of indigenous riparian species (derived from evaluating exotic species, terrestrial invasive species and invasive reeds and then subtracting this from the total extent of vegetation cover) (PCIRS)
- Recruitment of indigenous riparian species (RIRS)

From these a total score for the site is obtained. This score is comparable with the 6 Ecological Reserve assessment classes and allows one to derive an assessment class as illustrated in Table 5.1 below. The equivalent River Health classes are also illustrated.

Table 5.1 Comparison of RVI, Ecological Reserve scores and River Health class

IRVI SCORE	ECOLOGICAL RESERVE ASSESSMENT CLASS	DESCRIPTION	EQUIVALENT RIVER HEALTH CLASS
19-20	A	Unmodified, natural	NATURAL
17-18	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.	GOOD (includes A/B, B, B/C)
13-16	C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	FAIR
9 to 12	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.	FAIR

IRVI SCORE	ECOLOGICAL RESERVE ASSESSMENT CLASS	DESCRIPTION	EQUIVALENT RIVER HEALTH CLASS
5 to 8	E	The loss of natural habitat, biota and basic ecosystem functions are extensive	POOR
0 to 4	F	Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	POOR

5.2.3 Deriving the Reference Condition

In order to establish an idea of the perceived reference state of riparian vegetation of the Mthatha River, historical information was required. An investigation of desktop data was conducted to contribute to this assessment. A search of Walter Sisulu University research archives however, revealed that no data were available to contribute to the formulation of a perceived reference state. Assessors' knowledge of other riparian vegetation in more 'pristine' conditions on similar rivers, as well as descriptions of vegetation in historical novels and notes that accompany the SA vegetation map, formed the sole and subjective basis on which relative vegetation conditions were evaluated. Ideally minimally impacted sampling sites in the upper middle and lower reaches of a river should serve as reference sites, but on the Mthatha River no such suitable sites were found that were also accessible for rapid assessment methods.

5.3 RESULTS

Results are discussed in terms of Assessment Units, with descriptions of the vegetation at the various sampling sites deemed representative of that unit, as well as reference to the scores for the sampling sites. Viewings of the aerial video contributed to the overall impression of the AUs. This data source, together with local knowledge of the area, provided the sole data input for AU4 as accessible field sites could not be reached in this AU downstream of Mthatha Dam. A brief summary of the scores for each sampling site within the Assessment Units is provided in Table 5.2 below.

The riparian zone along almost the entire length of the Mthatha River was impacted and transformed by various anthropogenic activities, with primary influences being commercial forestry, subsistence agriculture and grazing of livestock. These activities have significantly contributed to the uncontrolled spread of invasive alien plants (IAPs) which significantly affect the riparian zone along the entire length of the Mthatha River. Other impacts include removal of plants for fuel, building materials and medicinal purposes.

Species list can be found in Appendix 4, Section 4-2, for each Assessment Unit. Detailed results are shown in Appendix 4, Section 4-3.

Table 5.2 Summary of IRVI scores for sampling sites within Assessment Units

ASSESSMENT UNITS, REPRESENTATIVE SITES + MONTH SAMPLED	TOTAL IRVI SCORE	ECOLOGICAL RESERVE ASSESSMENT CLASS	RIVER HEALTH ASSESSMENT CLASS
Assessment Unit 1			
HEADWATERS Oct	13.881	**C**	Fair
Assessment Unit 2			
LANGENI UPPER Oct	9.0164	**D**	Fair
LANGENI UPPER Feb	9.3564	**D**	Fair
Assessment Unit 3			
LANGENI LOWER Oct	10.9322	**D**	Fair
KAMBI Oct	10.9504	**D**	Fair
KAMBI Feb	9.92608	**D**	Fair
Assessment Unit 4		**D**	Fair
(no sample site)			
Assessment Unit 5			
MTHATHA TOWN Oct	5.713	**E**	Poor
MTHATHA TOWN Feb	4.878	**E/F**	Poor
Assessment Unit 6			
TAKATA Oct	6.9142	**E**	Poor
TAKATA Feb	8.2574	**E**	Poor
Assessment Unit 7			
MPINDWENI Oct	11.0164	**D**	Fair
MPINDWENI Feb	9.7888	**D**	Fair
MDUMBI Oct	8.0792	**E**	Poor
MDUMBI Feb	5.284	**E**	Poor
Assessment Unit 8			
CICIRA Oct	10.056	**D**	Fair
CICIRA Feb	10.155	**D**	Fair
Assessment Unit 9			
NGQUNGQU Oct	10.3432	**D**	Fair
NGQUNGQU Feb	8.3564	**E/D**	Poor

5.3.1 Assessment Unit 1

This Assessment Unit includes the headwaters and upper catchment area of the Mthatha River. The natural vegetation of the area consists predominantly of grassland with patches of Afromontane forest in the rocky hills and fire-protected sites. Commercial forestry has a large influence here and encroaches on a large portion of the riparian zone. The upper peak areas and the lower valley area closer to Langeni are naturally grassland, whilst the middle portions could reasonably be expected to have been covered predominantly by woody vegetation. A number of forestry roads wind through this area and grazing activities (cattle, sheep and horses) were observed.

The sampling site for this unit was S**ite 1 (Headwaters)** and was intended for use as a reference site as it was the least impacted site that could be found in the upper part of the catchment. However, forestry had extended even to this altitude and the left and right banks of the river at this point are under cultivation of pine forest, so it is by no means pristine. This site was sampled once in October 2005. The river splits immediately upstream of the sample midpoint and most of the indigenous vegetation was found on the middle 'island'. Site disturbances were evident from forestry activities as well as what appears to have been a relatively recent high flow event which, in conjunction with reduced vegetation cover, resulted in large sections of bank destabilisation.

The vegetation consisted of forest canopy to approximately 18 m high. In the pine plantations, which reached into the edge of the riparian zone, understorey vegetation was minimal, whilst those sections in the remaining indigenous forest displayed various horizontal strata with an array of different sized tree, shrub and forb plants. Sedges, as was to be expected in this zone, were not evident. Various sedges and ferns were noted on bank edges, but it is possible that a proportion of them may have been washed away by the recent flood event. Common woody species included 3 species of *Podocarpus*, *Ekebergia capensis*, *Nuxia floribunda* and *Dias cotonifolia*. Common shrubs and forbs included *Burchelia bubalina*, *Dietes grandiflora* and *Plectranthus* sp.. Occasional plants of *Scadoxus nuniaus* and vines and lianas such as *Rhoicissus rhomboidea* and *Behnia reticulata* were also present. Species of special concern included trees on the National list of protected trees, i.e., *Podocarpus* and *Curtisia*, as well as protected plants such as *Scadoxus* and *Orchis* species.

The Ecological Reserve rating for the riparian vegetation was a **C**, whilst the River Health Class was **Fair**. The primary impact on this section is commercial forestry which is considered significant, not only where it encroaches into the riparian zone, but also for its cumulative impact on water flow in areas adjacent the immediate riparian zone. Grazing of livestock on the lower slopes is a secondary impact.

5.3.2 Assessment Unit 2

This AU falls within an area that was naturally Döhne sourveld grassland, but what is now partially covered on the left bank by pine plantation under commercial production. The representative sample site was **Site 2 (Upper Langeni)** situated just southwest of Langeni sawmills. The sample site consisted predominantly of a grassy groundcover layer with relatively few emergent trees and shrubs. The emergent sapling trees were scattered sparsely at the east end of the site and consisted predominantly of exotic species such as *Pinus patula* and *Acacia mearnsii*. This site was sampled in February 2005 and again in October 2005. The site had changed considerably between the two sampling dates, due to the artificial widening and damming of the river just east of the road bridge, so that a weir and pool were formed for the purposes of abstracting water for dust suppression of road-building activities. Extensive vegetation damage was seen and vegetation scores indicated a reduced vegetation cover at the second sampling date. A number of forbs such as *Watsonia gladioloides*, *Wahlenbergia* sp., *Lobelia* sp. and *Helichrysum* sp. were found amongst the grass species. *Gomphocarpus* and *Miscanthus* species were growing in the marginal zone. A small backwater section had formed in an area where slopes had been made for access by vehicles down to the river. This had been colonised by sedges and grasses and was populated with river frogs.

The Ecological Reserve rating for this section was a **D**, whilst the River Health Class was **Fair**. Long term impacts appear to have been primarily associated with cattle grazing activities. More recently temporary impacts from the activities of road construction are having direct effects in terms of the physical attributes of the riparian zone as well as destruction of vegetation. It is anticipated that permanent transformation of the riparian vegetation will exist over a localised area post road construction. The influence of fire burning regimes, which has been a common practise in grasslands, should also be considered.

5.3.3 Assessment Unit 3

Assessment Unit 3 lies in the upper catchment grassland area. The left bank of the Mthatha River (for almost the entire length of this unit) is used for commercial forestry and the right bank is grassland used for communal grazing. Large erosion scars in the grassland areas adjacent to the river were evident in many places along this unit as seen from the aerial video. However, forest patches were seen in sections where topography creates areas that are sheltered from fire.

Two sites in the AU were sampled, namely **Site 3 (Lower Langeni)** and **Site 4 (Kambi Forest Station)**. Site 3 is on a sharp bend of the river where the road runs along the downstream side of the left bank, whilst the upstream side of the left bank is a steep hill populated with indigenous trees, shrubs and forbs. On the right side the river bank rises from the channel about 3 m to a flat grassland plain used for grazing, which was evident from the cattle and horses present as well as the sparse basal cover. Erosion scars from animal access to the river were also visible. Emergent *Acacia mearnsii* saplings were seen on the right bank amongst clumps of *Pteridium aquilinum* (Bracken fern) which were under 1m high. Shallow terraces and some bank slump occured on this side. Palatable grasses were cropped short and small forbs such as *Lobelia* and *Helichrysum* are present.

On the left bank woody vegetation grows to an average of 4 m. Understorey plants consisted of a relatively diverse variety of geophytes and forbs such as *Scadoxus puniceus*, *Kniphofia* sp. and ferns. The left bank was relatively well vegetated, particularly where access by cattle was limited. Species such as *Carex austro-africana* and *Gunnera perpensa* were found near the marginal zone. The Ecological Reserve assessment category for Site 3 was an **upper D**, which equates to a River Health Class of **Fair**.

The second sampling site in Assessment Unit 3 was **Site 4 (Kambi Forest station)**. This sampling area is located upstream and downstream of a bridge across the river with commercial forestry activities taking place on the left bank and communal grazing lands on the right bank. In the riparian zone the left river bank rises at a gradient of about 1:1 for approximately 4 m up to a large flat terraced area which would be flooded when the river overtops its banks. The right bank rises at a gradient of between 1:4 for approximately 1-2 m and then more or less steadily at a gradient of 1:2 up a grassed hill. The right bank is heavily overgrazed as was evident from the sparse vegetation cover and lower species diversity. IAP present included black wattle, silver wattle *Populus* sp. and *Lantana camara*. Clumps of indigenous woody vegetation occurred on the left bank with an average canopy height of about 5 m. Shrub and forb layers were more substantial on the left bank, whilst that on the right bank was relatively sparse in comparison with bare ground in many patches being clearly visible. Emergent trees on the right bank were mostly IAP interspersed with *Diospyros* and *Ziziphus mucronata*. Site 4 was sampled in February and October in 2005 and on both occasions scored a **D**, with the resulting River Health Class being **Fair**.

5.3.4 Assessment Unit 4

This section was assessed from observations of an aerial video of the river, as well as observations made on the ground whilst driving through Mthatha town. The riparian zone in this section is relatively thickly vegetated with woody vegetation to heights of between 2 and 8 m. Vegetation appears to be a mosaic of indigenous Eastern Thorn Bushveld and Valley Thicket into which many alien species such as wattle, eucalyptus, and *Solanum mauritianum* (bugweed) have encroached. Indigenous instream vegetation appears to be minimal, but large sections are occupied by large drifts of *Eichornia crassipes* (water hyacinth) which covers the entire width of the surface of the river. There is little invasion of the channel by reeds, probably due to the regular high flows released from the dam that prevents their establishment.

The banks of the river in this section appear to be relatively stable as a result of good vegetation cover. *Acacia karoo* was identifiable from the video, and ground observations included plants such as *Leucosidea sericea* and *Grewia occidentalis*. A shrubby layer combined with forbs and grasses was apparent. Other IAP observed included *Arundo donax* and *Sesbania punicea*. It is likely that *Lantana camara*, *Xanthium stromarium* and *Opuntia* sp. would also be found in the riparian zone.

Impacts from overgrazing, footpaths, littering and subsistence agriculture were visible. In addition, infrastructure associated with urban areas, namely roads, bridges and effluent inputs, were also apparent. If scored on the basis of evidence from the video, this unit would score a D in the better areas, but if scored within an area covered by water hyacinth, it would likely score an **E**. This would mean that the riparian vegetation in this area would be considered **Fair** to **Poor**.

5.3.5 Assessment Unit 5

AU5 stretches from below Mthatha town to First Falls Dam and is primarily an urban landscape with associated degraded land. The representative sample site for this stretch was **Site 5 (below Mthatha town)**.

This site was sampled mostly from the right bank, although some species were identifiable on the left bank. The channel is fairly wide and shallow with a road to an informal settlement occupying a terrace on the right side of the floodplain, before rising almost vertically up a steep partial cliff slope. Riparian vegetation on this right bank was confined to a narrow strip between the road and the river approximately 2- 4 m wide. On the left bank the vegetation followed a slope with an average gradient of 1: 3.5 up a hill covered in a mosaic of bush clumps and grass. Disturbance was high, particularly on the right bank and whilst overall canopy cover is quite good, floral composition is severely transformed by the presence of IAP such as bugweed, *Lantana camara* and *Ricinus communis*. On the left bank grass and sedge basal cover appeared to be quite good, whilst on the right bank basal cover was reduced. Woody indigenous trees grow to a high of about 3-5 m, with prominent species being *Ziziphus mucronata*, *Acacia caffra* and *Combretum erythrophyllum*.

Litter levels were high and impacts from foraging pigs, dogs and humans included use of the riparian zone as an ablution area and removal of vegetation. Site 5 scored an Ecological Category of **E** and equivalent River Health Class of **Poor**.

5.3.6 Assessment Unit 6

Assessment Unit 6 lies in the middle reaches of the Mthatha River. Natural vegetation along the river in this area appears to have consisted of a mosaic of Eastern Thorn Bushveld and Valley Thicket. The sampling site for this Assessment Unit was **Site 6 (Takata)** which lies on a right bend in the river below Takata village. On the left side of the bank a series of sloped shallow terraces lie above the main channel before rising up a steep, west-facing scarp where the bend turns south. Thicket species such as *Euphorbia* and *Aloe ferox* grow on this scarp slope. On the right side the bank rises up from the main incised channel to a wide topographic floodplain which is probably below the 100 year flood line. Soils are a sandy red colour and appear highly erodable.

Pure stands of the IAP, *Sesbania punicea*, have formed on both banks. Other IAP species included *Lantana camara*, *Solanum mauritianum* and instream *Eichornia crassipes* (water hyacinth). There seemed to be relatively little indigenous woody vegetation present, which included sparse canopy cover by species such as *Dovyalis caffra* and *Combretum*. Differences in vegetation cover seem to be affected by seasonal rainfall as is evidenced by the slightly higher February vegetation cover score and photographs, which show a good recovery of the grass layer after spring and summer rains. During the October sampling grass was cropped short by sheep and goats and had not had time to recover after the winter dry season. Forbs such as *Helichrysum* and *Gomphocarpus rivularis* were present, but were sparsely distributed and contributed minimally to cover. The riparian vegetation strip appears to be heavily impacted by grazing activities and removal of wood for firewood. Erosion scars in the riparian zone are frequent and the site is also used for washing clothes. This site scored an Ecological Category of **E** during both the February and October sampling periods, which equates to a River Health class of **Poor**.

5.3.7 Assessment Unit 7

This Assessment Unit includes the lower reaches of the Mthatha River in an area in which one would naturally expect to see Valley Thicket vegetation and forested areas in the riparian zones. Two sampling sites fall within this unit namely, **Site 7 (Mpindweni)** and **Site 8 (Mdumbi)** just above the estuary.

Site 7 near **Mpindweni** village is unlike many of the other sites and is more remote, although an old road track does go down to the river. The site is well-vegetated with a good basal and canopy cover, however floristic composition is fairly heavily influenced by encroachment of IAP species such as *Sesbania punicea*, *Lantana camara*, *Cestrum laevigatum* and *Cardiospermum grandiflorum*. Encroachment by these and other exotics is high in the riparian zone and they significantly impair indigenous biodiversity. Prominent indigenous woody vegetation consists of *Combretum erythrophyllum*, *Phoenix reclinata*, *Clerodendron glabrum* and *Ficus sur*. Grasses, shrubs and forbs are present in a mosaic of layers and include *Stenotaphrum secundatum* (buffalo grass), *Miscanthus capensis*, *Hypoxis* sp. and *Ageratum houstianum*. The area is impacted by grazing activities, and subsistence agriculture is evident on the opposite bank, although the lands may not have been cultivated for some time.

This site was sampled on two occasions in February and October 2005. For both sampling periods the site scored an Ecological Category of **D**. The equivalent River Health Class is a **Fair**.

The second sampling site in the area was **Site 8 (Mdumbi)**, which was sampled in February and October. This site is traversed by a bridge over the river where the road goes to Mdumbi and the Mthatha River mouth. The riparian zone has been affected by destruction of vegetation during bridge-building activities. Upstream of the bridge the flood plain extends onto the right bank, whilst the left bank rises steeply up a scarp slope. Downstream of the bridge the riparian zone narrows on the right bank until it butts against a steep right side scarp slope, whilst the left bank widens out into a topographic floodplain.

Vegetation on the right bank consisted of grasses and shrub clumps. In sections emergent IAP and indigenous plants formed continuous stands. Vegetation cover was high, but many species were invasive exotics including *Lantana camara*, *Sesbania punicea*, *Cestrum laevigatum* and *Cardiospermum grandiflorum*. Sedges and rushes populated the marginal zone with woody indigenous vegetation including *Phoenix reclinata* and *Ficus sur*. This site was sampled in February and October of 2005 and scored an Ecological Category of **E** on both occasions. The equivalent River Health Class was **Poor**.

5.3.8 Assessment Unit 8

This tributary of the Mthatha River flows through degraded land and grasslands and the urban and peri-urban areas of Mthatha town. This unit is in the middle reaches of the river where transition zones between grassland, Valley Thicket, Thorn Bushveld and forest patches would normally occur. The riparian area would be expected to at least be partially covered by woody vegetation.

The data collection point for this Assessment Unit is near a road bridge over the **Cicira River** called **Site 9.** This incised river is on average 3 m wide with steep grassy slopes rising about 4 m on either side. The bridge is about 8 m above the channel bed. The site was sampled on two occasions and the effect of summer rainfall was evident by the thicker grass cover observed during the February sampling period. Woody vegetation was heavily over-utilised and mostly removed. Most of the remaining trees showed signs of having large branches removed and where trees were attempting to coppice, grazing by animals such as sheep was evident. Sparsely distributed specimens of *Combretum*, *Salix* and *Acacia caffra* were the most prominent trees. On the upper slopes of the right bank the remnants of a *Eucalyptus* woodlot was evident. *Cyperus* species occupied the marginal zone where access to the water's edge was more difficult. Species diversity was low and ecological function was severely impaired.

This site scored an Ecological Category of D, which equates to a River Health Class of Fair. However, it is felt that this could more appropriately fall into an **E** category with the equivalent status of **Poor**.

5.3.9 Assessment Unit 9

This AU lies in the Eastern Coastal Belt ecoregion. The sampling site is at a bridge crossing on the lower end of the Ngqungqu River, and lies in an area where natural riparian vegetation could be expected to consist of Valley Thicket and forest species. The river substrate is predominantly boulder bed and cobbles, with sandy, red soils on the relatively steep river banks. The riparian zone is limited in width by a cliff on the right bank upstream of the bridge whilst downstream the 1:100 year flood line appears to top both the right and left banks, with the right bank being the wider topographical floodplain area.

Woody vegetation here has been severely impacted by encroachment of IAP such as *Sesbania punicea* and *Lantana camara*, the latter forming dense almost pure stands on the right bank downstream of the bridge. Dominant woody indigenous species included *Combretum* and *Acacia caffra*. *Ficus* sp. Dais and *Diospyros* were also present. The average tree canopy height was about 4 m and was almost continuous along both river banks, except for areas immediately adjacent to the bridge which are used as access by people and animals. Forbs occur in open areas and as a variable height understorey where indigenous trees are growing. They include *Cymbopogon*, *Plantago*, *Amaranthus* and *Dietes* species. Transformation of riparian vegetation at this site appeared to be related to infrastructure development, inappropriate grazing activities and lack of control over encroachment of IAP species.

This site scored an Ecological Category of D in October and E/D in February with an average **D.** This equates to a River Health Class of **Fair**.

Table 5.3 summarizes the impacts on the riparian zone and assigns ratings to the primary impacts on riparian vegetation at the sampling sites on the Mthatha River.

Table 5.3 Ratings of primary impacts on riparian vegetation at RHP sampling sites on the Mthatha River in 2005. Impacts are rated 1-6 with 1 indicating the impact with highest significance. Those impacts not rated are not considered to be directly significant.

IMPACT	SITE 1 HEADWATERS	SITE 2 UPPER LANGENI	SITE 3 LOWER LANGENI	SITE 4 KAMBI FOREST	SITE 5 BELOW MTHATHA
Commercial forestry	1	2	2	1	
Overgrazing	3	3	1	3	2
Removal of fuel wood					1
Alien plant invasion.	2		3	2	4
Littering + dumping					5
Unmitigated infrastructure 'development'		1			3
IMPACT	**SITE 6 TAKATA**	**SITE 7 MPINDWENI**	**SITE 8 MDUMBI**	**SITE 9 CICIRA TRIBUTARY**	**SITE 10 NGQUNGQU TRIBUTARY**
Commercial forestry					
Overgrazing	1	2	2	2	2
Removal of fuel wood	2	3	4	1	4
Alien plant invasion	3	1	3	5	1
Littering + dumping				4	
Unmitigated infrastructure 'developement'			1	3	3

5.4 CONCLUSION AND RECOMMENDATIONS

The IRVI method, which uses the original RVI scoring system to provide Ecological Categories, relies on historical data to make assumptions about a perceived reference state for the site. Where the historical data is limited, as was the case in this instance, the method requires assessors to make inferences based on their prior knowledge and what they observe on site. Where knowledge is limited and where the site is severely transformed, the inherent validity of the results is questionable. This is particularly so with regard to the lack of an appropriate field manual which would clearly define acceptable considerations of the 'reference state' relative to plant succession theory.

As one of the original objectives of this method was that it could be used by those with limited vegetation knowledge, it has been shown that the method is inadequate in this regard and it is recommend that the team of vegetation assessors, when using this method, have at least one member with experience in assessment of riparian vegetation state. Should this method continue to be used in riparian vegetation assessments, it is recommended that an appropriate field manual be developed.

Photographs showed marked differences in the grassland areas between February and October 2005, in that grass lengths in February (presumably after good summer rains) were much longer than in October (insufficient rains after winter to bring on good grass production). It is recommended that further monitoring on the Mthatha River take these seasonal influences into account and that if only one sampling exercise is undertaken each year, it should preferably be done in the peak flowering season.

Management recommendations for the riparian vegetation of the Mthatha River relate to the direct causes of vegetation degradation, which are commercial forestry activities, overgrazing and removal of vegetation by communities who live in the river catchment, which results in encroachment. Appropriate environmental education in local communities, appropriate monitoring of the commercial forestry industry, and programmes to remove IAP (all of which are currently attended to by DWAF in varying degrees) are recommended. The issues of land tenure and communal grazing rights also need to be effectively addressed in consultation with the appropriate organisations.

Section 5.4.1 summarizes the main limitations of this vegetation assessment method, although it is noted that this method has been superceded by the development of VEGRAI. It is therefore recommended that the riparian vegetation gathered during this study be reassessed using VEGRAI.

5.4.1 Limitations of the vegetation assessment method

A number of issues are associated with the use of this index, many of which have been discussed in the Buffalo River Technical Report (CES, 2004). Concerns raised on these sampling trips included the following:

- The lack of field manual to accompany the use of the sheets, since this would resolve issues of differing interpretations of the meaning of questions, through careful definition of terms.
- The apparent redundancy of questions concerning physical attributes such as the types of bank instability (i.e. undercutting, bank slump and incision), since these questions

can be more appropriately addressed by the geomorphology index. They may however be useful on those sampling expeditions where a geomorphologist is not present, and if adequate explanation of these terms is supplied in the field manual.

- It was felt that an explanation of the weightings behind the RVI formula would be useful as well as the significance of negative figures on formula results.
- The interpretation of scores will require clear definitions if variance in scoring from assessor to assessor is to be reduced.
- The subjective nature of assigning scores to a site relative to its 'perceived' reference state is still a source of concern, especially where assessors have limited confidence in the formulation of a reference site in the absence of historical information.
- The species list format was found to be cumbersome and it is proposed that it be changed. An alternative to the species list format is offered in Appendix 4, Section 4-1b.

The concept of an IRVI field manual was not taken further as problems with the RVI (on which IRVI is based) have been recognised on a national level, and a new index has been developed, i.e. VEGRAI or the Vegetation Response Assessment Index. This approach has been developed as the vegetation component of the suite of EcoStatus models for the EcoClassification of rivers (Kleynhans et al., 2005). The VEGRAI index is intended to replace the RVI and IRVI indices and therefore no further developmental work on these indices was deemed appropriate. Decisions will need to be taken on whether the new index will be used on its own or in conjunction with IRVI for evaluation purposes.

CHAPTER 6

GEOMORPHOLOGICAL CLASSIFICATION AND ASSESSMENT

6.1 INTRODUCTION

The assessment of the geomorphological condition of a river channel is an important step in the assessment of a river's overall 'health'. This chapter includes the following:

- A brief explanation regarding the relevance of geomorphology within the National River Health Programme (NRHP)
- A description of the way in which geomorphological condition is assessed
- The results of the geomorphological assessment undertaken for the Mthatha River
- A discussion of the results and conclusions which could be drawn from the geomorphological surveys

In the context of the NRHP (which focuses primarily on the ecological status of the river in terms of its ability to support biotic communities), a river's geomorphology forms the template on which instream and riparian biological communities exist and function. Thus, geomorphology is a very important component of habitat (Freeman and Rowntree, 2005; Rowntree and Wadeson, 1999).

Rivers can be conceptualized as networks across the landscape that facilitate the transport of water and sediment from the land to the sea. As water and sediment make their way along the channel network, they may also be stored within the network. It is the stored sediment of different types (at a range of spatial and temporal scales) along a channel network which, along with bank material (which may also consist of stored sediment), becomes synonymous with habitat substrate for various fauna and flora within the river catchment.

For the purposes of the NRHP, a number of sites are selected to represent, as closely as possible, the river as a whole. Assessments in terms of macroinvertebrate and fish populations tend to be site specific. However, assessments in terms of riparian vegetation and geomorphology necessitate a wider perspective. Geomorphological evaluation is undertaken, as far as possible, for the *river reach* in which the site is located, rather than only for the immediate vicinity of the site itself.

A river reach is defined as "a length of channel within which the local constraints on channel form are uniform resulting in a characteristic channel pattern, degree of incision and cross-section form and within which a characteristic assemblage of channel morphologies occur" (Rowntree and Wadeson, 1999, p.47). Reaches are classified into *types* based on the morphological units that are located within them. Morphological units include pools, riffles, rapids, plane beds, cascades and many others (Rowntree and Wadeson, 1999).

Two of the most important variables affecting reach type are valley form and channel gradient. Firstly, valley form dictates the degree of freedom that a river has to alter its planform in response to changes (either autogenic or allogenic) that occur within the river system. If there is a change in the energy regime of a river (e.g. drought or flood conditions), a river will adjust accordingly. If the river is unable to alter its planform, it is more likely to alter its in-channel morphology and hence its reach type. Secondly, gradient is important because (along with discharge) it affects stream power which, in turn, plays an important role in determining the caliber (size) and amount of sediment that the river will transport and store (deposit). Rivers are classified into zones based on gradient (Rowntree et al., 2000). Zones with similar gradients are expected to exhibit similar reach types (i.e. to include similar morphological units). Zone gradients, and the morphologies expected to be associated with them, are presented in Table 6.1.

Table 6.1 Zone gradients and associated channel morphology (from Rowntree et al., 2000)

A. Zonation associated with a 'normal' profile		
1. Source zone	not specified	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
2. Mountain headwater stream	***0.1 - 0.7***	***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.***
3. Mountain stream	0.01 - 0.1	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool, plane bed, pool-rapid or pool riffle. Approximate equal distribution of 'vertical' and 'horizontal' flow components.
4. Foothills (cobble bed)	0.005 - 0.01	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plane 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.
5. Foothills (gravel bed)	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.
6. Lowland sand bed or Lowland floodplain	0.0001- 0.001	Low gradient alluvial sand bed channel, typically regime reach type. Often 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		
7. Rejuvenated bedrock fall / cascades	0.01 - 0.5	Moderate to steep gradient, often 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.
8. Rejuvenated foothills	0.001 - 0.01	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 flood plain may be present between the active and macro-channel.
9. ***Upland flood plain***	9.0.0001- 0.001	9.An upland low gradient channel, often associated with uplifted plateau areas as occur beneath the eastern escarpment.

A geomorphological assessment is carried out for each site (reach) using the newly developed GAI (Geomorphological Assessment Index). The output of the GAI model is a numerical value which is an indication of the site's present geomorphological state (PGS). PGS categories range from 'A' to 'F', with 'A' representing an unmodified channel and 'F' representing a critically modified channel (Table 6.2). When values fall on the boundaries between categories, sub-categories are created, e.g. a value that falls between the 'A' and 'B' categories will be assigned a rating of A/B, etc.

Table 6.2 Meanings of PGS categories A to F (Rowntree, 2003)

CATEGORY	GEOMORPHOLOGICAL CHANGE	ANTHROPOGENIC INDICATORS
A: unmodified natural	No changes, erosion and deposition within reach are in balance.	No human impacts identified in the catchment.
B: largely natural	Short-term changes that can be reset within the frequency of the 'bankfull' flood.	Human impacts identified, but no clear evidence of channel response.
C: moderately modified	Slow trajectory of change, can be reset within five to ten 'bank full' events by restoring natural flow / sediment regime and bank stability.	Significant human impacts, changes to bed structure evident, localised bank erosion and channel widening, or deposition and narrowing. Changes reversible in the short term.
D: largely modified	Well into the trajectory of change, may be difficult to restore natural conditions; river adjusting its form to the current sediment load and flow regime.	Major human impacts resulting in significant long term changes to channel geometry, pattern or reach type that may be irreversible.
E: seriously modified	Engineering intervention required for rehabilitation.	Channel structure largely engineered, but bed perimeter includes some natural materials that can be worked by fluvial processes (includes gabions, engineered bank stabilisation, channel straightening or re-alignment, bulldozing.
F: critically modified	Major engineering intervention required for rehabilitation.	Totally engineered channel, no natural material in the channel perimeter.

For the purposes of state-of-rivers reports which are produced from technical reports such as this one, PGS categories 'A' to 'F' are reduced to four larger classes, namely **Natural**, **Good**, **Fair** and **Poor**. PGS categories are translated to these four classes in a standardized way as follows:

A	=	Natural
A/B, B + B/C	=	Good
C, C/D + D	=	Fair
E + F	=	Poor

6.2 MATERIALS AND METHODS

The assessment of the geomorphological condition of a reach involves two steps. The first is to classify the channel, and the second is to assess the degree to which the reach has been altered from its natural or Reference Condition.

6.2.1 Channel classification

Channel classification requires both desktop and field data. In South Africa, geomorphological classification of rivers is done hierarchically (see Rowntree and Wadeson, 1999). The six tiers of the hierarchy are as follows:

1. Catchment :- *"the land surface which contributes water and sediment to any given stream network"* (Rowntree and Wadeson, 1999, p.84).
2. Zone :- *"areas within a catchment which can be considered as homogenous zones with respect to flood runoff and sediment production"* (Rowntree and Wadeson, 1999, p.ii). Zones can also be understood as areas with similar valley form and channel gradient (Rowntree et al., 2000).
3. Segment :- *"a length of channel which carry a spatially uniform discharge and sediment load along their length. Segment boundaries are defined by major tributary junctions at which there will be a significant change in the discharge of runoff or sediment passing through the channel."* (Rowntree and Wadeson, 1999, p.69).
4. Reach :- *"a length of channel within which the local constraints on channel form are uniform resulting in a characteristic channel pattern, degree of incision and cross-section form and within which a characteristic assemblage of channel morphologies occur"* (Rowntree and Wadeson, 1999, p.47).
5. Morphological units:- *"the basic structures recognized by fluvial geomorphologists as comprising the channel morphology and may be either erosional or depositional features."* (Rowntree and Wadeson, 1999, p.26).
6. Hydraulic biotope :- *"a spatially distinct instream flow environment with characteristic hydraulic attributes. They occur at a spatial scale of the order of 1m^2 and although they can be related to morphological features they are temporarily unstable."* (Wadeson, 1994, cited by Rowntree and Wadeson, 1999, p.27).

Within the context of geomorphological assessments for the NRHP, only three levels of the hierarchy are important, namely the zone, the reach and the morphological unit. Study *reaches* are classified into *zones* on the basis of their gradients according to the guidelines presented in table 1 (Rowntree et al., 2000). *Reaches* themselves are classified on the basis of channel type (i.e. whether the channel flows through bedrock, alluvium or a mixture of these) and the *morphological units* which constitute them, e.g. pool-riffle, pool-rapid etc. (Rowntree and Wadeson, 1999).

Division of the channel into zones is done on a desktop basis. The channel is digitized using a GIS package such as ArcView and gradients are calculated by dividing horizontal distance by change in altitude at regular intervals along the channel. A longitudinal profile of the stream from source to mouth is plotted using a spreadsheet programme and zone boundaries are designated by gradient breaks that are greater than 20% (Rowntree et al., 2000).

The classification of channel and reach type takes place in the field upon observation of each study reach in terms of its dominant substrate and morphological units according to the classification section of the field form (available on the data CD accompanying this report).

6. 2.2 Degree to which reach has been altered from RC

The present geomorphological state (PGS) of a reach is defined as the degree to which it has been altered (by human activity) from its natural or Reference Condition. This is done according to a newly developed standardized method known as the geomorphological assessment index (GAI). The completed GAI spreadsheets for each study reach (or Assessment Units in the case of Mthatha River) are presented in Appendix 5.

Within the GAI model, changes to the channel are assessed under four main headings known as the geomorphological drivers. These are system connectivity, sediment balance, perimeter resistance and channel morphology.

Changes to *system connectivity* are important as they alter the amount of water and sediment as well as the caliber of sediment that is added to and transported down the channel network. Changes to the *sediment balance* (i.e. transport capacity vs. sediment input/removal) need to be considered as they determine the efficiency of the river in transporting material, and give an indication of the likelihood of sediment deposition in the channel. Changes to *perimeter resistance* will cause changes to habitat substrate and to the stability of the channel in terms of its banks, bed and bars. Alterations to *channel morphology* also need to be considered as they can result in alterations to habitat, bed roughness and reach type.

A detailed description of the development of the GAI and an explanation of how the model is populated in the field, is presented in a WRC report by du Preez and Rowntree (in press).

6.3 RESULTS

6.3.1 Classification of main stream into zones

The longitudinal profile of the Mthatha River from source to mouth is presented in Figure 6.1. Zone breaks are indicated on the profile by heavy black lines. It should be pointed out that the zone class labels ‘A’, ‘B’, ‘C’ etc. refer to zone classes ‘A’ to ‘F’ presented in Table 6.1 (Rowntree et al., 2000) and *not* to impact classes ‘A’ to ‘F’ that are presented in Table 6.2.

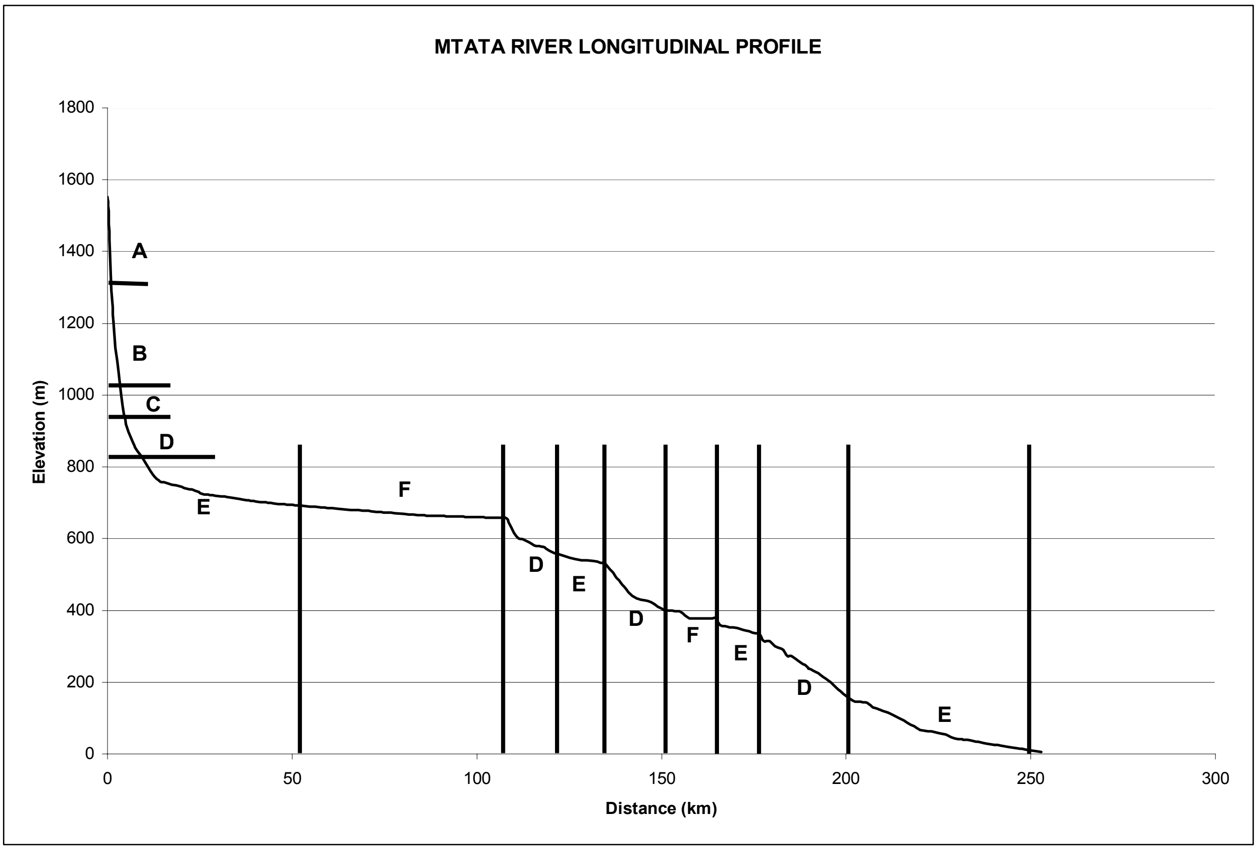

Figure 6.1 Longitudinal profile of the Mthatha River indicating major geomorphological breaks

6.3.2 Classification of reach types and morphological units, and an assessment of the degree to which each reach has been altered from its RC

Assessment Unit 1

- Location of site(s) assessed in unit: Site 1 (31˚ 30' 32.2'' S ; 28˚ 23' 47.7'' E)
- Geomorphological classification of unit: This site represents a single thread, straight boulder bed reach which exhibits boulder cascade morphology. The study reach is at an altitude of 1300-1400 m.a.s.l which places it in the mountain headwater zone category (Figure 6.1 and Rowntree et al., 2000). Morphological units observed include steps, rapids, runs and shallow pools which are common in mountain headwater streams. The reach has ravine valley morphology and as such has no clear flood bench features, nor does it have well defined banks. The slopes directly adjacent to the channel, however, are unstable and only sparsely vegetated.
- Nature and causes of geomorphological change: The main cause of geomorphological change in this reach is the extensive forestry activity along both left and right hand banks. The channel has become incised due to stabilization of the channel margins by pine trees, though this incision is not severe. It is also thought that the net flow volume in the channel has been reduced due to water uptake by the plantations, reducing the transport capacity of the flow in the channel. It is likely that coarse boulders were dumped in the stream channel when land was cleared for planting, altering the channel substrate, though this has not been confirmed.
- Impact Class: B (PGS score = 84.28)

- State of Rivers Report Impact Class: **Good**

Assessment Unit 2

- Location of site(s) assessed in unit: Site 2 (31˚ 29' 34.1''S; 28˚ 28' 37.0''E)
- Geomorphological classification of unit: This site is located in a single thread, straight channel with a mixed substrate consisting predominantly of boulders but including cobbles, gravel and sand. The altitude of this site is between 820 and 840 m.a.s.l which places it in the upper foothills zone category (Figure 6.1 and Rowntree et al., 2000). Within this reach, both v-shaped valleys and confined valley flood plains were observed. The reach exhibits both pool-riffle and pool-rapid morphology and, in terms of morphological units, includes steps, rapids, riffles, shallow pools, deep pools and flat sand bed sections. In addition, point bars and vegetated islands were observed in the reach. A small wetland was observed along the right hand flood zone.
- Nature and causes of geomorphological change: Causes of geomorphological change in this reach include grazing, water abstraction, vegetation clearance from the riparian zone, sand mining (of the bed and flood zone) and commercial forestry with its related infrastructure development (i.e. road construction and temporary stream impoundment). These factors have resulted in changes to the channel bed; sediment has been added to the system as a result of erosion, and has also been removed by sediment mining. Thus, the bed has been changed from reference condition but the nature of this change varies within the reach. Overall, it is thought that there is more fine sediment in the channel than there would have been under reference conditions. What compounds the effect of the additional sediment within the system is the reduction in transport capacity due to water abstraction. Banks have been destabilized due to removal of vegetation from the riparian zone which has resulted in a change to the channel cross section (channel widening) and hence an increase in its width-depth ratio.
- Impact Class: C (PGS score = 63.71)
- State of Rivers Report Impact Class: **Fair**

Assessment Unit 3

- Location of site(s) assessed in unit: Site 3(31˚ 28' 57.0''S; 28˚ 29' 35.8''E)
Site 4(31˚ 28' 16.6''S; 28˚ 36' 54.4''E)
- Geomorphological classification of unit: Two sites were used to assess this unit. The first is located downstream of Langeni sawmills whilst the second is located at Kambi forest station. The first of the two sites is considered to be more representative of the unit as a whole than the second site. Most of the unit consists of a single, sinuous, incised alluvial, cobble dominated channel which exhibits pool-riffle morphology. However, there are straight mixed sections dominated by bedrock (and including gravel and sand) which exhibit pool-rapid morphology and have a confined valley floodplain. The site below the saw mill has an altitude of between 820 and 840 m.a.s.l, placing it in the upper foothills zone category, whilst the Kambi forest station site has an altitude between 686-701 m.a.s.l, which places it in the lowland river zone class (Figure 6.1 and Rowntree et al., 2000). Morphological units observed in this AU include rapids, riffles, runs, shallow pools and deep pools. In addition, both point and lateral bars were observed in the unit.
- Nature and causes of geomorphological change: The main causes of geomorphological change in this reach are erosion (largely as a result of overgrazing), and commercial forestry. Erosion is severe in the lower part of this unit (in the region of the Kambi

forest station) and has resulted in the addition of large quantities of sediment to this part of the system. The effect of this sediment addition is likely to be compounded by a reduction in the stream transport capacity due to water uptake by plantations as well as water abstraction by the sawmill operation. The result has been an increase in the amount of fine sediment on the channel bed in the lower part of the Assessment Unit. The majority of the unit exhibits natural incision of the channel, but over stabilization of banks in the commercial forestry section is likely to increase the rate of channel incision in this section.
- Impact Class: B/C (PGS score = 79.92)
- State of Rivers Report Impact Class: **Good**

Assessment Unit 4
- Location of site(s) assessed in unit: No sites assessed in this Assessment Unit. Rapid assessment of impacts made from aerial video.
- Geomorphological classification of unit: From what could be seen on the video, this AU of the river was classified as single thread, sinuous, alluvial channel exhibiting pool-riffle morphology. Morphological units that could be seen were pools, riffles, runs and various types of depositional bar features including point, lateral, mid-hannel and tributary bars. There were also a number of secondary channels and vegetated islands in the channel.
- Nature and causes of geomorphological change: The main cause of geomorphological change in this Assessment Unit is the Mthatha Dam which forms the boundary between Assessment Units 3 and 4. The dam has altered both flow and sediment regimes in this unit. Sediment has been added to the channel as a result of catchment erosion. These impacts have resulted in changes to the channel bed as well as the channel cross-section.
- Impact Class: C/D (PGS score = 59.94)
- State of Rivers Report Impact Class: **Fair**

Assessment Unit 5
- Location of site(s) assessed in unit: Site 5 (31˚ 35’ 35.3’’S; 28˚ 48’ 4.6’’E)
- Geomorphological classification of unit: The site used to assess this unit is located directly downstream of Mthatha town. Access was restricted due to health concerns related to extremely poor water quality. Thus, confidence in observations is lower than at other sites. The site is located in a single thread, straight, boulder-dominated reach exhibiting pool-rapid morphology. The only morphological units observed were rapids and long stretches of deep pool. The gradient of the site is 640-660 m.a.s.l which places it in the lowland river zone class (Figure 6.1 and Rowntree et al., 2000).
- Nature and causes of geomorphological change: The main causes of geomorphological change in this unit are the Mthatha Dam not far upstream of the site, as well as erosion caused by grazing and extensive use of the channel by informal settlements on the banks of the river and the resultant erosion increased by vegetation clearance and gathering of firewood.
- Impact Class: D (PGS score = 56.31)
- State of Rivers Report Impact Class: **Fair**

Assessment Unit 6
- Location of site(s) assessed in unit: Site 6 (31˚ 41’ 07.3’’S; 28˚ 49’ 15.0’’E)

- Geomorphological classification of unit: The site chosen to represent this Assessment Unit is located near the rural village of Takata. It represents a single thread, sinuous channel with a confined valley flood plain. The channel has mixed bed material dominated by cobble but also including bedrock and gravel. The gradient of the channel at the site is 520-540 m.a.s.l, which classifies it as a lower foothills zone channel (Figure 6.1 and Rowntree et al., 2000). Both pool-rapid and pool-riffle morphology were observed in the reach. Morphological units in the reach include steps, rapids, riffles, runs, shallow pools and deep pools. Mid-channel and tributary bars were noted in the reach.
- Nature and causes of geomorphological change: The main agents of geomorphological change in this unit are the dams upstream of the site (i.e. the Mthatha Dam and the First Falls Dam), gully erosion (largely due to overgrazing) and vegetation clearance (mostly as a result of firewood collection). There is evidence of the land having been cultivated on both sides of the channel, though the land is not currently being cultivated. Much of the sediment that has been added to the system higher up in the catchment will have been trapped by First Falls Dam, so there is no marked effect on the substrate of the river at this point. However, the addition of sediment to the system as a result of erosion has resulted in increased deposition in the form of bars. Flows have been completely altered from reference, but are erratic making discernment of the effect of these flows difficult. Communication with residents of Takata revealed that there are flood flows which overtop the channel quite regularly, suggesting that there are still a number of largely natural geomorphologically effective flows that occur in the system, i.e. the dam does not attenuate all flood flows. Removal of vegetation from the riparian zone has resulted in destabilization of the banks and subsequent widening of the channel.
- Impact Class: C (PGS score = 71.48)
- State of Rivers Report Impact Class: **Fair**

Assessment Unit 7

- Location of site(s) assessed in unit: Site 7 (31˚ 52’ 00.2’’S; 29˚ 1’ 7.7’’E)
  Site 8 (31˚ 55’ 32.9’’S; 29˚ 8’ 10’’E)
- Geomorphological classification of unit: Two sites were used to assess this unit. The first is located at Mpindweni (Site 7) and the second closer to the estuary at Mdumbi (Site 8). The site at Mpindweni is considered to be more representative of the reach as a whole than the site at Mdumbi. At Site 7 the valley form is a combination of a gorge and a v-shaped valley, whilst at Site 8 there is a flood plain confined on one side by the hillslope. The gradient at Site 7 is 107-122 m.a.s.l, which places it in the lower foothills zone class. The gradient at Site 8 is 0-15 m.a.s.l, which also places it in the lower foothills zone class (Figure 6.1 and Rowntree et al., 2000). The unit consists of a straight, single thread channel with a mixed boulder and sand bed channel exhibiting pool-rapid morphology, though there are pool-riffle sections (with cobble as a substrate) in the lower part of the Assessment Unit. Morphological units observed in the unit include rapids, riffles, runs, shallow pools and deep pools. There are lateral and point bars in the unit as well as secondary channels and vegetated islands.
- Nature and causes of geomorphological change: There is not a great deal of direct geomorphological impact on this Assessment Unit. Impact is limited to grazing which has resulted in some erosion, though not as much as in other parts of the catchment. The main impact on this unit is the indirect effect of an altered flow regime due to releases from three dams upstream of the unit (i.e. Mthatha Dam, First Falls Dam and

Second Falls Dam). The affect of this altered flow regime is still significant at this point although it has been reduced by the addition of sediment and flow by tributaries joining the main channel downstream of the dams. Other impacts in this unit include bridges with in-channel supports and water abstraction at Mdumbi or local rural villages and Coffee Bay.

- Impact Class: B/C (PGS score = 79.44)
- State of Rivers Report Impact Class: **Good**

Assessment Unit 8

- Location of site(s) assessed in unit: Site 9 (31˚ 33’ 23.6’’S; 28˚ 44’ 15.1’’E)
- Geomorphological classification of unit: The site used to assess this tributary is located in a v-shaped valley in an incised, single thread, straight alluvial channel with gravel as the dominant bed material and pool-riffle morphology. Morphological units observed in the unit include riffles, runs, shallow pools and deep pools.
- Nature and causes of geomorphological change: The main cause of geomorphological change in the channel is extensive gully erosion due to over-grazing. There has been removal of vegetation from the riparian zone and gathering of firewood continues from what sparse woody vegetation there still is on the banks, though this vegetation is mostly exotic. There has been an addition of fine sediment to the channel as a result of erosion in the catchment. The bed substrate has also been changed due to extensive dumping in the area (e.g. scrap metal, tires etc.). The lack of vegetation and use of the river by the community and cattle has resulted in extensive slumping of both banks. There is a bridge across the channel at the site which has had a localized impact on channel cross-section and bank stability.
- Impact Class: C (PGS score = 77.14)
- State of Rivers Report Impact Class: **Fair**

Assessment Unit 9

- Location of site(s) assessed in unit: Site 10 (31˚ 51’ 06.5’’S; 28˚ 44’ 15.1’’E)
- Geomorphological classification of unit: The site used to assess this tributary has a flood plain, confined on one side by the hillslope, and is incised. The channel is classified as being single thread and straight. The channel is alluvial with boulder, cobble and sand as the dominant bed materials and exhibits both pool-rapid and pool-riffle morphology. Morphological units observed include rapids, riffles, runs, shallow pools and deep pools. In addition, point bars, lateral bars and mid-channel bars as well as secondary channels were noted.
- Nature and causes of geomorphological change: The main agents of geomorphic change in this unit are erosion in the catchment, cultivation and livestock. There has been an addition of fine sediment to the system as a result of erosion. This has resulted in the formation of various types of depositional bars in the channel. There has been no significant change to the flow regime in this Assessment Unit. Additional localized, relatively minor impacts include an old road which crosses the channel at one point, as well as a bridge with in-channel supports. These have affected bank stability and channel cross-section (channel has been widened) in their immediate vicinity. Overall, bank stability is moderate to high in the unit.
- Impact Class: B/C (PGS score = 80.76)
- State of Rivers Report Impact Class: **Good**

6.4 CONCLUSIONS AND RECOMMENDATIONS

The main causes of geomorphological change in this system are the major impoundments, i.e. First Falls Dam and Mthatha Dam, and catchment erosion; most often as a result of over-stocking and/or overgrazing of the land. The effects of commercial forestry are not clear but are likely to be significant. The main geomorphological drivers which are affected by human activity in this system are connectivity and sediment balance (du Preez and Rowntree, in press). It is difficult to gauge the geomorphological effect of the dams as they do not have established release patterns. This is largely because First Falls Dam is a source of hydro-electric power which is made available to consumers on a demand/need basis which is, it would seem, largely erratic.

Overgrazing of the land has led to the establishment of some extensive gully networks in the system that are a constant source of fine sediment for the channel. This fine sediment may result in the formation of depositional features like bars and/or islands, or the destruction of habitat as it embeds cobbles and gravels to a point where there is no longer interstitial space in the substrate matrix.

Commercial forestry activities have affected the geomorphology of the system directly as a result of impoundments along the river for forestry purposes, and on a highly localized level in terms of the over-stabilization of river banks (e.g. the reach near Kambi forest station) and the addition of some large woody debris to the system which alters local flow hydraulics and substrate, as well as inhibiting flow at some points (e.g. the large woody flood debris which has blocked the area under the railway bridge at Kambi). However forestry activities are also thought to have indirectly altered the geomorphology as a result of an increased uptake of water by alien species which constitute the plantations. This is likely to have reduced the transport capacity of flow in the channel, though the degree of this reduction is difficult to gauge due to various other factors altering the natural flow regime in this system.

There is no obvious linear decline in the geomorphic condition of the system as one proceeds from source to mouth. All of the sites have PGS values which classify them as Good or Fair. There are no sites that exhibit a truly “Poor” Present Geomorphological State.

The realistic mitigation of geomorphological impacts in the Mthatha River system would necessitate initiatives such as land care programmes to control erosion processes occurring in the catchment, as well as a reconsideration of current release policies for the major impoundments in the system. Further studies into the effects of commercial forestry activities on fluvial geomorphology processes would potentially be an interesting area of research which may reveal more about how to effectively address these impacts.

CHAPTER 7

WATER QUALITY

7.1 INTRODUCTION

Water quality is a term describing the physical, chemical, microbial and radiological properties of water and, together with flow and geomorphology, is considered one of the drivers of biological responses in river systems. It is an important attribute of rivers affecting the state of biotic communities, and subsequent health of aquatic ecosystems (Dallas and Day, 1993). It is important to note that water quality state varies naturally as a result of the combined influences of physical characteristics such as climate, geomorphology, geology and soils of a particular catchment (Davies and Day, 1998). Anthropogenic activities also extensively influence water quality or the physico-chemical state of water, which subsequently impacts on biotic responses. To ensure the continued survival of aquatic ecosystems, it is necessary to provide their particular water quality requirements (Davies and Day, 1998). Water quality data, therefore, are an essential component of any assessment of Present Ecological State of aquatic resources.

Recent developmental methods for determining Ecological Water Requirements (EWR) of rivers includes an approach called EcoClassification, i.e. the process by which the Present Ecological State of various biophysical attributes of rivers are determined and combined to arrive at an EcoStatus for the selected river reach or Resource Unit. The Physico-chemical Assessment Index (PAI) was developed to determine the present status of the physical and chemical water quality component of an EWR study. It can be applied along with the other driver models to undertake a stand-alone assessment or it can be applied as the water quality contribution to a water quantity Reserve determination in the EcoClassification of rivers. However, an EcoStatus Level 3 assessment, which does not require a PAI assessment for water quality, is the appropriate level for the RHP. At this level, the Index of Habitat Integrity (IHI) is used as a surrogate for driver information (Kleynhans et al., 2005).

Water quality data available for the catchment area, and collected during the study, was therefore qualitatively assessed as an indication of water quality state for the Mthatha River RHP assessment.

7.1.1 Water quality status of the Mthatha River

The following water quality issues have been identified for the Mthatha River catchment area (DWAF, 2004a):

- **Discharge of untreated sewage and stormwater runoff into rivers**

The water quality of rivers in the Mthatha River catchment is severely deteriorating as a result of the discharge of untreated or inadequately treated sewage, primarily from Mthatha town, and has previously resulted in cholera outbreaks (DWAF, 2004b). The effluent settles in the First Falls and Second Falls dams, enhancing eutrophication and causing the stimulated growth of undesirable algae.

Stormwater runoff from urban areas in the catchment therefore results in the pollution of rivers. This pollution is in the form of both organic and chemical pollutants. Organic pollutants include human waste and bacteria, while chemical pollutants include oils, solvents, petrols, etc.

- **Dense rural and informal settlements along the banks of the Mthatha River**

There are many densely populated informal settlements along the banks of the Mthatha River. These settlements do not have access to formal sanitation infrastructure and therefore impact on the river, downstream of their position, through the increase of nitrate and ammonia levels (eutrophication), high faecal coliform counts and the presence of pathogenic bacteria (e.g. *Salmonella typhosa*) in the river, which cause water-borne diseases.

- **Forestry and associated activities**

A biomonitoring survey was conducted for Singisi in 2005 regarding the health status of the rivers around the Matiwane plantations (Graham, 2005). Although the water quality status of most rivers and streams of the upper Mthatha catchment were good, a few exceptions were noted. The list below refers to some of these examples:

- The Qelana River 200 m upstream of the confluence with the Mthatha River had elevated *Escherichia coli* counts and unionised ammonia concentrations within the chronic effect value range. This result was largely influenced by the poor water quality emerging from around the mill and attendant settlement (including the sewage works).
- The Ndenko system appears to have elevated concentrations of ammonia which may be toxic to aquatic life (i.e. unionised ammonia >0.1 mgN/L). This was unexpected and possibly related to construction activities around the new bridge. Alternatively the upstream village may be the cause of this pollutant.
- The major water quality problems appear to be associated with the presence of the Langeni saw mill (inclusive of associated factories and activities) and associated settlement. Within these areas the key water quality issues appear to relate to sewage and industrial effluent pollution. The former emanating from the squatter settlement (and surcharging sewer lines) and the Langeni village sewage treatment plant, and the latter from the area around the chipboard factory.

- **Solid waste management**

At the time of writing the 2004 report, there were no waste management plans for the informal settlements around the town of Mthatha and along the Mthatha River, resulting in the continued pollution of the riverine environment and affecting the availability of water resources for downstream users. No effective waste management system was evident during field surveys of 2005.

- **Soil erosion**

Soil erosion is a major problem in the upper and central regions of the catchment area. Soil erosion is predominantly caused by over-grazing of cattle and the clearing of vegetation for human settlements, but is also the result of the steep topography of the area and the dispersive nature of the geological formations of the region. The eroded soil is washed into the rivers during the rains, increasing the turbidity of the rivers. Large sections of the upper catchment have also been cleared of natural vegetation for commercial forestry, which impacts on the status of the riparian zones of rivers.

- **Alien vegetation in the rivers**

Alien aquatic weeds have been observed in the upper reaches of the catchment and at the headwaters of the Mthatha River. Water hyacinth (*Eischhornia crassipes*) is invading most of the watercourses of the Mthatha River catchment. Alien weeds are problematic in that they increase the incidence of diseases such as malaria and schistosomiasis by providing favourable habitats for disease vectors (mosquitoes and aquatic snails) and intermediate hosts (fish). Alien weeds compete with indigenous fish and macroinvertebrates for space and nutrients, and might also interfere with the operation of the hydro-electric generation scheme downstream. The extent of alien aquatic weeds, however, is unknown. The 2005 surveys did not show evidence of extensive infestations, although this is known to occur and some infestation was evident.

7.2 MATERIALS AND METHODS

Two water quality samples were collected from every site on at least one survey for metal and nutrient analyses at the DWAF-approved laboratory, Pollution Control Technologies in East London. One sample was preserved for metal analyses using nitric acid, while the nutrient sample was preserved with mercuric chloride. Electrical conductivity, Total Dissolved Solids (TDS), pH and temperature readings were taken on-site using a Hanna HI98130 hand-held meter, while Dissolved Oxygen (DO) was measured using a WTW Oxi 320 DO meter. Duplicate samples were taken for quality control purposes from selected sites. Duplication was deemed appropriate by the water quality analyst on the team (Ntozakhe, Water Sisulu University, pers. comm.).

All field-collected and analytical data were combined with existing data available from the DWAF office in Mthatha (also analysed by Pollution Control Technologies), and summary statistics calculated. The DWAF Mthatha office collects monthly (initiated in January 2004) water quality samples for the following variables from 9 sites in the catchment.

- pH
- Electrical conductivity
- Turbidity
- Total Suspended Solids (TSS)
- Phosphate (as P)
- Ammonia (as N)
- Nitrate (as N)
- Coliforms
- *E. coli*

As DWAF primarily monitors for compliance to discharge standards, samples are collected upstream and downstream of impact points. Only the sampling points that duplicated the RHP biomonitoring sites were used for statistical analysis.

Sites well represented in terms of water quality data are therefore Sites 2 and 3 (upstream and downstream of Langeni sawmills), Site 5 at Mthatha town, Site 6 at Takata and Site 9 on the Cicira River. Summary statistics were not prepared for Site 1 (uppermost site on the system), Site 4 (Kambi), Site 7 (Mthatha River at Mpindweni) or Site 10 on the Ngqungqu River, as only one data point exists for these sites.

DWAF monitoring, as part of the national chemical monitoring programme, is very poor for the T20 catchment. Although stated in DWAF (2004b) that water quality data is collected from the following points - T7H001, T2H002 (Norwood below Mhtatha Dam) and T2R001 (Mthatha Dam) – data requested from DWAF (presumably sites registered on WMS) only showed one water quality sample collected in July 2005 from gauging weir T2H008, i.e. the Thornhill weir downstream of Mthatha Dam (Erasmus, DWAF, pers. comm.).

7.3 RESULTS

Table 7.1 is a summary of statistics for water quality data for selected monitoring points sampled during the RHP surveys. Data is only shown if more than one sample was taken at the site. Assessment criteria are shown on the bottom of the table for comparative purposes. Ninety fifth percentiles are generally compared to criteria, except for nutrients where the mean is used so as to incorporate seasonal fluctuations.

Results verify the expected impacts at Sites 5 and 8 around Mthatha town (Site 5 is on the Mthatha River downstream of town and Site 8 is on the Cicira tributary near Mthatha). Although Site 6 at Takata is some distance downstream from Mthatha, water quality impacts were still evident at this site.

Note that the confidence in electrical conductivity results is poor, as it is unclear whether the units were accurately reflected on data sheets. Results do however show that the highest values were seen at Sites 5 and 8 around Mthatha town and Site 6 further down at Takata.

TSS and turbidity results reflect the state of the catchment in terms of erosion and poor land management practices, with very high sediment loads in the rivers.

Phosphate results indicate that most sites were eutrophic when sampled, with the site above Langeni being hypertrophic. These results need verification as it is unlikely that Site 2 is eutrophic. Ammonia levels were elevated at all sites shown on Table 7.1, indicating pollution events at these sites.

E. coli and coliform counts were extremely high for most points shown on Table 7.1, and always exceeded guideline values. These results reflect known information regarding contamination at these sites.

Aquatic ecosystem guidelines were exceeded for zinc and copper; however, these guidelines are currently being reviewed as they often fall below analytical quantification limits. Iron levels at Takata (Site 6) seem particularly high; long-term monitoring of this variable is recommended.

Table 7.1 Summary statistics for selected water quality variables for selected sites sampled during the Mthatha River RHP surveys

AU	SITE NO.	SUMMARY STATISTICS	pH	El. Con. mS/m	TSS Mg/L	PHOSPHATE Mg/L P	NITRATE Mg/L N	AMMONIA Mg/L N	TURBIDITY NTU	COLIFORMS cfu/100 ml	*E.coli*	IRON Mg/L	ZINC Mg/L	COPPER Mg/L
2	2 (above Langeni)	No. of samples	22	22	21	24	23	23	20	21	21	3	2	2
		Mean	7.18	67	9.1	0.324	1.70	2.87	10.9	1196	104	0.47	0.25	0.07
		5^{th} %ile	6.7	33	4	0.01	0.1	0.1	1.99	35	2	0.19	0.043	0.034
		95^{th} %ile	7.77	273	21	1.233	4.16	8.22	32.02	24.19	299	0.671	0.45	0.1
3	3 (below Langeni)	No. of samples	23	23	22	24	25	25	22	22	22	3	2	2
		Mean	7.3	66	136.7	0.11	1.27	1.48	81	1755	607	0.48	0.15	0.21
		5^{th} %ile	6.8	41.1	4	0.01	0.12	0.1	5.04	136	17	0.22	0.05	0.05
		95^{th} %ile	8.0	101.5	178.2	0.88	3.24	4.4	400.4	2419	2419	0.65	0.26	0.37
	4 (Kambi)	No. of samples				3	3	2				3	2	2
		Mean				0.043	0.5	2.45				0.62	0.2	0.02
		5^{th} %ile				0.015	0.21	0.34				0.26	0.03	0.01
		95^{th} %ile				0.06	0.93	4.56				0.9	0.4	0.02
5	5 (below Mthatha)	No. of samples	23	23	23	24	24	24	22	22	22	2	2	
		Mean	7.33	164.9	119.3	0.192	1.155	2.55	219.3	2222	2038	6.9	0.04	
		5^{th} %ile	6.95	44.3	16.3	0.01	0.1	0.1	37.3	1800	41	6.4	0.02	
		95^{th} %ile	7.78	335.3	196	1.102	3.34	11.51	359.2	2419	2419	7.4	0.05	
6	6 (Takata)	No. of samples	22	22	21	24	24	23	21	21	21	3	3	2
		Mean	7.51	171.7	294.5	0.07	1.42	1.1	289	2215	2035	7.28	0.26	0.1
		5^{th} %ile	7.1	80.3	41	0.01	0.1	0.1	184	1800	0	2.4	0.05	0.06
		95^{th} %ile	7.85	392.6	310	0.21	3	2.98	491	2419	2419	14.11	0.52	0.14
7	8 (Mdumbi)	No. of samples	2	2		2	2	2				2	2	
		Mean	7.26	9		0.025	1.7	1.45				3.81	0.21	

AU	SITE NO.	SUMMARY STATISTICS	pH	El. Con. mS/m	TSS Mg/L	PHOSPHATE Mg/L P	NITRATE Mg/L N	AMMONIA Mg/L N	TURBIDITY NTU	COLIFORMS cfu/100 ml	*E.coli*	IRON Mg/L	ZINC Mg/L	COPPER Mg/L
		5th %ile	6.76	8.1		0.011	1.16	0.24				2.87	0.07	
		95th %ile	7.77	9.9		0.04	2.15	2.67				4.74	0.34	
8	9 (Cicira River)	No. of samples	24	24	22	24	23	24	22	22	22	2	2	
		Mean	8.07	170	162.3	0.14	1.22	0.98	175.5	1939	982	5.5	0.21	
		5th %ile	7.34	112	4	0.01	0.11	0.1	8.7	379	21	1.83	0.12	
		95th %ile	8.84	897	532.7	1	3.18	2.17	500	2419	2419	9.1	0.3	
Aquatic ecosystem guideline - TWQR (DWAF, 1996a)			♦	-	<100	<0.005: Oligotrophic; 0.005 – 0.025: Mesotrophic; 0.025 – 0.25: Eutrophic; >0.25: Hypertrophic		<0.2	-	DWAF full-contact recreational use (DWAF, 1996b): 0-130: low risk 130-200: slight risk 200-400: some risk		Not vary > 10% of back-ground	≤ 0.002	≤ 0.0003 - ≤ 0.0014, depends on hardness
Other guidelines (e.g. World Bank discharge standards or IncoMaputo receiving water standards)			6-9: domestic use	150: receiving water std			6.6: special effluent std		5: receiving water guideline	10 000: receiving water guideline		2: effluent discharge std	1: effluent discharge std	0.3: effluent discharge std

♦ Fluctuate within 0.5 of a pH unit

El. Con.: electrical conductivity

%ile: percentile

7.4 CONCLUSIONS AND RECOMMENDATIONS

If an EcoStatus approach is to be adopted for an assessment of water quality or physico-chemical data, data collection and analysis must include the following variables. This is particularly important if data is also to be used for EWR assessments in the future.

Salts

- *Selected inorganic salts*: sodium chloride, sodium sulphate, magnesium chloride, magnesium sulphate, calcium chloride and calcium sulphate are assessed, so the ions related to these salts must be included in a monitoring programme, i.e. Na, Cl, SO_4^{2}-, K and Mg.
- As this data is not always available, *Electrical Conductivity* can be used as a surrogate for salts during a rapid assessment.

Nutrients

- *Phosphate* (PO_4^{-3}) *and total inorganic nitrogen (TIN)*. TIN is comprised of nitrate and ammonium.

Physical variables

- *Turbidity*. Although only a qualitative method exists for this variable, it is important to include turbidity in any monitoring programme, particularly for the Mthatha River catchment.
- *pH*
- *Dissolved oxygen*
- *Temperature* (only required if thermal impacts are expected, e.g. downstream of a dam or industry discharging heated effluents)

Toxic substances

- A list of toxic substances can be found in the Ecoclassification manual of Kleynhans et al. (2005). *Ammonia* should always be monitored as a toxic.

Response variables

- *Algal abundance*, i.e. chlorophyll-a (phytoplankton and periphyton)

Additional variables

There may be additional specific variables of concern, for example, because of local geology, or because of discharges and impacts. Additional variables can be motivated in on a site-specific basis.

CHAPTER 8

HABITAT INTEGRITY AND ECOSTATUS

8.1 INTRODUCTION

Ecological State, or **EcoStatus**, is the totality of the features of the river and its riparian zone that enables it to support an appropriate natural flora and fauna. Once field data has been collected following the methods of the NRHP-approved indices, e.g. SASS5 and FAII, the data is interrogated using the following models, so as to arrive at an integrated EcoStatus:

- Hydrological Driver Assessment Index (HAI): not undertaken during this study
- Geomorphology Driver Assessment Index (GAI)
- Physico-chemical Driver Assessment Index (PAI): not undertaken during this study
- Fish Response Assessment Index (FRAI)
- Macroinvertebrate Response Assessment Index (MIRAI)
- Vegetation Response Assessment Index (VEGRAI): currently been tested

The state of the river is therefore expressed in terms of its biophysical components:

- Drivers (physico-chemical, geomorphology, hydrology) which provides a particular habitat template, and
- Biological responses (fish, riparian vegetation and aquatic invertebrates).

Fundamental to the EcoClassification process is therefore the determination of Present Ecological State (PES) and the deviation of the PES from the natural state or Reference Condition. This approach is common to EcoStatus assessments for both the Ecological Reserve and the RHP. An EcoStatus **Level 3** assessment has been defined as appropriate for the RHP, as the RHP mostly focuses on biological responses with only a very generalized indication of cause-and-effect relationships, and is often done for purposes of State-of-Rivers Reports (SoR). (Kleynhans et al., 2005).

The EcoStatus approach therefore relates to (1) determining Ecological Water Requirements (as part of the Ecological Reserve), (2) Ecological Reserve monitoring, and (3) the **River Health Programme** (Kleynhans et al., 2005).

The general relationship between the levels of detail, scale and purpose for the Ecological Reserve and the RHP is indicated in Figure 8.1. Within the RHP the scale and delineation of the resource for EcoStatus assessments vary widely. Ecoregions form the basis of the assessment and, within these, catchments with similar kinds of impacts are usually combined, while DWAF management units are also taken into consideration. The combination of these are termed Assessment Units (Kleynhans et al., 2005). This approach was adopted for the Mthatha River biomonitoring programme, with Assessment Units defined for the catchment. These AU, and representative sampling sites in each AU, are defined in Chapter 2 of this report. All data were therefore collected and analysed per AU (Chapters 3-7), and habitat integrity determined per AU (this chapter). The EcoStatus was also determined per AU (this chapter).

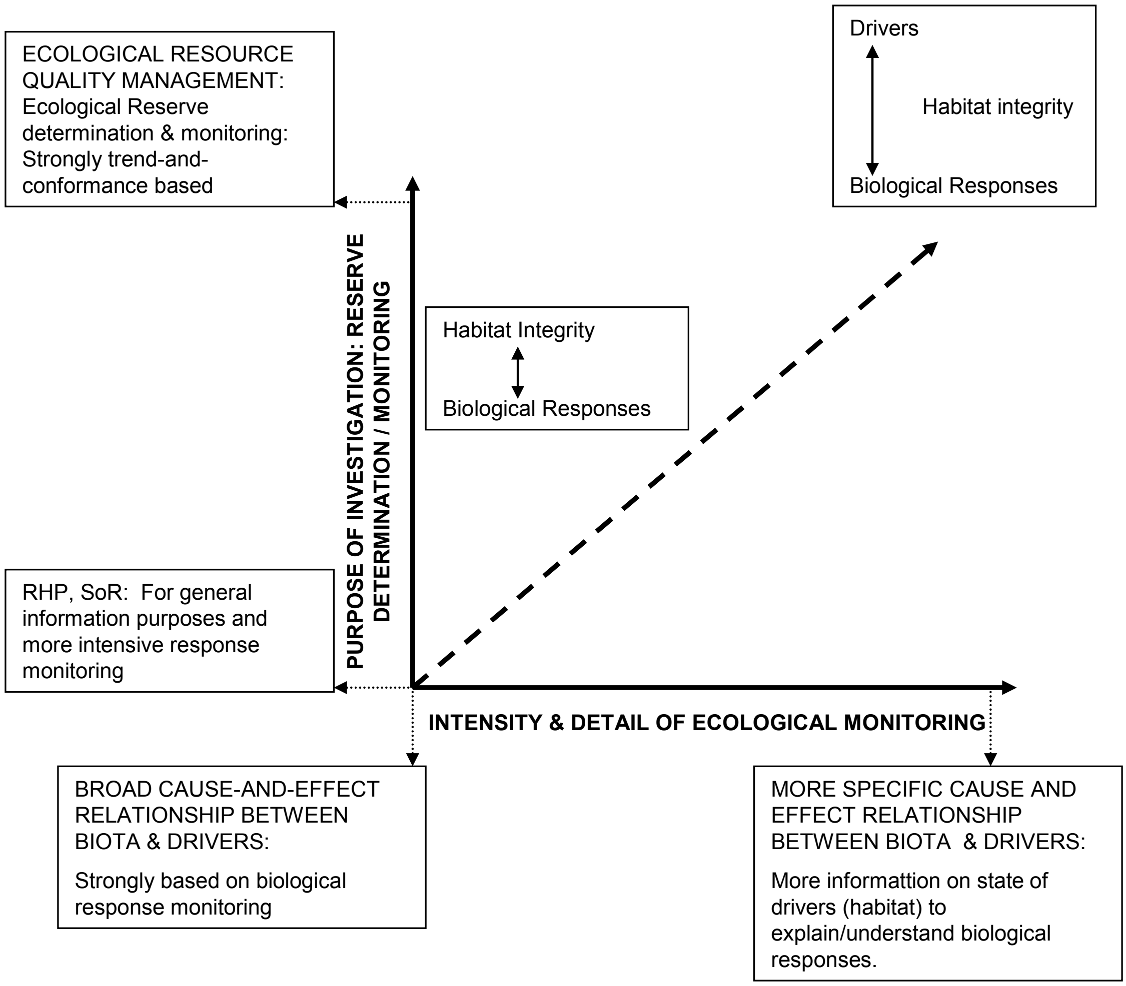

Figure 8.1 Levels of detail for EcoStatus determination for Reserve and RHP purposes

8.2 HABITAT INTEGRITY ASSESSMENT

An EcoStatus Level 3 assessment generally does not include detailed analyses for physical drivers, i.e. flow, water quality and geomorphology. Due to the specialists available to the Mthatha RHP study, geomorphology and some form of water quality assessment was included. However, when conducting EcoStatus Level 3 assessments, the Index of Habitat Integrity (IHI) (Kleynhans, 1996) is generally used as a surrogate for driver information (Figure 8.2). The IHI is applied for both the Instream (nine metrics) and the Riparian areas (eight metrics) (Figure 8.3) (Kleynhans and Louw, 2006). Two levels of IHI exist, one based on an aerial video of the river, and one based on site- or ground-based information.

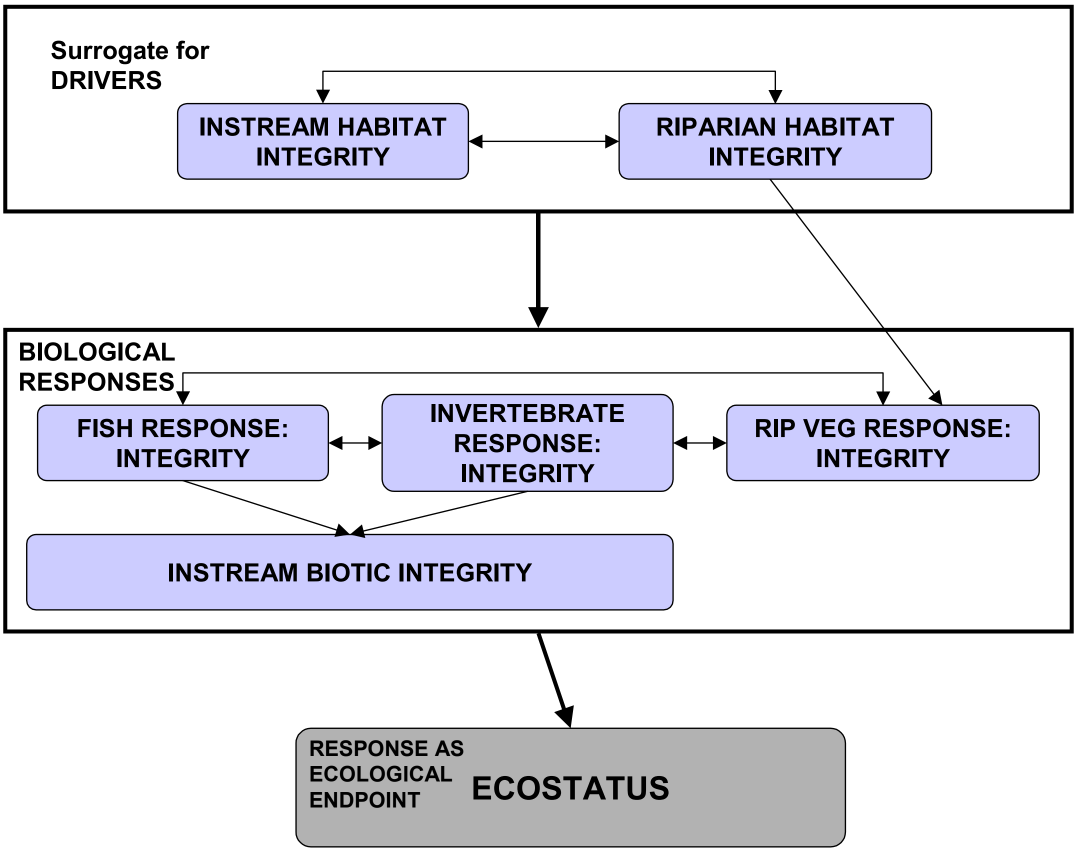

Figure 8.2 A diagrammatic representation of how the IHI is used in EcoStatus Level 3 assessments for the RHP (Kleynhans et al., 2005)

DELINEATION:	**Diep River**
PRIMARY	
WATER ABSTRACTION	10
FLOW MODIFICATION	10
BED MODIFICATION	8
CHANNEL MODIFICATION	11
WATER QUALITY	6
INUNDATION	4
TOTAL (OUT OF 150)	
SECONDARY	
EXOTIC MACROPHYTES	0
EXOTIC FAUNA	0
SOLID WASTE DISPOSAL	0
TOTAL (OUT OF 75)	
INSTREAM HABITAT INTEGRITY SCORE	71
ECOLOGICAL CATEGORY	C

NONE(0); SMALL (0-5); MODERATE (6-10);
LARGE (11-15); CRITICAL (21-25)

DELINEATION	**Diep River**
VEGETATION DECREASE	13
EXOTIC VEGETATION	21
BANK EROSION	14
CHANNEL MODIFICATION	11
WATER ABSTRACTION	2
INUNDATION	2
FLOW MODIFICATION	2
WATER QUALITY	0
TOTAL (OUT OF 200)	65
RIPARIAN ZONE HABITAT INTEGRITY SCORE	**30.25**
ECOLOGICAL CATEGORY	**E**
RIPARIAN VEGETATION RESPONSE SCORE	**37.44**
ECOLOGICAL CATEGORY	**E**

NONE(0); SMALL (0-5); MODERATE (6-10); LARGE (11-15);
CRITICAL (21-25)

Figure 8.3 IHI models: Instream IHI shown on left and Riparian IHI shown on right (Kleynhans and Louw, 2006)

The IHI was conducted for the Mthatha River study area using the approach shown in the tables of Figure 8.3 above. Notes related to completing IHI and EcoStatus tables for the Mthatha River study are as follows:

- It should be noted that the Riparian IHI sheet has two scores that are included in the EcoStatus table (Figure 8.4); firstly the Riparian Zone Habitat Integrity Score, and secondly the Riparian Vegetation Integrity/Response Score. The latter score includes the assessments for *Vegetation Decrease* and *Exotic Vegetation*, i.e. an assessment of the state of riparian vegetation itself. Both these scores are included in the EcoStatus table, with the Riparian Vegetation Integrity/Response score (Figure 8.3, riparian IHI sheet) included as the line '(derived from Rip Zone Integrity)' on Figure 8.4.

COMPONENTS	Diep River
FRAI	65.0
BRAI	64.6
INSTREAM BIOTIC INTEGRITY	64.8
INSTREAM HABITAT INTEGRITY	70.6
RIPARIAN ZONE INTEGRITY	30.2
(DERIVED FROM RIP ZONE INTEGRITY)	37.4
ECOSTATUS SCORE	**50.8**
ECOSTATUS ECOLOGICAL CATEGORY	**D**

Figure 8.4 An example of an EcoStatus table (Kleynhans and Louw, 2006). Note that the BRAI score refers to the MIRAI.

- In the absence of hydrological data for Mthatha Dam, qualitative judgement was applied for potential changes from natural state. Note that releases were conducted (mostly) throughout 2005, with the exception of 19-29 July. This period fell within the second field survey, although large flow changes were not seen. The indication is therefore that the dam attenuates flow, thereby preventing small floods or dry periods.
- Over-stabilization of banks by excessive growth in riparian zones: This can be partly attributed to high instream nutrient levels, but primarily due to attenuated flood flows due to the presence of upstream dams (in the relevant Assessment Units).
- IHI should only consider stretches of river; the presence of dams is only scored under 'inundation'.
- Conditions must be assessed across the AU; localized impacts must therefore be considered as impacts across the AU.

Table 8.1 below is a summary of the IHI scores used to determine EcoStatus per AU. Detailed tables are shown on the Data CD provided with this report.

Table 8.1 IHI scores used to determine EcoStatus per AU for the Mthatha River RHP surveys

ASSESSMENT UNIT	IHI SCORES AND CATEGORY		
	INSTREAM HABITAT INTEGRITY	RIPARIAN ZONE HABITAT INTEGRITY	RIPARIAN VEGETATION INTEGRITY/RESPONSE SCORE
1: upper catchment to Qelana tributary	90: A/B	79.1: B/C	69.4: C
2: below Qelana to Langeni sawmills	88: A/B	56.2: D	35.9: E
3: Langeni sawmills to Mthatha Dam (but excluding Mthatha Dam)	79: B/C	64.5: C	52.1: D
4: Mthatha Dam to Mthata town	68: C	83: B	73.3: C
5: Below Mthatha town to First Falls Dam	46: D	40.3: D	37.4: E
6: Below First Falls Dam to Ngqungqu River confluence	69: C	35.7: E	30.6: E
7: Ngqungqu River confluence to Mthatha estuary	89: A/B	76.3: C	54.6: D
8: Cicira River	67: C	31.9: E	25.3: E
9: Ngqungqu River	95: A	76.7: C	62.7: C – C/D

Table 8.1 clearly shows the poor state of the riparian zone for large parts of the Mthatha River catchment, with the state of the vegetation being particularly poor (scores in far right column).

8.3 ASSESSMENT OF INTEGRATED ECOSTATUS

The tables shown below per section are an integration of data shown in this report, and shows the integrated EcoStatus per Assessment Unit. Although the EcoStatus model was run under a range of scenarios, e.g. EcoStatus without the impact of alien fish, the tables shown in this section pertain to the current status of the catchment. Various scenarios are shown on the data CD accompanying this report.

Also shown per AU are *Ecological Importance and Sensitivity Class* (EISC) tables. These tables (Tables 8.2 – 8.9) capture some of the detail that explains the scoring in the specialist and EcoStatus tables, and are designed to capture any information regarding important indicator species that may affect the overall EcoStatus by their presence or absence. Note that no table exists for AU4 as no data exists for this AU; below Mthatha Dam to Mthaha town. Table 8.10 is a summary table showing the EcoStatus results for all Assessment Units.

8.3.1 EcoStatus of Assessment Unit 1: Upper catchment to Mthatha – Qelana tributary

Table 8.2 EIS table for AU1

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			3		A number of protected trees under the Nat Forestry Act e.g *Podocarpus* (3 spp) + *Curtisiadentata*
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			1		
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			2		Presence of Blethaceridae (**check sp.**) + Perlidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			2		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			3		Boulder cascades, glides, runs, pools, broken water
Refugia (4=Very high - 1=marginal/low)			1		Not NB on a local scale
Sensitivity to flow changes (4=Very high - 1=marginal/low)			1		Fairly narrow channel so not very sensitive
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			2		High in catchment but small stream. Little shading.
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			3		Some natural vegetation on both banks, + connectivity in riparian habitats
Importance of conservation & natural areas (range, 4=very high - 0=very low)			2		Upstream of site in a natural state as not accessible
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**MODERATE**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	1	100			
2.What is the natural diversity of **fish** species with a preference for different cover types	1	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	1	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	1	100			
FISH ECOLOGICAL CATEGORY	4	400	**43.1**	**D**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	3	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9**	300	**75.4**	**C**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		700	**68.9**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	1	0.29	12.31
Confidence rating for **macro-invertebrate** information	2.5	0.71	53.86
	3.5	1.00	66.17
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	68.9	45.50
Derived riparian vegetation	69.4	22.90
		68.40
ECOSTATUS EC		**C**
BOUNDARY EC		

8.3.2 EcoStatus of Assessment Unit 2: Below Mthatha – Qelana tributary to Langeni sawmills

Table 8.3 EIS table for AU2

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			0		
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			1		Presence of Oligoneuridae
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			2		Presence of Oligoneuridae + Perlidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			2		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			2		Minimal glides, riffles, pools, minimal broken water
Refugia (4=Very high - 1=marginal/low)			1		Not NB on a local scale
Sensitivity to flow changes (4=Very high - 1=marginal/low)			2		Wider channel than AU 1
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			2.5		High in catchment but small stream. Little shading.
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			1		Forestry provides some type of migration route
Importance of conservation & natural areas (range, 4=very high - 0=very low)			1		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**MODERATE**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	1	100			
2.What is the natural diversity of **fish** species with a preference for different cover types	1	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	1	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	1	100			
FISH ECOLOGICAL CATEGORY	4	400	**41.1**	**D**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	4	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	85			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3.5	90			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**10.5**	275	**83.4**	**B**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		675	**76.0**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	1	0.22	9.13
Confidence rating for **macro-invertebrate** information	3.5	0.78	64.87
	4.5	1.00	74.00
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	76.0	50.15
Derived riparian vegetation	35.9	11.85
		62.00
ECOSTATUS EC		**C**

8.3.3 EcoStatus of Assessment Unit 3: Below Langeni sawmills to Mthatha Dam

Table 8.4 EIS table for AU3

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			0		
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			1		Presence of Oligoneuridae + Prosopistomatidae
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			2		Presence of Oligoneuridae + Perlidae + Prosopistomatidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			2		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			1		Minimal glides + runs, riffles, rapids, pools
Refugia (4=Very high - 1=marginal/low)			1		Not NB on a local scale
Sensitivity to flow changes (4=Very high - 1=marginal/low)			2		Wider channel than AU 1
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			2		
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			1		Forestry provides some type of migration route
Importance of conservation & natural areas (range, 4=very high - 0=very low)			1		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**MODERATE**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	1	100			
2.What is the natural diversity of **fish** species with a preference for different cover types	1	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	1	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	1	100			
FISH ECOLOGICAL CATEGORY	4	400	**43.1**	**D**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	3	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9**	300	**75.4**	**C**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		700	**68.9**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	1	0.29	12.31
Confidence rating for **macro-invertebrate** information	2.5	0.71	53.86
	3.5	1.00	66.17
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	68.9	45.50
Derived riparian vegetation	52.1	17.19
		62.69
ECOSTATUS EC		**C**
BOUNDARY EC		

8.3.4 EcoStatus of Assessment Unit 4: Below Langeni sawmills to Mthatha Dam to Mthata town

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	1	100			
2.What is the natural diversity of **fish** species with a preference for different cover types	1	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	1	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	1	100			
FISH ECOLOGICAL CATEGORY	4	400	**43.1**	**D**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	3	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9**	300	**75.4**	**C**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		700	**68.9**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	1	0.29	12.31
Confidence rating for **macro-invertebrate** information	2.5	0.71	53.86
	3.5	1.00	66.17
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	68.9	45.50
Derived riparian vegetation	73.3	24.19
		69.69
ECOSTATUS EC		**C**
BOUNDARY EC		

8.3.5 EcoStatus of Assessment Unit 5: Mthatha Dam to First Falls Dam

Table 8.5 EIS table for AU5

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			0		
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			0		
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			1		Presence of Hydropsychidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			1		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			1.5		Minimal glides, runs + riffles, rapids, some pools + broken water
Refugia (4=Very high - 1=marginal/low)			0		
Sensitivity to flow changes (4=Very high - 1=marginal/low)			1		
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			1		
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			1		Particularly in AU4
Importance of conservation & natural areas (range, 4=very high - 0=very low)			0		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**LOW**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	2	70			
2.What is the natural diversity of **fish** species with a preference for different cover types	3	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	3	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	70			
FISH ECOLOGICAL CATEGORY	10	340	**30.4**	**E**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	2.5	60			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**8.5**	260	**45.2**	**D**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		600	**39.2**	**E**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	1	0.40	12.14
Confidence rating for **macro-invertebrate** information	1.5	0.60	27.12
	2.5	1.00	39.26
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**E**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	39.2	25.89
Derived riparian vegetation	37.4	12.34
		38.23
ECOSTATUS EC		**E**
BOUNDARY EC		

8.3.6 EcoStatus of Assessment Unit 6: Below First Falls Dam to Ngqungqu – Mthatha confluence

Table 8.6 EIS table for AU6

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			0		
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			0		
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			1		Presence of Heptageniidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			1		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			2.5		Glides, runs, rapids, riffles, pools, minimal broken water
Refugia (4=Very high - 1=marginal/low)			1.5		
Sensitivity to flow changes (4=Very high - 1=marginal/low)			2		
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			2		Wide and shallow
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			1		Migration possible for eels as below dam
Importance of conservation & natural areas (range, 4=very high - 0=very low)			1		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**LOW**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	2	70			
2.What is the natural diversity of **fish** species with a preference for different cover types	3	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	3	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	70			
FISH ECOLOGICAL CATEGORY	10	340	**75.1**	**C**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	3	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9**	300	**57.8**	**D**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		640	**64.6**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0.50	37.57
Confidence rating for **macro-invertebrate** information	3	0.50	28.90
	6	1.00	66.47
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	64.6	42.64
Derived riparian vegetation	30.6	10.10
		52.74
ECOSTATUS EC		**D**
BOUNDARY EC		

8.3.7 EcoStatus of Assessment Unit 7: Ngqungqu – Mthatha confluence to Mthatha Estuary

Table 8.7 EIS table for AU7

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			4		Pipe-fish (1 record of pipe-fish in a river)
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			4		*Caffiogobius* sp. (unique fish species)
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			2		Presence of Tricorythidae, Prosopistomatidae, Heptageniidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			2		Due to macroinvertebrate diversity
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			2.5		Glides, runs, limited types of pools, minimal broken water, riffles, rapids
Refugia (4=Very high - 1=marginal/low)			2.5		Presence of pipe-fish + *Caffiogobius* sp.
Sensitivity to flow changes (4=Very high - 1=marginal/low)			1.5		
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			1		Wide, deep+ fast-flowing
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			2		Migration possible for eels + river prawns
Importance of conservation & natural areas (range, 4=very high - 0=very low)			2.5		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**HIGH**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	3	100			
2.What is the natural diversity of **fish** species with a preference for different cover types	2	50			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	2.5	70			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	50			
FISH ECOLOGICAL CATEGORY	9.5	270	**88.7**	**B**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	3	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	2.5	80			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**8.5**	280	**70.8**	**C**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		550	**77.9**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	3	0.46	40.94
Confidence rating for **macro-invertebrate** information	3.5	0.54	38.12
	6.5	1.00	79.06
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	77.9	51.41
Derived riparian vegetation	54.6	18.02
		69.43
ECOSTATUS EC		**C**
BOUNDARY EC		

8.3.8 EcoStatus of Assessment Unit 8: Cicira River

Table 8.8 EIS table for AU8

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			0		
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			0		
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			1		Presence of Hydropsychidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			1		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			1.5		Frequent pools, limited glides + runs, minimal broken water, minimal riffles
Refugia (4=Very high - 1=marginal/low)			1		
Sensitivity to flow changes (4=Very high - 1=marginal/low)			3		
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			3		
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			0		
Importance of conservation & natural areas (range, 4=very high - 0=very low)			0		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**LOW**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	2	70			
2.What is the natural diversity of **fish** species with a preference for different cover types	2	70			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	2.5	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	2	70			
FISH ECOLOGICAL CATEGORY	8.5	310	**36.8**	**E**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	1.5	60			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	2	80			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	2.5	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**6**	240	**66.7**	**C**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		550	**53.6**	**D**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	2	0.40	14.72
Confidence rating for **macro-invertebrate** information	3	0.60	40.02
	5	1.00	54.74
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**D**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	53.6	35.39
Derived riparian vegetation	25.3	8.35
		43.74
ECOSTATUS EC		**D**
BOUNDARY EC		

8.3.9 EcoStatus of Assessment Unit 9: Ngqungqu River

Table 8.9 EIS table for AU9

DETERMINANTS	NATURAL		PRESENT		
	SCORE	CONF	SCORE	CONF	
	(0-4)		(0-4)		
BIOTA (RIPARIAN & INSTREAM)					**COMMENTS**
Rare & endangered (range: 4=very high - 0= none)			0		
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)			1		Isolated population of *Barbus anoplus*
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)			2		Presence of Perlidae, Tricorythidae + Heptageniidae
Species/taxon richness (range: 4=very high - 1=low/marginal)			3		
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)			2.5		Pools, rapids, glide, runs, riffles, minimal broken water
Refugia (4=Very high - 1=marginal/low)			3		Good quality of Mthatha River, NB for *Barbus anoplus*
Sensitivity to flow changes (4=Very high - 1=marginal/low)			2		
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)			2		Wide and shallow
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)			2		Migration route for eels
Importance of conservation & natural areas (range, 4=very high - 0=very low)			3		
MEDIAN OF DETERMINANTS					
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)			**MODERATE**		

INSTREAM BIOTA	Importance Score	Weight	EC %	EC	Boundary EC
FISH					
1.What is the natural diversity of **fish** species with different flow requirements	1	100			
2.What is the natural diversity of **fish** species with a preference for different cover types	1	100			
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	1	100			
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	1	100			
FISH ECOLOGICAL CATEGORY	4	400	**43.1**	**D**	
AQUATIC INVERTEBRATES					
1. What is the natural diversity of **invertebrate** biotopes	3	100			
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3	100			
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	3	100			
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**9**	300	**75.4**	**C**	
INSTREAM ECOLOGICAL CATEGORY (No confidence)		700	**68.9**	**C**	**n/a**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	Confidence rating	Proporitons	Modified weights
Confidence rating for **fish** information	1	0.29	12.31
Confidence rating for **macro-invertebrate** information	2.5	0.71	53.86
	3.5	1.00	66.17
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**
	Boundary EC		**n/a**

ECOSTATUS WITH CONFIDENCE	Percentage	Modified weights
Instream EC	68.9	45.50
Derived riparian vegetation	62.7	20.69
		66.19
ECOSTATUS EC		**C**
BOUNDARY EC		

Table 8.10 A summary of EcoStatus category per AU and resulting River Health Class

ASSESSMENT UNIT	DESCRIPTION OF LOCATION	ECOSTATUS CATEGORY	RIVER HEALTH CLASS
1	Upper catchment to the confluence of the Qelana and Mthatha rivers	C (68.40)	Fair
2	Below the Qelana tributary to the Langeni sawmills	C – C/D (62.01)	Fair
3	Langeni sawmills to Mthatha Dam (but excluding Mthatha Dam)	C (62.69)	Fair
4	Downstream Mthatha Dam to Mthatha town (no data; qualitative assessment based on aerial video only)	C (69.69)	Fair
5	Below Mthatha town to First Falls Dam	E (38.23)	Poor
6	Below First Falls Dam to Ngqungqu River confluence	D – D/E (52.74)	
7	Ngqungqu River confluence to Mthatha estuary	C (69.43)	Fair
8	Cicira River	D (43.74)	Fair
9	Ngqungqu River	C (66.19)	Fair

CHAPTER 9

FINAL DISCUSSION AND CONCLUSION

9.1 MANAGEMENT PLAN FOR THE MTHATHA RIVER CATCHMENT

A Management Plan (MP) has been developed for the Mthatha River catchment. The MP was developed for DWAF in 2004 by Toriso Tlou for Ninham Shand Inc., in association with Goba Moahloli and Associates. Although the MP addressed a wide range of issues, only those directly related to water resources are outlined here. The MP consisted of the following strategic components. Notes from this study are shown in *itaclics.*

9.1.1 Water quality

- **Discharge of untreated sewage and stormwater runoff into rivers**

The town of Mthatha and Mthatha Prison need to upgrade their sewage systems and sewage treatment works. Additionally, the quality of the effluent discharge must be monitored. Stormwater drainage systems must generally be improved in order to prevent stormwater runoff from entering the rivers.

- **Dense rural and informal settlements along the banks of the Mthatha River**

Two potential strategic options were developed around this issue. Firstly, relocate informal settlements to areas where services such as water and sanitation are already established, particularly for residents living below the 1:50 year floodline. Secondly, provide sanitation infrastructure to the settlements and ensure that not dense settlements are located near the river.

- **Solid waste management**

A solid waste management plan needs to be drawn up for the informal settlements around Mthatha and along the river banks.

The River Health Class for the Assessment Unit below Mthatha town was determined as Poor; proving this to be the worst section of the Mthatha River. No evidence of water quality management strategies (as outlined above) was seen at the time of RHP surveys.

- **Soil erosion**

A grazing management system should be developed, as well as soil conservation measures to reduce soil erosion. Reducing poverty in the region would also result in less pressure on the land through less reliance on subsistence farming.

- **Alien vegetation in the rivers**

The impact of alien weeds on the water resources of the catchment had not yet been quantified at the time of writing in 2004. The first step would therefore be to identify the extent of alien weeds in the system.

The impact of poor land management practices (resulting in erosion) and alien vegetation on the status of the riparian zone, and the impact of aquatic weeds, was assessed during the

Mthatha River RHP surveys. Impacts attributable to these factors were shown to be high, resulting in the riparian zones along most river stretches being poor.

9.1.2 Water quantity

A comparison between the available surface and groundwater resources and the current water requirements of the system indicated that there was surplus water in the Mthatha River catchment area in 2004, providing an opportunity for further water resource development. Possible developments include tourism, irrigated agriculture and forestry. It is important to note, however, that the requirements of the ecological component of the Reserve have not yet been fully quantified, and as such the estimated availability of water in the region may be inaccurate.

The existing water resource infrastructure, in particular Mthatha Dam and the ESKOM hydro-electricity generation scheme, is affecting the functioning of the ecosystems of the rivers and estuaries in the catchment area. The Mthatha River and its estuary have been negatively impacted by the reversal of the natural water flow due to the hydro-electricity scheme. As a result, the Mthatha River and its catchment are highly degraded. The following strategic options were therefore recommended for water quantity and flow (DWAF, 2004).

- **Ecological Water Requirements (EWR) or the Ecological Reserve**

Ecological Reserve requirements need to be determined at higher confidence levels in order to accurately calculate the total water requirements of the catchment.

In order to address the conflict between the environmental flow regime needed for the ecological sustainability of the Mthatha River and the economic benefits of ESKOM's hydro-electricity scheme, the operation of the Mthatha Dam, as well as the First Falls and Second Falls Dams (30 kms apart and downstream of Mthatha Dam), needs to be reviewed. Additionally, it is essential to create a greater awareness of the importance of environmental considerations in existing and future developments.

The results of the RHP survey provide some data for future EWR studies. It is critical that such a study be conducted.

- **Water supply and sanitation infrastructure**

Although there were surplus surface and groundwater resources in the Mthatha River catchment area at the time of the assessment in 2004, there is inadequate access to potable water supply due to a lack of basic infrastructure. As a result, most of the rural population is dependent on untreated river water or groundwater. The use of groundwater is costly to develop in rural areas.

The majority of rural villages also had no adequate sanitation infrastructure, resulting in the deterioration of the quality of both ground and river water resources.

Through the District and Local Municipalities, the Provincial Department of Local Government and Housing carries the constitutional responsibility for providing water services to the communities in their area of jurisdiction. One of the major problems facing the local authorities, however, is the lack of technical, managerial and financial capacity to take on these projects. It is therefore essential that the responsible organisations address these issues by negotiating and influencing organisations such as donors, user groups, other government departments and input suppliers to assist them in the planning, controlling and implementing of water supply and sanitation projects.

- **Water conservation and demand management issues**

Although no study (as at 2004) had been conducted regarding the water use efficiencies and water losses in water use sectors such as irrigation, electricity generation, etc., a desktop study of the municipal use of water for the town of Mthatha indicated that there were high levels of unaccounted water losses and high per capita consumption problems in the town. Water losses in Mthatha, and other towns in the catchment area, may be due to the poor state of repair of the water supply infrastructure and meter reading errors in the town.

There are a number of strategic options to combat water losses, including: (i) engineering options, through passive and active leak detection and pressure management programmes; (ii) consumer demand management, through the implementation of a stepped tariff structure; (iii) economic incentives, by providing water to economically sustainable activities such as irrigation and livestock farming; and (iv) the replacement of consumer meters to improve the revenue generation.

It is also essential that similar water conservation and water demand management programmes be installed for all water use sectors such as irrigated agriculture and electricity-generation.

9.1.3 Institutional issues

The Mthatha River Catchment Forum lacks representation by various stakeholders, including the local authorities and the OR Tambo District Municipality. Stakeholders appear to view water resources management as the function and responsibility of the government through the Department of Water Affairs and Forestry. The DWAF must therefore create awareness among stakeholders, particularly the institutional stakeholders, of the need for integrated management at local and catchment level.

Another strategy would be for the DWAF to consider establishing Water User Associations in the catchment area. These would aim to improve the management of water resources and the water resources infrastructure, as well as giving the local stakeholders a say in the management of their resources.

9.2 SUMMARIZED RESULTS OF THE MTHATHA RIVER RHP STUDY

Table 9.1 is a summer of results for the Mthatha River study per AU, showing a breakdown of results per index, as well as the overall EcoStatus.

The results of the study clearly show the major problems experienced in the catchment are due to the over-utilization and degradation of riparian vegetation, the introduction of alien fish to the system, erosion and poor landuse management, the impact of flow modification downstream from Mthahta Dam and water quality issues, particularly downstream Mthatha town and the Cicira tributary.

INDICATORS	ASSESSMENT UNITS								
	AU1	**AU2**	**AU3**	**AU4**	**AU5**	**AU6**	**AU7**	**AU8**	**AU9**
EC: MIRAI	C	B	C	-	D	C/D	C	C	B
EC: FRAI	D	D	E	D	E	C	B	E	C
EC: GAI	B	C	B/C	C/D	D	C	B/C	C	B/C
EC: IRVI	C	D	D	D	E	E	D	E	D
EISC	M	M	M	-	Low	Low	High	Low	M
EcoStatus	C	C-C/D	C	C	E	D-D/E	C	D	C
River Health Class	**Fair**	**Fair**	**Fair**	**Fair**	**Poor**	**Fair**	**Fair**	**Fair**	**Fair**

M: moderate

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APPENDIX 1

PHOTOGRAPHIC RECORD OF MONITORING SITES

SITE 1, SOURCE OF THE MTHATHA RIVER: Least impacted site, although still located in commercial forestry plantations. Site was below the confluence of two mountain streams, with large boulders and loose gravel dominating the site. Site was on a gradient with large pools further downstream. Stream width approximately 2m.

SITE 2, MTHATHA RIVER UPSTREAM OF LANGENI SAWMILLS: Long riffle stretch immediately downstream of the road bridge, with pools dominating just upstream of the bridge. Site very disturbed further down with a small access road bulldozed to the river on the left bank to collect water for dust suppression during road-building. A berm had also been constructed across the stream to contain water for collection.

SITE 3, MTHATHA RIVER DOWNSTREAM OF LANGENI SAWMILLS: Site in meandering section of river; deep pools, runs and some riffle area present. Road and plantations on left bank. Distrubed riparian vegetation.

SITE 4, MTHATHA RIVER AT KAMBI FOREST STATION: The river channel is wide with flood damage evident upstream of the bridge. The river is shallow and sediment deposition is extensive. Pools evident, with little riffle area. The site is above Mthatha Dam.

SITE 5, MTHATHA RIVER AT MTHATHA TOWN: The site is below Mthatha Dam, and is wide and fast-flowing. Quality conditions are very poor, with unserviced informal settlements located in the riparian zone. Little vegetation remains in the riparian zone.

SITE 6, MTHATHA RIVER AT TAKATA: This site is below First Falls Dam, with the river channel being wide and shallow. Extensive pools and riffles are evident, although this stretch serves as a cattle crossing point. Disturbed riparian zone.

SITE 7, MTHATHA RIVER AT MPINDWENI: The terrain in this lower part of the catchment is very mountainous, with boulders dominating the instream habitat. The river is wide and fast-flowing, with the riparian zone being invaded by alien vegetation. The area is relatively unimpacted by settlements.

SITE 8, MTHATHA RIVER AT MDUMBI: This is the last site above the influence of the estuary. Water hyacinth was seen floating down the river at this point - the flow is slower than at Site 7. Pools and backwaters are seen at the site, with a riffle stretch below the bridge. The riparian zone is invaded by alien vegetation.

SITE 9, CICIRA RIVER: Tributary of the Mthatha River at Mthatha town and flowing into Mthatha Dam. Site is litter-infested, with a small channel (a few meters across) and little instream habitat. Pools are found under the bridge and downstream of the bridge. Rocks were extensively covered by algae indicating nutrient enrichment at the site.

SITE 10, NGQUNGQU RIVER: Tributary in the lower section of the Mthatha River, which joins the main stem above sites 7 and 8. Extensive riffle stretch upstream of the bridge, with pools upstream and downstream of the road bridge. Little riparian vegetation upstream of the bridge due to the geology of the area. Few impacts in the area.

APPENDIX 2

MACROINVERTEBRATES

THE RIVER HEALTH PROGRAMME

DEPT. OF WATER AFFAIRS & FORESTRY
WATER RESEARCH COMMISSION
DEPT. OF ENVIRONMENTAL AFFAIRS & TOURISM

Date: / /200__

Grid References:
S: ° ' , "
E: ° ' , "

WGS-84	Cape datum

Site code:……………………

River:……………………………………………

Site description:……………………………………

Weather Condition:…………………………………

Temp:……………°C pH:………………

DO:………………mg/l Cond:…………mS/m

Biotopes sampled:

SIC ……………… Time……………minutes
SOOC………………
Bedrock……………
Aquatic veg'n……… Dom. sp.……………………
MvegIC………… Dom. sp.……………………
MvegOOC……… Dom. sp.……………………
Gravel………… Sand……………
Mud………………
Hand picking/Visual observation……………

Flow: Low/Medium/High/Flood
Turbidity: Low/Medium/High
Riparian land use:

Disturbance in the river: eg. sandwinning, cattle drinking point, floods etc.

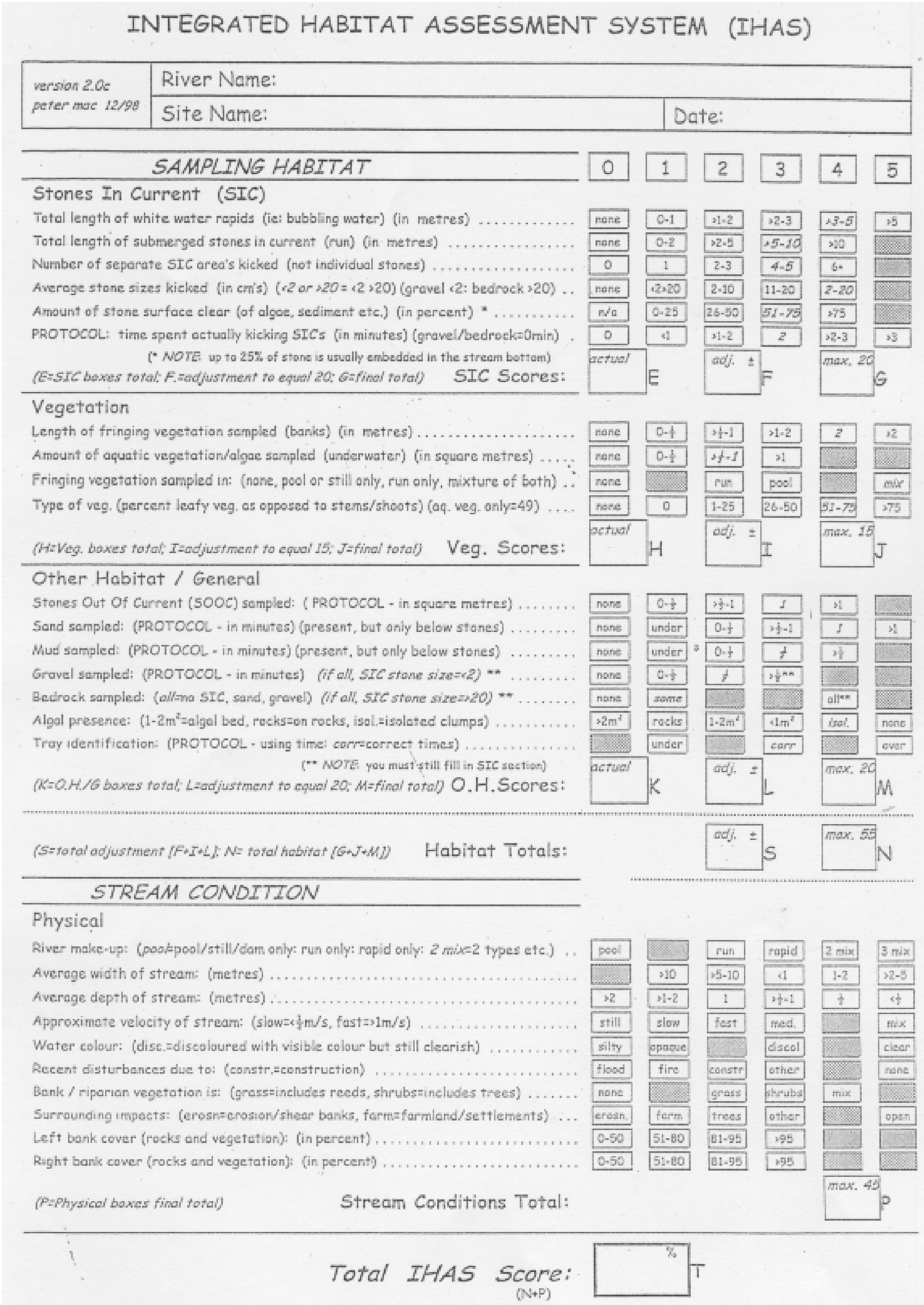
Signs of pollution: eg. smell and colour of water, petroleum, dead fish, etc.

Other observations:

Taxon		S	VG	GSM	TOT	Taxon		S	VG	GSM	TOT	Taxon		S	VG	GSM	TOT
PORIFERA	5					HEMIPTERA						DIPTERA					
COELENTERATA	1					Belostomatidae*	3					Athericidae	10				
TURBELLARIA	3					Corixidae*	3					Blepharoceridae	15				
ANNELIDA						Gerridae*	5					Ceratopogonidae	5				
Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
Leeches	3					Naucoridae*	7					Culicidae*	1				
CRUSTACEA						Nepidae*	3					Dixidae*	10				
Amphipoda	13					Notonectidae*	3					Empididae	6				
Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
Atyidae	8					Veliidae/M...veliidae*	5					Muscidae	1				
Palaemonidae	10					MEGALOPTERA						Psychodidae	1				
HYDRACARINA	8					Corydalidae	8					Simuliidae	5				
PLECOPTERA						Sialidae	6					Syrphidae*	1				
Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
Baetidae 1sp	4					Hydropsychidae 1 sp	4					Ancylidae	6				
Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
Heptageniidae	13					Psychomyiidae/Xiphoce	8					Planorbinae*	3				
Leptophlebiidae	9					**Cased caddis:**						Thiaridae*	3				
Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
ODONATA						Lepidostomatidae	10					Sass score					
Calopterygidae ST,T	10					Leptoceridae	6					No. of taxa					
Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT					
Chlorolestidae	8					Pisuliidae	10										
Coenagrionidae	4					Sericostomatidae SWC	13					IHAS					
Lestidae	8					COLEOPTERA											
Platycnemidae	10					Dytiscidae*	5					Other biota:					
Protoneuridae	8					Elmidae/Dryopidae*	8										
Zygoptera juvs.	6					Gyrinidae*	5										
Aeshnidae	8					Haliplidae*	5										
Corduliidae	8					Helodidae	12					Comments:					
Gomphidae	6					Hydraenidae*	8										
Libellulidae	4					Hydrophilidae*	5										
LEPIDOPTERA						Limnichidae	10										
Pyralidae	12					Psephenidae	10										

Procedure: Kick stones in current & bedrock for 2 mins, max. 5 mins. Kick SOOC & bedrock +/- 1m2. Sweep vegetation (IC & OOC) for 2m total. Stir & sweep gravel, sand, mud for 30 secs total. * = airbreathers
Hand picking & visual observation for 1 min - record in biotope where found. Tip net contents into tray. Remove leaves, twigs & trash. Check taxa present for 15 mins and stop if no new taxa seen after 5 mins.
Estimate abundances: 1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000 S = Stone and rock; VG = All vegetation; GSM = Gravel, sand, mud SWC = South Western Cape, T = Tropical, ST = Sub-tropical
Rate invertebrate biotope sampled: 1=very poor (i.e. limited diversity), 5=highly suitable (i.e. wide diversity)

Figure 2-1 A SASS5 data sheet used for scoring macroinvertebrate samples



INTEGRATED HABITAT ASSESSMENT SYSTEM (IHAS)

version 2.0c *peter mac 12/98*	River Name:	
	Site Name:	Date:

SAMPLING HABITAT	0	1	2	3	4	5
Stones In Current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone sizes kicked (in cm's) (*<2 or >20* = <2 >20) (gravel <2: bedrock >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment etc.) (in percent) *	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking *SICs* (in minutes) (gravel/bedrock=0min)	0	<1	>1-2	2	>2-3	>3
(* *NOTE*: up to 25% of stone is usually embedded in the stream bottom)	*actual*	E	*adj. ±*	F	*max. 20*	G
(E=SIC boxes total; F.=adjustment to equal 20; G=final total) **SIC Scores:**						
Vegetation						
Length of fringing vegetation sampled (banks) (in metres)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: (none, pool or still only, run only, mixture of both)	none		run	pool		mix
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49)	none	0	1-25	26-50	51-75	>75
(H=Veg. boxes total; I=adjustment to equal 15; J=final total) **Veg. Scores:**	*actual*	H	*adj. ±*	I	*max. 15*	J
Other Habitat / General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) (present, but only below stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) (present, but only below stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) *(if all, SIC stone size=<2)* **	none	0-½	½	>½**		
Bedrock sampled: (*all=no SIC, sand, gravel*) *(if all, SIC stone size=>20)* **	none	*some*			all**	
Algal presence: (1-2m² =algal bed, rocks=on rocks, isol.=isolated clumps)	>2m²	rocks	1-2m²	<1m²	*isol.*	none
Tray identification: (PROTOCOL - using time: *corr*=correct times)		under		*corr*		over
(** *NOTE*: you must still fill in SIC section)	*actual*	K	*adj. ±*	L	*max. 20*	M
(K=O.H./G boxes total; L=adjustment to equal 20; M=final total) **O.H.Scores:**						
(S=total adjustment [F+I+L]; N= total habitat [G+J+M]) **Habitat Totals:**			*adj. ±*	S	*max. 55*	N

STREAM CONDITION						
Physical						
River make-up: (*pool*=pool/still/dam only: run only: rapid only: *2 mix*=2 types etc.)	pool		run	rapid	2 mix	3 mix
Average width of stream: (metres)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (metres)	>2	>1-2	1	>½-1	½	<½
Approximate velocity of stream: (slow=<½m/s, fast=>1m/s)	still	slow	fast	med.		mix
Water colour: (disc.=discoloured with visible colour but still clearish)	silty	opaque		discol		clear
Recent disturbances due to: (constr.=construction)	flood	fire	constr	other		none
Bank / riparian vegetation is: (grass=includes reeds, shrubs=includes trees)	none		grass	shrubs	mix	
Surrounding impacts: (erosn=erosion/shear banks, farm=farmland/settlements)	erosn.	farm	trees	other		open
Left bank cover (rocks and vegetation): (in percent)	0-50	51-80	81-95	>95		
Right bank cover (rocks and vegetation): (in percent)	0-50	51-80	81-95	>95		
(P=Physical boxes final total) **Stream Conditions Total:**					*max. 45*	P

Total IHAS Score: (N+P) ___ % T

Figure 2-2 An IHAS datasheet used for assessing habitat quality

Table 2-1 SASS scores, number of taxa, ASPT and IHAS for each site for each of the sampling surveys of the Mthatha River

	Summer			Winter			Spring		
	SASS	No. taxa	ASPT	SASS	No. taxa	ASPT	SASS	No. taxa	ASPT
	Site 1								
Stones	Not sampled			Not sampled			77	9	8.6
Vegetation							Biotope unavailable		
Gravel, sand, mud							44	8	5.5
Total site score							101	14	7.2
IHAS							70		
	Site 2								
Stones	109	17	6.4	92	12	7.7	82	12	6.8
Vegetation	51	9	5.7	69	13	5.3	28	6	4.7
Gravel, sand, mud	51	7	7.3	26	6	4.3	43	7	6.1
Total site score	151	21	7.2	130	21	6.2	110	17	6.5
IHAS				75			70		
	Site 3								
Stones	68	8	8.5	56	8	7	24	7	3.4
Vegetation	45	5	9	51	11	4.6	50	10	5
Gravel, sand, mud	18	5	3.6	41	8	5.1	13	4	3.3
Total site score	90	12	7.5	85	15	5.7	61	14	4.4
IHAS				59			68		
	Site 4								
Stones	74	10	7.4	71	10	7.1	100	14	7.1
Vegetation	35	5	7	17	4	4.3	Biotope unavailable		
Gravel, sand, mud	52	9	5.8	31	6	5.2	47	8	5.9
Total site score	116	17	6.8	93	14	6.6	122	18	6.7
IHAS				62			54		
	Site 5								
Stones	17	5	3.4	11	3	3.7	Not sampled		
Vegetation	13	3	4.3	9	2	4.5			
Gravel, sand, mud	0	0	0	8	2	4			
Total site score	22	6	3.6	23	6	3.8			
IHAS				62					

	Summer			Winter			Spring		
	SASS	**No. taxa**	**ASPT**	**SASS**	**No. taxa**	**ASPT**	**SASS**	**No. taxa**	**ASPT**
	Site 6								
Stones	40	7	5.7	49	8	6.1	11	2	3.7
Vegetation	38	7	5.4	19	4	4.8	13	2	6.5
Gravel, sand, mud	13	3	4.3	18	4	4.5	4	1	4
Total site score	50	9	5.5	67	12	5.6	24	5	4.8
IHAS				67			66		
	Site 7								
Stones				88	13	6.8	78	8	9.8
Vegetation				43	6	7.2	57	9	6.3
Gravel, sand, mud	Not sampled			59	11	5.4	Biotope unavailable		
Total site score				126	20	6.3	94	12	7.8
IHAS				71			65		
	Site 8								
Stones	35	4	8.8	63	12	5.3	48	7	6.9
Vegetation	20	4	5	36	7	5.1	29	6	4.8
Gravel, sand, mud	22	3	7.3	27	4	6.8	26	6	4.3
Total site score	53	7	7.6	91	17	5.4	66	11	6
IHAS				75			74		
	Site 9								
Stones	46	9	5.1	44	9	4.9	20	5	4
Vegetation	44	9	4.9	25	7	3.6	59	12	4.9
Gravel, sand, mud	26	5	5.2	39	9	4.3	11	4	2.8
Total site score	78	15	5.2	70	17	4.1	80	18	4.4
IHAS				67			?		
	Site 10								
Stones	76	12	6.3	130	19	6.8	107	16	6.7
Vegetation	71	16	4.4	29	7	4.1	44	9	4.9
Gravel, sand, mud	27	6	4.5	37	9	4.1	48	8	6
Total site score	131	25	5.2*	194	28	6.9	147	24	6.1
IHAS				80			71		

* A different site was sampled on the Ngqungqu River during summer. It has been included in the table for completeness, but in calculating the mean ASPT score it has been excluded.

Table 2-2 Summary of the in-stream macroinvertebrates sampled during each of the biomonitoring surveys in the Mthatha River (Sites 1-8), and selected tributaries (Sites 9 and 10). Results for individual biotopes at each site are combined to provide presence / absence summary per site) (Su: summer; W: winter; Sp: spring). Shaded columns were not sampled.

SITE	**1**			**2**			**3**			**4**			**5**		
Season	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**
Turbellaria					●			●		●					
Annelida															
Oligochaeta			●		●		●	●	●				●		
Leeches													●		
Crustacea															
Potamonautidae				●	●	●	●	●	●						
Hydracarina			●	●		●									
Plecoptera															
Perlidae			●	●	●	●	●								
Ephemeroptera															
Baetidae			●	●	●	●	●	●	●	●	●	●	●	●	
Caenidae				●	●			●		●					
Heptageniidae			●	●	●	●	●	●			●	●			
Leptophlebiidae			●	●	●		●			●	●	●			
Oligoneuridae				●			●			●					
Prosopistomatidae												●			
Tricorythidae			●	●	●	●				●	●	●			
Odonata															
Chlorocyphidae										●					
Chlorolestidae									●						
Coenagrionidae				●	●				●	●					
Aeshinidae			●	●	●	●	●			●	●	●			
Gomphidae				●	●	●	●	●	●	●		●			
Libellulidae				●	●	●	●	●	●	●	●	●			
Hemiptera															
Belostomatidae													●		
Corixidae				●							●		●	●	
Gerridae										●					
Naucoridae						●						●			
Notonectidae					●	●									
Vellidae						●	●		●	●	●				
Trichoptera															
Hydropsychidae			●	●	●	●		●		●	●	●	●	●	
Philopotamidae						●									
Leptoceridae			●		●					●	●			●	
Coleoptera															
Dytiscidae					●			●	●	●		●			
SITE	**1**			**2**			**3**			**4**			**5**		
Season	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**
Elmidae				●							●				

SITE	**1**			**2**			**3**			**4**			**5**		
Season	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**
Gyrindae			●	●	●	●						●		●	
Hydraenidae					●										
Diptera															
Athericidae				●				●				●			
Blepharoceridae			●												
Ceratopogonidae								●		●	●	●			
Chironomidae			●	●	●	●	●	●	●		●	●			
Culicidae														●	
Simuliidae			●	●	●	●			●		●	●			
Tabanidae									●						
Tipulidae				●				●				●			
Gastropoda															
Ancylidae								●	●			●			
Planorbinae									●						

SITE	**6**			**7**			**8**			**9**			**10**		
Season	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**
Turbellaria		●									●	●		●	●
Annelida															
Oligochaeta		●			●			●		●	●	●	●	●	
Leeches	●				●						●		●		
Crustacea															
Potamonautidae							●	●	●				●	●	●
Atyidae							●	●	●	●					
Palaemonidae							●								
Plecoptera															
Perlidae					●	●			●					●	●
Ephemeroptera															
Baetidae	●	●	●		●	●	●	●	●	●	●	●	●	●	●
Caenidae					●			●		●			●	●	●
Heptageniidae		●			●	●		●					●	●	●
Leptophlebiidae	●	●			●	●	●	●	●	●	●	●	●	●	●
Prosopistomatidae						●									
Tricorythidae						●		●	●					●	●
Odonata															
Chlorocyphidae					●	●								●	
Chlorolestidae			●									●			
Coenagrionidae		●			●					●	●	●	●	●	●
Lestidae												●			
Aeshinidae											●			●	
Gomphidae					●					●			●	●	●
Libellulidae					●					●		●	●	●	●
Hemiptera															
Belostomatidae												●	●		
Corixidae		●			●			●			●	●	●	●	●
Gerridae													●		

SITE	6			7			8			9			10		
Season	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**	**Sm**	**W**	**Sp**
Hydrometridae													●		
Naucoridae	●	●			●					●					●
Nepidae														●	
Notonectidae	●							●				●	●	●	●
Vellidae	●		●		●	●	●	●	●	●	●	●	●	●	
Trichoptera															
Hydropsychidae	●	●			●	●	●	●	●	●	●	●	●	●	●
Philopotamidae														●	●
Leptoceridae					●								●	●	●
Coleoptera															
Dytiscidae											●	●	●		
Elmidae		●						●		●					●
Gyrindae	●									●	●		●	●	●
Hydrophilidae														●	
Diptera															
Athericidae														●	●
Ceratopogonidae											●		●	●	
Chironomidae	●	●	●			●		●	●	●	●	●	●	●	●
Culicidae											●				
Muscidae								●			●				
Simuliidae		●	●					●	●	●	●	●	●	●	●
Tabanidae					●			●						●	●
Tipulidae					●										
Gastropoda															
Ancylidae					●	●							●		●
Lymnaeidae												●			
Physidae					●										
Pelecypoda															
Corbiculidae													●		
Sphaeriidae						●			●						

APPENDIX 3

FISH ASSESSMENT

Figure 3-1 A FAII data sheet used for scoring fish samples

Date:	Time:	System:
River:	Stream:	Ecoregion:
Geomorphological Zone:	Geomorphological segment: Fish segment:	Geomorphological Reach:

5 km sector:	Farm:
Altitude:	Stream order:
Coordinates S: Degrees: Minutes: Seconds:	
Coordinates E: Degrees: Minutes: Seconds:	
Site number:	

Approximate width:	General flow (none, low, moderate, strong, fresh, flood):	Water colour:	Turbidity (clear, moderate, turbid):
Water temperature:	Conductivity (mS/m):	pH:	Oxygen (mg/l):
Water quality sample taken? (Y/N):		Remarks:	

FISH VELOCITY-DEPTH CLASSES AND COVER PRESENT AT SITE
(Abundance: 0=absent; 1=rare; 2=sparse; 3=moderate; 4=extensive)

SLOW DEEP:	SLOW SHALLOW:	FAST DEEP:	FAST SHALLOW:
Overhanging vegetation:	Overhanging vegetation:	Overhanging vegetation:	Overhanging vegetation:
Undercut banks & root wads:	Undercut banks & root wads:	Undercut banks & root wads:	Undercut banks & root wads:
Substrate:	Substrate:	Substrate:	Substrate:
Aquatic macrophytes:	Aquatic macrophytes:	Aquatic macrophytes:	Aquatic macrophytes:
Remarks:	Remarks:	Remarks:	Remarks:

INSTREAM USE & SURROUNDING AREA LAND USE
(0=absent; 1=rare; 2=sparse; 3=moderate; 4=extensive/intensive)

Weirs:	Cultivated lands:	Grazing:	Plantations:
Impoundments:	Residential:	Mines:	Industries:
Roads:	Bridges/crossings:	Pumps:	Canals:
Exotic vegetation:	Aquaculture:	Fishing:	Recreation/ Conservation:
Remarks:			

FISH HABITAT INTEGRITY AT SITE: ESTIMATED IMPACT OF MODIFICATIONS

(Severity of impact: 0=none; 1=small; 3=moderate; 5=large)

Water abstraction:	Flow modification:	Bed modification:	Channel modification:
Inundation:	Exotic macrophytes:	Solid waste disposal:	Indigenous vegetation removal:
Exotic vegetation encroachment:	Bank erosion:	Remarks:	

HABITATS SAMPLED AND EFFORT

SAMPLING EFFORT	SLOW DEEP	SLOW SHALLOW	FAST DEEP	FAST SHALLOW
Electro schocker (min)				
Small seine (mesh size, length, depth, efforts)				
Large seine (mesh size, length, depth, efforts)				
Cast net (dimensions, efforts)				
Gill nets (mesh size, length, time)				

REMARKS

FISH CAUGHT (COMBINED/HABITAT/SAMPLING METHOD)

HABITAT:	
SAMPLING METHOD:	

SPECIES	NUMBER (J=juvenile, A=abnormality)

HABITAT:	
SAMPLING METHOD:	

SPECIES	NUMBER (J=juvenile, A=abnormality)

FISH CAUGHT (COMBINED/HABITAT/SAMPLING METHOD)

HABITAT:	
SAMPLING METHOD:	

SPECIES	NUMBER (J=juvenile, A=abnormality)

HABITAT:	
SAMPLING METHOD:	

SPECIES	NUMBER (J=juvenile, A=abnormality)

FISH EC METRIC GROUP RESULTS

The following tables (Table 3-1 to 3-9) show the results from the output of the FRAI model per Assessment Unit. This information relates to the EC and river health classes based on fish assemblages of the study area shown in Chapter 4.

Table 3-1 Fish EC metric group results: Assessment Unit 1

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	21.82	3	60
COVER METRICS	100.00	27.27	2	75
FLOW MODIFICATION METRICS	100.00	3.64	5	10
MIGRATION METRICS	100.00	3.64	5	10
PHYSICO-CHEMICAL METRICS	100.00	7.27	4	20
IMPACT OF INTRODUCED SPP (NEGATIVE)	56.47	-20.53	1	100
	6.00			275.00
FRAI (%)			43.10	
EC: FRAI			D	
BOUNDARY EC				

Table 3-2 Fish EC metric group results: Assessment Unit 2

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	21.43	3	60
COVER METRICS	100.00	28.57	2	80
FLOW MODIFICATION METRICS	100.00	3.57	5	10
MIGRATION METRICS	100.00	3.57	5	10
PHYSICO-CHEMICAL METRICS	100.00	7.14	4	20
IMPACT OF INTRODUCED SPP (NEGATIVE)	64.71	-23.11	1	100
	6.00			280.00
FRAI (%)			41.18	
EC: FRAI			D	
BOUNDARY EC				

Table 3-3 Fish EC metric group results: Assessment Unit 3

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	18.46	3	60
COVER METRICS	100.00	23.08	2	75
FLOW MODIFICATION METRICS	100.00	3.08	5	10
MIGRATION METRICS	15.00	1.85	4	40
PHYSICO-CHEMICAL METRICS	90.00	11.08	4	40
IMPACT OF INTRODUCED SPP (NEGATIVE)	82.35	-25.34	1	100
	6.00			325.00
FRAI (%)			32.20	
EC: FRAI			E	
BOUNDARY EC				

Table 3-4 Fish EC metric group results: Assessment Unit 4

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	100.00	21.82	3	60
COVER METRICS	100.00	27.27	2	75
FLOW MODIFICATION METRICS	100.00	3.64	5	10
MIGRATION METRICS	100.00	3.64	5	10
PHYSICO-CHEMICAL METRICS	100.00	7.27	4	20
IMPACT OF INTRODUCED SPP (NEGATIVE)	56.47	-20.53	1	100
	6.00			275.00
FRAI (%)			43.10	
EC: FRAI			D	
BOUNDARY EC				

Table 3-5 Fish EC metric group results: Assessment Unit 5

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	90.12	9.24	5	40
COVER METRICS	80.95	8.30	5	40
FLOW MODIFICATION METRICS	86.95	13.38	4	60
MIGRATION METRICS	15.00	3.08	2	80
PHYSICO-CHEMICAL METRICS	88.07	15.81	3	70
IMPACT OF INTRODUCED SPP (NEGATIVE)	75.83	-19.44	1	100
	6.00			390.00
FRAI (%)			30.36	
EC: FRAI			E	
BOUNDARY EC				

Table 3-6 Fish EC metric group results: Assessment Unit 6

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	87.02	14.50	4	50
COVER METRICS	78.71	15.74	3	60
FLOW MODIFICATION METRICS	76.29	25.43	1	100
MIGRATION METRICS	100.00	3.33	5	10
PHYSICO-CHEMICAL METRICS	76.29	17.80	2	70
IMPACT OF INTRODUCED SPP (NEGATIVE)	50.00	-1.67	5	10
	6.00			300.00
FRAI (%)			75.14	
EC: FRAI			C	
BOUNDARY EC				

Table 3-7 Fish EC metric group results: Assessment Unit 7

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	94.75	15.79	4	50
COVER METRICS	93.31	18.66	3	60
FLOW MODIFICATION METRICS	94.96	31.65	1	100
MIGRATION METRICS	100.00	3.33	5	10
PHYSICO-CHEMICAL METRICS	90.00	21.00	2	70
IMPACT OF INTRODUCED SPP (NEGATIVE)	50.00	-1.67	5	10
	6.00			300.00
FRAI (%)			88.77	
EC: FRAI			B	
BOUNDARY EC				

Table 3-8 Fish EC metric group results: Assessment Unit 8

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	90.32	10.63	5	40
COVER METRICS	47.47	11.17	2	80
FLOW MODIFICATION METRICS	53.78	1.58	6	10
MIGRATION METRICS	41.18	6.06	4	50
PHYSICO-CHEMICAL METRICS	55.08	16.20	1	100
IMPACT OF INTRODUCED SPP (NEGATIVE)	50.00	-8.82	3	60
	6.00			340.00
FRAI (%)			36.81	
EC: FRAI			E	
BOUNDARY EC				

Table 3-9 Fish EC metric group results: Assessment Unit 9

FISH EC METRIC GROUPs	METRIC GROUP: CALCULATED RATING	WEIGHTED RATING FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
VELOCITY-DEPTH METRICS	95.06	15.01	3	60
COVER METRICS	87.22	16.07	2	70
FLOW MODIFICATION METRICS	90.00	23.68	1	100
MIGRATION METRICS	100.00	13.16	4	50
PHYSICO-CHEMICAL METRICS	85.82	11.29	4	50
IMPACT OF INTRODUCED SPP (NEGATIVE)	48.57	-6.39	4	50
	6.00			380.00
FRAI (%)			72.82	
EC: FRAI			C	
BOUNDARY EC				

APPENDIX 4

VEGETATION ASSESSMENT

Section 4-1a ***INTEGRATED RIPARIAN VEG FORM (IRVI)*** 1.walkabout fill in species form;2 fill in this form;3 fill in RVI form; +c/s map

DATE

RIVER NAME	**ASSESSOR NAME**	
SEGMENT	**REACH**	Length
COORDINATES		
ALTITUDE	Gradient (Vert/Horiz)	

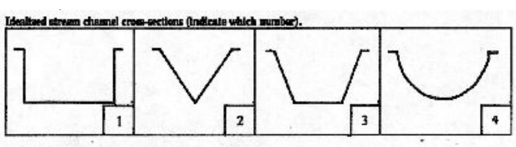
LANDUSE: Place a cross in relevant block

Landuse category per reach	Industrial	Inf. Setlmt	Open spc	Com. Agr	Comm.	Sportsfield	Sewage treatment	other
	Nat Reserv	Sbs Agrc.	Residential	Park	ComFrstry	Dumping	Mining quarry	
Current use riparian area	Birding	Picnic	Walking	Cycling	Swimming	Canoeing	sports	other
Educational Use	Research	Env. Awar	Schooling	Other				
Aesthetics	Has area been managed to improve beauty of surround					Yes	No	Partly
Use of Nat Resource	Water	Wood	Pumping	Grazing	Plant coll.	Fishing	Other	
Domestic use	Washing	Dumping Household		Dumping Rubble		Other		
Agricultural use	Cm Frstry	Sbs agric	Cm crops	Other				
Ind infrastructure/ waste disposal	Perm.Strc	Dump ind.waste	Inds eff. Drains	Other				
Urban infrastruct	Housing	S-wter drains	Hrdnd srfcs	Vendors	Other			
Current activities to solve problems	Struct flood control measures	Improve urban infrastructure	Cutting alien veg	Pesticides/ herbicide use	Other:			

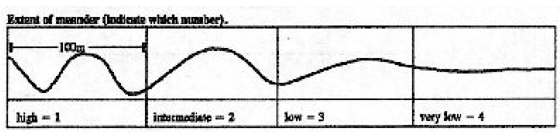
PHYSICAL ATTRIBUTES OF THE REACH

Substrate type	0	1-5%	6-25%	26-50%	51-75%	76-100%	
Bedrock							
Rock							
Cobble							
Coarse sand/gravel							
Sand and fines							
Expected substrate type							
Soil types (if known)							
Average channel depth	Top of reach (m)			Bottom of reach (m)			
Idealised ch cross sect.	1	2	3	4		(choose a number from idealised pictures below)	
Extent of meander	1	2	3	4			

Idealised stream ch cross section▼



Extent of meander



DISTURBANCE

How much of the streambank morphology has been altered through straightening/deepening (Tick appropriate block/s)

Unaltered	
Human intervention: straightened/deepened, some features maintained, or small area	
Straightened/deepened and few natural features retained, but not canalised	

Straightened/deepened and transformed to concrete canal or running u/ground	
Extent of erosion along streambanks:	
Banks stable along reach	
Moderately stable. Erosion scars at intervals of more than 50m on average	
Moderately unstable, breaks are frequent, some gullies and scars at least every 50m	
Unstable, with many eroded areas along entire length	

DISTURBANCE CONT.

Type of bank instability	GRAPHIC	%LB	%RB
Undercutting			
Undercutting at toe			
Scouring			
Bank Slump			
Instability due to vegetation			
Vegetation type			

Channel instability	
Incision	
Headcutting	
Channel widening	

In-channel sedimentation	None	Moderate	Excessive

Additional Disturbances	VL	L	M	H	VH
Floods, elevated flows					
Flow regulation (dam upstream)					
Weir/Dam (local inundation)					
Bush clearing / ploughing					
	VL	L	M	H	VH
Vegetation removal (fuel, materials, feed)					
Crop farming					
Forestry					
Grazing/browsing, trampling (stock)					
Sand winning, quarrying, mining					
Picnicking, golf courses, trails, paths					
Roads, bridges, footpaths, other infastructures					
Other: specify					

Percentage of total area altered by human activity	
<5% nat. veg. altered	
Most natural veg, but 5-25% altered by human activity	
From 36-75% of area altered by human activity	
> 75% of area altered and this associated with human activity	

INVASIVE VEGETATION

Alien plant invasion (Riparian)

<5%	5-25%	26-75%	>75%

Total cover of aliens				
In your opinion is the alien woody veg harvestable?			Yes	No
	LB		RB	
Accessibility to Site for Alien Mgmt				

Water weed invasion (In-channel) List the water weeds present (Based on guideline)	
IS THERE ANY CHROMOLAENA, PERESKIA, EICHORNIA CRASSIPES, OR OPUNTIA AURANTIACA? IF SO, CONTACT WORKING FOR WATER PE URGENTLY AT THE FOLLOWING NUMBER: 041 5864884 OR your Nearest WFW office.	
TOTAL NO OF INDIGENOUS SPECIES NOTED:	
TOTAL NO OF ALIEN SPECIES NOTED:	

Date: **River:** **Reach:**

SHEET 1: Walkabout sheet for SPECIES COMPOSITION: Add additional sheets if necessary

	LEFT SIDE	**Rec**	**RIGHT SIDE**	**Rec**	**CHANNEL**	**Rec**
WOODY ALIENS e.g. Pine	Cover class (0-4)		Cover class (0-4)		Cover class (0-4)	
	Species list		Species list		Species list	
OTHER ALIENS e.g. Balloon vine	Cover class (0-4)		Cover class (0-4)		Cover class (0-4)	
	Species list		Species list		Species list	

	LEFT SIDE	Rec	RIGHT SIDE	Rec	CHANNEL	Rec
WOODY INDIGENOUS e.g. Acacia	Cover class (0-4)		Cover class (0-4)		Cover class (0-4)	
	Species list		Species list		Species list	

OTHER INDIGENOUS e.g. Sedge	Cover class (0-4)		Cover class (0-4)		Cover class (0-4)	
	Species list		Species list		Species list	

Rec = Recruitment (Tick)

To your knowledge are there any red data species?

	SHEET 2: RVI SCORING DATASHEET					
D1	River name		**D3**	Channel Type		
D2	Site/Seg No/Reach		**D4**	Width (m)		
D3	Site Name		**D5**	Substrate general		

GUT SCORE (see below for definitions)		
A	Unmodified natural	
B	Largely natural with few modifications. A small change in natural habitats and biota may have occurred but ecosystem functions are essentially unchanged.	
C	Moderately modified. Loss of biota & habitat change but ecosystem functions predominantly unchanged.	
D	Largely modified. Large loss of biota and habitat as well as basic ecosystem functions.	
E	Extensive loss of natural habitat biota and basic ecosystem functions	

F	Modifications critical, almost complete loss of biota, ecosystem funtions, Worst instances changes irreversible.

EXTENT OF VEG COVER (EVC)

		0	1-5%	6-25%	26-50%	51-75%	76-100%	SCORE	FIN SCORE
	EVC1								
F1	**EVC1 = Combined veg score out of 10 for LHB, RHB and islands (F1)**	0	2	4	6	8	10		
F2	**EVC2 Site Disturbances**	0	VL	L	M	H	VH		
	EVC2 = [10-total site disturbance)	0	1	2	4	6	10		
	Total EVC = (EVC1+EVC2)/2								

F3 STRUCTURAL INTACTNESS (SI)

Expected: → / Observed ↓	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

		Record Observed	Record expected	SCORE	FIN SCORE
S11	Trees				
S12	Shrubs				
S13	Reeds				
S14	Sedges				
S15	Grasses				
	Total SI: [(Sum SI1-SI5)/5*0.33]				

% COVER INDIG. RIPARIAN SPP (PCIRS)

		0	VL	L	M	H	VH	
	Cover score values							
	PCIRS sub-score	0	1	2	3	4	5	subscores
F4	Exotic species							
F5	Terrestrial invasive species							
F6	Invasive Reeds							
	Total PCIRS = [(EVC/2)-((exotics*0.7)+(terrestrial*0.1)+(reeds*0.2))]						total ►	

If no indigenous at site then PCIRS (min) = 0

	RECRUITMENT OF INDIGENOUS RIPARIAN SPP (RIRS)								
F7	Ext of recruitment	0	VL	L	M	H	VH	**SCORE**	**FIN SCORE**
	RIRS Score	0	1	2	3	4	5		
	TOTAL RIRS = RIRS Score								
	TOTAL RVI =[(EVC) + ((SIxPCIRS)+(RIRS))]								
	ASSESSMENT CLASS								

DESCRIPTION OF ASSESSMENT CLASSES	IRVI SCORE	ER ASSESSMENT CLASS
Unmodified natural	19 - 20	A
Largely natural with few modifications. A small change in natural habitats and biota may have occurred but ecosystem functions are essentially unchanged.	17 -18	B
Moderately modified. Loss of biota & habitat change but ecosystem functions predominantly unchanged.	13 - 16	C
Largely modified. Large loss of biota and habitat as well as basic ecosystem functions.		D
Extensive loss of natural habitat biota and basic ecosystem functions		E
Modifications critical, almost complete loss of biota, ecosystem funtions, Worst instances changes irreversible.	0 - 4	F

Section 4-1b An example of a species list datasheet that can be used during vegetation surveys

SPECIES LIST LOCATION: River, site, lat, long: **ASSESSOR/S:** **DATE:**							
For origin- Indicate A if IAP,E if exotic, I if indigenous, P if known protected, Pt if known as protected tree, **Indicate left bank L, right bank R. State which cover scale is being used if any...**							
Description /botanical name	**Bank (L/R)**	**origin**	**Cover class**	**Description/botanical name**	**Bank (L/R)**	**Origin**	**Cover class**

Section 4-2 Species list per site surveyed

Species list: Site 1 Mthatha River – Headwaters

Pinus patula
Cestrum laevigatum
Solanum mauritianum
Bidens pilosa
Conzya sp..
Podocarpus falcatus
Podocarpus henkellii
Podocarpus latifolius
Curtisia dentata
Olea capensis
Nuxia floribunda
Burchelia bubalina
Canthium ciliatum
Ekebergia capensis
Cussonia sphaerocephala
Trichocladus ellipticus
Dias cotinifolia
Gymnosporia mossambicensis
Canthium spinosum
Grewia occidentalis
Rhoicissus rhomboidea
Centella asiatica
Behnia reticulata
Momordica foetida
Chlorophytum comosum
Plectranthus sp..
Plectranthus ambiguus
Asplenium sp..
Asparagus virgata
Solanum incanum
Scadoxus membranaceous
Cyperus textiles
Mystacidium sp.
Selaginella caffrorum

Species list: Site 2 Mthatha River - Upper Langeni

Acacia mearnsii
Acacia longifolia
Populus sp..
Solanum mauritianum
Pinus patula
Cirsium vulgare
Pteridium aquilinum
Cladium mariscus
Persicaria lapathifolia
Persicaria senagalensis
Phytolacca octandra

Dicliptera clinopodia
Chamaecrista mimosoides
Citrullus lanatus
Physalis viscosa
Solanum nigrum
Watsonia gladioloides
Lobelia flaccida
Helichrysum sp..
Wahlenbergia cuspidata
Cliffortia sp..
Solanum diplo-sinuatum
Plectranthus sp..
Senecio sp..
Solanum aculeastrum
Senecio bupleuroides
Ranunculus mulitfidus
Leucosidea sericea
Juncus effusus
Phragmites mauritianus
Cotula nigellifolia
Gomphocarpus rivularis
Hibiscus trionum
Miscanthus capensis
Aspalathus sp..
Mariscus solidus
Scirpus sp..
Phalaris sp..

Species list: Site 3 Mthatha River - Lower langeni
Grewia occidentalis
Monopsis unidentata
Momordica foetida
Helichrysum sp..
Passerina sp..
Alsophila dregeii (upper slopes)
Cliffortia sp..
Kiggelaria africana
Diospyros dichrophylla
Hibiscus peduncularis
Rhus rhemanniana
Leucosidea sericea
Acalypha glabrata
Trimeria grandifolia
Rhamnus prunoides
Buddleja dysophylla
Acacia caffra
Diospyros dichrophylla
Laportea peduncularis
Zantededscia albomaculata
Pteridium aquilinum

Gunnera perpensa
Scadoxus puniceous
Conzya albida
Lobelia flaccida
Kniphofia sp..
Carex austro-africanus
Miscanthus capensis
Helichrysum sp..
Diospyros lycoides
Monopsis decipiens
Juncus sp..
Cyperus dives
Mariscus solidus
Solanum mauritianum
Acacia mearnsii
Acacia dealbata
Pinus pinaster
Cirsium vulgare

Species list: Site 4 Mthatha River – Kambi Forest Station
Acacia mearnsii
Acacia melanoxylon
Lantana camara
Solanum mauritianum
Argemone ochroleuca
Populus deltoides
Quercus robur
Sesbania punicea
Acacia dealbata
Passiflora caerulea
Bidens pilosa
Pteridium aquilinum
Salix mucronata
Centella asiatica
Bidens pilosa
Datura ferox
Ziziphus mucronata
Rhus sp..
Kiggelaria africana
Canthium inerme
Diospyros lycioides
Diospyros dichrophylla
Putterlicka verrucosa
Dais cotinifolia
Rhamnus prunoides
Halleria lucida
Diospyros scabrida
Leucosidea sericea
Buddleja dysophylla
Grewia occidentalis

Dovyalis rhamnoides
Canthium ciliatum
Solanum aculeastrum
Cyperus rotundus
Miscanthus capensis
Oplimenus hirtellus
Dactyloctenium australe
Centella asiatica
Hypoxis sp..
Oxalis sp..
Senecio sp..
Persicaria sp..
Cotula nigellifolia
Dryopteris sp..
Lobelia flaccida
Pleopeltis macrocarpa
Juncus sp..
Scirpus sp..

Species list: Site 5 Mthatha River – below Mthatha town
Salix mucronata subsp. capensis
Ricinus communis
Aceranthes aspera
Solanum mauritianum
Sesbania punicea
Cirsium vulgare
Xanthium stromarium
Cardiospermum grandiflorum
Passiflora caerulea
Eichornia crassipes
Datura ferox
Phytolacca dioica
Salix mucronata
Putterlicka verrucosa
Grewia occidentalis
Combretum erythrophyllum
Acacia karoo
Trimeria trinervis
Leonotus intermedia
Miscanthus capensis
Phragmites sp..
Ziziphus mucronata
Diospyros dichrophylla
Laportea peduncularis
Solanum nigrum
Momordioca foetida
Persicaria senagalensis
Plectranthus sp..
Cyperus dives
Juncus sp..

Species list: Site 6 Mthatha River – Thakatha

Eichornia crassipes
Zinnia peruviana
Argemone ochroleuca
Tribulus terestris
Cuscuta campestris.
Lantana camara
Solanum mauritianum
Opuntia sp.
Sesbania punicea
Myriophyllum aquaticum
Dovyalis caffra
Buddleja pulchella
Ptaeroxylon obliquum
Combretum erythrophyllum
Acacia caffra
Salix mucronata
Miscanthus capensis
Clematis brachiata
Physalis viscose
Cyphostemma hypoleucum
Amaranthus sp.
Schotia brachypetala
Gomphocarpus rivularis
Cynodon sp.
Helichrysum sp.
Coddia ruddis
Gymnosporia mossambicensis
Acacia karoo
Acalypha glabrata
Clerodendrum glabrum
Laportea peduncularis
Cotula nigellifolia
Hypoxis sp.
Rumex sp.
Ficus sp.
Juncus sp.
Viscum sp.
Dais cotinifolia
Lippia javanica
Pseudognaphalium leutioalbum
Leucas lavandifolia
Commelina benghalensis
Peristrophe cernua
Centella asiatica
Commelina eckloniana
Cyperus dives
Oenothera tetraptera
Plantago longissima

Berula erecta
Cyperus rotundus

Species list: Site 7 Mthatha River – Mpindweni

Sesbania punicea
Senna didymobotrya
Ricinus communis
Cestrum laevigatum
Solanum mauritianum
Ageratum houstiannum
Solanum sisymbrifolium
Datura ferox
Cardiospermum grandiflorum
Myriophyllum aquaticum
Eichornia crassipes
Solanum mauritianum
Ficus sur
Ziziphus mucronata
Euphorbia triangularis
Phoenix reclinata
Grewia villosa
Combretum erythrophyllum
Rhus sp.
Acacia karoo
Acacia caffra
Trimeria grandifolia
Clerodendron glabrum
Plumbago auriculata
Acacia robusta
Rumex sp.
Stenotaphrum secundatum
Vigna unguiculata
Gomphocarpus rivularis
Persicaria lapathifolia
Hypoxis sp.
Commelina sp.
Plantago longissima
Cyperus dives
Lippia javanica
Miscanthus capensis
Persicaria lapathifolia
Corchorus asplenifolius
Hypoxis sp.
Sida dregei
Berula erecta
Juncus sp.
Cyperus rotundus

Species list: Site 8 Mthatha River - Mdumbi

Senna didymobotrya

Lantana camara
Solanum sisymbrifolium
Cestrum laevigatum
Psidium guajava
Ricinus communis
Datura stramonium
Myriophyllum aquaticum
Argemone mexicana
Tagetes minuata
Ageratum houstianum
Persicaria senagalensis
Bidens pilosa
Sesbania punicea
Cardiospermum grandiflorum
Eichornia crassipes
Xanthium stromarium
Spilanthes mauritiana
Rhus pentheri
Ficus sur
Erythrina caffra
Dalbergia obovata
Clerodendrum glabrum
Grewia occidentalis
Tecomaria capensis
Ziziphus mucronata
Adenopodia spicata
Acacia karoo
Salix mucronata
Phoenix reclinata
Miscanthus capensis
Lippia javanica
Senecio sp.
Passerina filiformis
Eleocharis dregeana
Hypericum
Dryopteris sp.
Cymbopogon vallidus
Berula erecta
Hibiscus trionum
Corchorus asplenifolius
Desmodium sp
Verbena bonariensis
Persicaria lapathifolia
Cotula nigellifolia
Commelina sp.

Species list: Site 9 Cicira River (tributary of Mthatha River)
Eucalyptus sp.
Sesbania punicea
Lantana camara

Spartium junceum
Cirsium vulgare
Argemone ochrolucae
Opuntia sp.
Combretum erythrophyllum
Salix mucronata
Sesbania punicea
Cyperus sexangularis
Diospyros dichrophylla
Gymnosporia buxifolia
Acacia caffra
Burchelia bubalina
Diospyros scabrida
Ziziphus mucronata
Laportea peduncularis
Digitaria sp
Persicaria sp.
Lobelia sp.
Sporobolus africanus
Berula erecta
Cyperus dives
Protasparagus sp.
Cynodon sp.

Species list: Site 10 Lower Ngqungqu River (tributary of Mthatha River)
Ficus thonningii
Diospyros lycoides
Acacia karoo
Cordia caffra
Leonotis intermedia
Sida dregei
Rhoicissus tridentata
Lippia javanica
Rumex sp.
Solanum retroflexum
Ricinus communis
Lantana camara
Miscanthus capensis
Berula erecta
Cyperus sexangularis
Acacia mearnsii
Eucalyptus sp.
Grewia lasiocarpa
Xanthium stromarium
Corchorus asplenifolius
Solanum nigrum
Commelina sp.
Phytolacca octandra
Physalis viscosa
Bidens pilosa

Nicandra physolodes
Acacia caffra
Dovyalis caffra
Coddia ruddis
Grewia lasiocarpa
Ficus sur
Dais cotinifolia
Solanum aculeastrum
Combretum sp.
Centella sp.
Persicaria senegalensis
Persicaria lapathifolia
Plantago longissima
Cotula nigellifolia
Cymbopogon Vallidus
Sporobolus africana
Amaranthus hybridus

Section 4-3 Results of the riparian vegetation study for the Mthatha RHP

ASSESSMENT UNITS AND REPRESENTATIVE SITES	EXTENT VEGETATION COVER	STRUCTURAL INTACTNESS	% COVER INDIGENOUS RIPARIAN SPECIES	RECRUITMENT OF INDIGENOUS RIPARIAN VEGETATION	TOTAL IRVI SCORE	ECOLOGICAL RESERVE ASSESSMENT CLASS	RIVER HEALTH ASSESSMENT CLASS
Assessment unit 1							
HEADWATERS oct	8	0.99	1.9	4	**13.881**	**C**	fair
Assessment unit 2							
LANGENI UPPER oct	6	0.924	1.1	2	**9.0164**	**D**	fair
LANGENI UPPER feb	8	0.594	0.6	1	**9.3564**	**D**	fair
Assessment unit 3							
LANGENI LOWER oct	7.5	0.924	1.55	2	**10.9322**	**D**	fair
KAMBI oct	7	0.792	1.2	3	**10.9504**	**D**	fair
KAMBI feb	6	0.924	-0.08	4	**9.92608**	**D**	fair
Assessment unit 4						**D**	fair
(no sample site)							
Assessment unit 5							
ETIPINI oct	5	0.99	-1.3	2	**5.713**	**E**	poor
ETIPINI feb	5	0.66	-1.7	1	**4.878**	**E**	poor
Assessment unit 6							
TAKATA oct	6	0.858	-0.1	1	**6.9142**	**E**	poor
TAKATA feb	7	0.858	0.3	1	**8.2574**	**E**	

ASSESSMENT UNITS AND REPRESENTATIVE SITES	EXTENT VEGETATION COVER	STRUCTURAL INTACTNESS	% COVER INDIGENOUS RIPARIAN SPECIES	RECRUITMENT OF INDIGENOUS RIPARIAN VEGETATION	TOTAL IRVI SCORE	ECOLOGICAL RESERVE ASSESSMENT CLASS	RIVER HEALTH ASSESSMENT CLASS
Assessment unit 7							
MPINDWENI oct	8	0.924	1.1	2	**11.0164**	**D**	fair
MPINDWENI feb	8	0.528	-0.4	2	**9.7888**	**D**	fair
MDUMBI oct	6	0.792	0.1	2	**8.0792**	**E**	poor
MDUMBI feb	4	0.858	-2	3	**5.284**	**E**	poor
Assessment unit 8							
CICIRA oct	7	0.528	2	2	**10.056**	**D**	fair
CICIRA feb	7	0.462	2.5	2	**10.155**	**D**	fair
Assessment unit 9							
NGQUNGQU oct	8	0.858	0.4	2	**10.3432**	**D**	fair
NGQUNGQU feb	6	0.594	0.6	2	**8.3564**	**E**	poor

APPENDIX 5

GEOMORPHOLOGICAL ASSESSMENT

Table 5-1 A summary of GAI results: Assessment Unit 1

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS		**RELATIVE WEIGHTING (%)**	**RATING**	**WEIGHT**	**Weighed score**	**flow related (event hydrology;high flows, floods)**	**CONFIDENCE**
System Connectivity	1.00	100.00	0.25	0.34	0.09	0.00	3.00
Reach sediment balance	4.00	50.00	1.75	0.17	0.30	67.00	3.00
Channel perimeter resistance	2.00	80.00	1.08	0.28	0.30	75.38	2.19
Morphological change	3.00	60.00	0.48	0.21	0.10	65.00	2.50
TOTALS		290.00		1.00	0.79		
System Driver status:					**0.79**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**84.28**		
HABITAT DRIVER CATEGORY					**B**		
FLOW RELATED (%)					**62.59**		**2.67**

Table 5-2 A summary of GAI results: Assessment Unit 2

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS		**RELATIVE WEIGHTING (%)**	**RATING**	**WEIGHT**	**Weighed score**	**flow related (event hydrology;high flows, floods)**	**CONFIDENCE**
System Connectivity	1.00	90.00	1.58	0.26	0.42	39.21	3.00
Reach sediment balance	4.00	100.00	2.00	0.29	0.59	20.00	3.00
Channel perimeter resistance	2.00	80.00	2.00	0.24	0.47	82.22	2.13
Morphological change	3.00	70.00	1.64	0.21	0.34	50.00	3.00
TOTALS		340.00		1.00	1.81		
System Driver status:					**1.81**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**63.71**		
HABITAT DRIVER CATEGORY					**C**		
FLOW RELATED (%)					**46.15**		**2.80**

Table 5-3 A summary of GAI results: Assessment Unit 3

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS		RELATIVE WEIGHTING (%)	RATING	WEIGHT	Weighed score	flow related (event hydrology;high flows, floods)	CONFIDENCE
System Connectivity	1.00	100.00	0.69	0.29	0.20	29.27	2.50
Reach sediment balance	4.00	90.00	2.00	0.26	0.53	50.00	2.00
Channel perimeter resistance	2.00	80.00	0.67	0.24	0.16	106.67	1.50
Morphological change	3.00	70.00	0.56	0.21	0.12	62.82	2.50
TOTALS		340.00		1.00	1.00		
System Driver status:					**1.00**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**79.92**		
HABITAT DRIVER CATEGORY					**B**		
FLOW RELATED (%)					**56.15**		**2.13**

Table 5.4 A summary of GAI results: Assessment Unit 4

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS		RELATIVE WEIGHTING (%)	RATING	WEIGHT	Weighed score	flow related (event hydrology;high flows, floods)	CONFIDENCE
System Connectivity	1.00	100.00	1.80	0.29	0.53	61.25	2.00
Reach sediment balance	4.00	90.00	3.50	0.26	0.93	75.00	2.50
Channel perimeter resistance	2.00	80.00	1.26	0.24	0.30	79.71	2.00
Morphological change	3.00	70.00	1.22	0.21	0.25	68.17	2.00
TOTALS		340.00		1.00	2.00		
System Driver status:					**2.00**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**59.94**		
HABITAT DRIVER CATEGORY					**C**		
FLOW RELATED (%)					**71.21**		**2.13**

Table 5-5 A summary of GAI results: Assessment Unit 5

FINAL DRIVER STATUS GEOMORPHOLOGY							
SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS		RELATIVE WEIGHTING (%)	RATING	WEIGHT	Weighed score	flow related (event hydrology;high flows, floods)	CONFIDENCE
System Connectivity	1.00	100.00	1.66	0.29	0.49	58.95	3.00
Reach sediment balance	4.00	90.00	4.50	0.26	1.19	70.00	3.00
Channel perimeter resistance	2.00	80.00	0.70	0.24	0.17	87.37	2.50
Morphological change	3.00	70.00	1.65	0.21	0.34	67.50	2.00
TOTALS		340.00		1.00	2.18		
System Driver status:					2.18		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					56.31		
HABITAT DRIVER CATEGORY					D		
FLOW RELATED (%)					68.45		2.68

Table 5-6 A summary of GAI results: Assessment Unit 6

FINAL DRIVER STATUS GEOMORPHOLOGY							
SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS		RELATIVE WEIGHTING (%)	RATING	WEIGHT	Weighed score	flow related (event hydrology;high flows, floods)	CONFIDENCE
System Connectivity	1.00	100.00	1.28	0.29	0.38	45.85	3.00
Reach sediment balance	4.00	90.00	3.00	0.26	0.79	50.00	3.00
Channel perimeter resistance	2.00	80.00	0.69	0.24	0.16	86.67	2.50
Morphological change	3.00	70.00	0.45	0.21	0.09	70.00	3.00
TOTALS		340.00		1.00	1.43		
System Driver status:					1.43		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					71.48		
HABITAT DRIVER CATEGORY					C		
FLOW RELATED (%)					54.40		2.88

Table 5-7 A summary of GAI results: Assessment Unit 7

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS

COMPONENTS		RELATIVE WEIGHTING (%)	RATING	WEIGHT	Weighed score	flow related (event hydrology;high flows, floods)	CONFIDENCE
System Connectivity	1.00	100.00	0.75	0.29	0.22	48.16	2.50
Reach sediment balance	4.00	90.00	2.00	0.26	0.53	67.00	2.00
Channel perimeter resistance	2.00	80.00	0.81	0.24	0.19	85.00	2.00
Morphological change	3.00	70.00	0.42	0.21	0.09	68.81	2.00
TOTALS		340.00		1.00	1.03		
System Driver status:					**1.03**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**79.44**		
HABITAT DRIVER CATEGORY					**C**		
FLOW RELATED (%)					**66.48**		**2.15**

Table 5-8 A summary of GAI results: Assessment Unit 8

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS

COMPONENTS		RELATIVE WEIGHTING (%)	RATING	WEIGHT	Weighed score	flow related (event hydrology;high flows, floods)	CONFIDENCE
System Connectivity	1.00	100.00	0.66	0.29	0.19	23.77	3.00
Reach sediment balance	4.00	90.00	2.00	0.26	0.53	0.00	3.00
Channel perimeter resistance	2.00	80.00	1.12	0.24	0.26	79.66	2.50
Morphological change	3.00	70.00	0.76	0.21	0.16	70.00	3.00
TOTALS		340.00		1.00	1.14		
System Driver status:					**1.14**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**77.14**		
HABITAT DRIVER CATEGORY					**C**		
FLOW RELATED (%)					**31.92**		**2.88**

Table 5-98 A summary of GAI results: Assessment Unit 9

FINAL DRIVER STATUS GEOMORPHOLOGY

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS		**RELATIVE WEIGHTING (%)**	**RATING**	**WEIGHT**	**Weighed score**	**flow related (event hydrology;high flows, floods)**	**CONFIDENCE**
System Connectivity	1.00	100.00	0.48	0.29	0.14	14.74	3.00
Reach sediment balance	4.00	90.00	1.75	0.26	0.46	20.00	3.00
Channel perimeter resistance	2.00	80.00	1.00	0.24	0.24	82.22	2.50
Morphological change	3.00	70.00	0.60	0.21	0.12	70.00	3.00
TOTALS		340.00		1.00	0.96		
System Driver status:					**0.96**		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**80.76**		
HABITAT DRIVER CATEGORY					**B**		
FLOW RELATED (%)					**40.89**		**2.88**