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ACRONYMS

CD: RDM	Chief Directorate: Resource Directed Measures
DRM	Desktop Reserve Model
DWA	Department of Water Affairs
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurance
GSM	Gravel, Mud and Sand
HI	Habitat Integrity
IHAS	Integrated Habitat Assessment System
MAR	Mean Annual Runoff
MIRAI	Macroinvertebrate Response Assessment Index
NWA	National Water Act
PES	Present Ecological State/Ecostatus
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
SASS5	South African Scoring System (version 5)
SIC	Stones in Current
SOC	Stones out of Current
VMAR	Virgin Mean Annual Runoff
WRCS	Water Resources Classification System

1. INTRODUCTION

1.1 Background

1.1.1 National Water Act

Chapter 3 of the National Water Act (NWA) (Act No. 36, 1998) requires the implementation of Resource Directed Measures (RDM) to protect the water resources of the country, based on the guiding principles of sustainability and equity. In terms of the Act, before the required authorization to utilise a particular water resource can be granted, it is necessary to determine the Reserve for the relevant ecological component of the resource that will be impacted by the proposed water use.

According to the Act all Reserve determinations that are currently determined and approved by the Department of Water Affairs (DWA) are preliminary Reserve determinations and the associated recommended class is a preliminary class (section 17(1)), until a system for the classifying of water resources has been prescribed.

The ecological component of the Reserve is defined as the quantity, quality and reliability of water required to "protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource" (National Water Act, 1998).

1.1.2 Resource Directed Measures (RDM)

Classification

The national Water Resource Classification System (WRCS) as required by the NWA in section 12 has been developed for the classification of all significant water resources. This system provides the 7 step process to classify all significant water resources and to determine the Management Class of a water resource. The Management Class is based on ecological, social and economic considerations.

Reserve

A suite of methods has been developed for determining the ecological Reserve depending on the level of accuracy and confidence in the results required. These are outlined in Volume 2 of the RDM method manuals (DWAF, 1999) and consist of approaches for Rapid, Intermediate and Comprehensive ecological Reserve determinations. The results of Reserve determinations are also linked to a level of confidence (very low to high), based on the availability of information and accuracy of the determination.

The application of the appropriate Reserve method to ensure that the necessary level of confidence in the results is obtained for the particular water resource under consideration depends on a number of factors. These include:

- The Ecological Importance and Sensitivity (EIS) of the catchment;
- The degree to which the catchment is already utilised;
- The potential impact of the proposed water use(s) to be authorised and possible future use; and
- The need to establish a catchment management plan.

The ecological Reserve is not intended to protect the aquatic ecosystem *per se*, but to maintain aquatic ecosystems in such a way that they can continue to provide the goods and services to society. The Reserve (ecological and basic human needs) is the only right to water; all other water uses are subject to authorizations.

A summary of the generic steps which form part of the procedure to determine the ecological Reserve for aquatic ecosystems is provided in **Figure 1**.

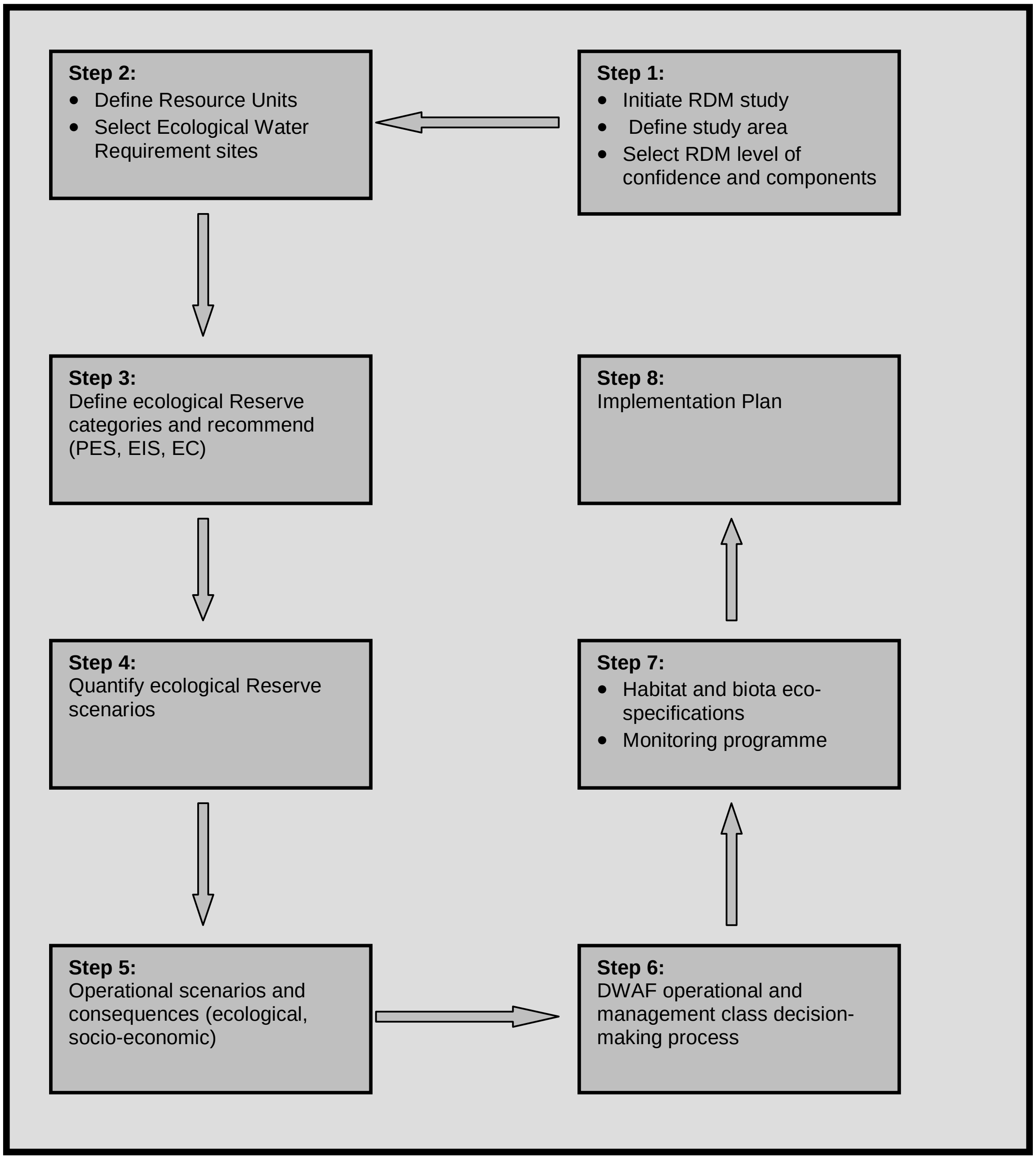

Figure 1: Generic procedure for the determination of the ecological Reserve

Resource Quality Objectives

Resource Quality Objectives (RQOs) are defined as clear goals (numerical or descriptive statements) relating to the quality of a water resource and are set in accordance to the management class (preliminary class in the absence of the classification system) specified for the resource to ensure the water resource is protected. The purpose of RQOs is to set clear objectives for the resource against which water use licenses and the related impacts can be evaluated and managed to achieve a balance between the need to protect and utilization of the resource.

1.1.3 Reserve determination procedures

The Reserve refers to the quantity and quality of water required to (i) supply basic human needs and (ii) protect aquatic ecosystems. The ecological component of the Reserve (i.e. water to protect aquatic ecosystems), refers to water quantity and water quality within the following four components:

- Groundwater;
- Wetlands;
- Rivers; and
- Estuaries.

The water quantity component for a river will typically refer to the flows and flow patterns (magnitude, timing and duration) needed to maintain a river ecosystem within acceptable limits of change, or the specified Ecological Category.

The DWA requires that a standard procedure be followed in order to determine the appropriate level of Ecological Reserve as set out in the RDM method manuals (DWAF, 1999) and any revised methodologies and approaches for each component of the water resource under consideration.

1.1.4 Purpose of this ecological Reserve determination study

The purpose of the ecological Reserve determination studies undertaken for the various tributaries of the Olifants River is to provide higher confidence results than the current available desktop requirements to be used in the WRCS and to provide the necessary protection of the respurce during the evaluation of water use license applications. The EWR sites selected for this study were in tributaries where no EWR information is available and where existing EWR information from previous high confidence studies could not be used for extrapolation and/or estimation.

This report provides the results of the determination of the quantity requirements of the preliminary Reserve for the surface water component of the selected tributaries in the Olifants River catchment on a rapid level of assessment.

The following main tasks were undertaken:

- Define the study area, delineate into resource units according to bio-physical considerations and select EWR sites.
- Undertake the field surveys for the fish, macro-invertebrates and hydraulics (flow measurement and profiling) at the selected EWR sites.
- Describe the reference conditions; determine the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), the Recommended Ecological

Category (REC) and the ecological water requirements of the rivers at the EWR sites.

- Prepare a report detailing the process followed, approaches, results and recommendations for the protection of the water resources and further analysis as part of the WRCS.

1.2 Study approach

The following main activities were undertaken to meet the objectives of the study:

- Field surveys were undertaken during August 2011 (low to medium flows) to collect data on fish, macroinvertebrates and to undertake the hydraulic measurements. It is important to note that rapid studies should ideally be undertaken during the dry season as this will provide the critical information required to ensure protection of the water resources.
- Integration of the results from the field surveys, to determine the ecostatus and ecological water requirements of the rivers at the EWR sites were done during a specialist workshop on 11 and 12 August 2011.

The activities and tasks for this ecological Reserve determination study were undertaken in accordance with the appropriate approaches and methodologies for rivers as prescribed by the CD: RDM of DWA, namely:

- The methodology as set out in *DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0 (Revised water quality methodology, 2002)*.
- The revised methods as outlined in Louw and Hughes (2002), the Habitat Flow Stressor Response (HFSR) manual of IWR Source-to-Sea (2004) and the EcoClassification manual of Kleynhans *et al* (2005).
- Principles of a process to estimate and/or extrapolate environmental flow requirements, Kleynhans, Birkhead and Louw (2008).

1.3 Structure of the report

This appendix is divided into 5 main chapters and applicable annexure, where necessary.

The main chapters are:

Chapter 1 provides the general background to RDM and the study approach.

Chapter 2 describes the study protocol followed for the assessment of the rivers at the EWR sites.

Chapter 3 provides the results of the field surveys and specialist workshop for the rivers assessed during August 2011.

Chapter 4 provides the main conclusions and recommendations.

Chapter 5 cites the references used in this report.

2. STUDY PROTOCOL

This section of the report provides the protocol followed for the determination of the EWRs of the various tributaries of the Olifants River catchment in WMA 4.

2.1 Study team

The specialists involved in the assessment are listed in **Table 1**.

Table 1: Study team for the rapid ecological Reserve determination

TEAM MEMBER	AFFILIATION	SPECIALIZATION/TASK
Stassen R	JMM Stassen	Co-ordination, SPATSIM
Todd, Colleen	JMM Stassen	Macroinvertebrate, habitat integrity
Engelbrecht, J	JS Engelbrecht	Fish, habitat integrity
Jordanova, A	Golder Associates	Hydraulics

2.2 Study area and site visit

The study area falls within the Olifants water management area (WMA 4) and focused on some of the smaller tributaries where no or limited data is available on EWRs to provide input to the WRCS.

The tasks undertaken during the site visit on 8 to 11 August 2011 included:

- A visual "survey" of the river reaches directly upstream and downstream of the proposed impacts to select EWR sites;
- Finding suitable EWR Sites. This was governed by the suitability of the river channel for accurate hydraulic modeling and flow measurement, as well as the presence of habitats critical for ecosystem functioning, such as riffles. Another criteria was that the selected sites were representative of the catchment to allow extrapolation and/or estimation of the results to identified hydronodes in the catchment;
- A cross-sectional profile and longitudinal water slope of the river channels were surveyed by the hydraulic specialist with a dumpy level and the discharge was measured with the aid of a current meter at the EWR sites;
- The fish specialist sampled fish in all suitable aquatic habitats in the vicinity of the EWR sites using an electro-fish shocker and nets, and noted any man-induced habitat modifications impacting on fish fauna; and
- The macroinvertebrate specialist surveyed the aquatic macroinvertebrates occurring within the range of instream habitats at the locality using the SASS5 methodology. A habitat assessment of the site pertaining to SASS was also conducted.

Table 2 provides information on the selected EWR sites and a map of the study area is provided in **Annexure 1**.

Table 2: EWR site information for the Olifants River catchment

EWR site	Quaternary catchment	River	Level of determination	Latitude	Longitude	Ecoregion level 2	MAR ($10^6 m^3$)
OLI-EWR1	B12C	Upper Klein Olifants	Rapid 3	S 25.8169°	E 29.5904°	11.05	44.46
OLI-EWR2	B41B	Upper Steelpoort	Rapid 3	S 25.3831°	E 29.8383°	9.05	63.46
OLI-EWR3	B32A	Kranspoortspruit	Rapid 3	S 25.4376°	E 29.4758°	11.01	4.71
OLI-EWR4	B41F	Klip	Rapid 1	S 25.2249°	E 30.0523°	9.02	5.20
OLI-EWR5	B42G	Watervals	Rapid 3	S 24.8912°	E 30.3105°	9.02	36.39
OLI-EWR6	B42D	Upper Spekboom	Rapid 3	S 25.0094°	E30.5003°	9.02	28.04
OLI-EWR7	B73A	Klaserie	Rapid 3	S 24.5427°	E31.0349°	3.07	25.54
OLI-EWR8	B60H	Ohrigstad	Rapid 2	S 24.5403°	E 30.7223°	9.02	65.49
OLI-EWR9	B42B	Dorpspruit	Rapid 1	S 25.0758°	E 30.4399°	9.02	63.19

2.3 Data collection, modelling and approach

2.3.1 Hydraulics

During the site visit the following activities were undertaken:

- EWR cross sections were selected and surveyed at each EWR site;
- Longitudinal water slope was surveyed;
- Discharge was measured; and
- EWR site photographs were taken.

The measured stage-discharge data for all the rapid 3 assessments are listed in **Table 3**.

Table 3: Measured stage-discharge data per EWR site

EWR site	River	Discharge, *Q* (m3/s)	Max. flow depth, y (m)	Slope
OLI-EWR1	Upper Klein Olifants	0.881	0.45	0.0492
OLI-EWR2	Upper Steelpoort	1.691	0.43	0.0033
OLI-EWR3	Kranskloofspruit	0.154	0.38	0.0054
OLI-EWR5	Watervals	0.848	0.50	0.0163
OLI-EWR6	Upper Spekboom	0.057	0.20	0.0167
OLI-EWR7	Klaserie	0.387	0.38	0.0127
OLI-EWR8	Ohrigstad	0.790	-[1)]	-[1)]

1) Only discharge was measured

The purpose of hydraulic modelling is to provide a stage-discharge rating curve. In order to develop stage-discharge relationships, based on a single set of observed rating data, understanding of flow resistance in natural channels is required. Flow resistance in natural channels is generally a function of stage, particularly at low flows where the flow depth is of the same order of magnitude as the size of the roughness elements constituting the bed (Birkhead et al., 1997; Broadhurst et al., 1997). With increased discharge, the local hydraulic controls become inundated, resulting in a tendency towards uniform water surface gradients and asymptotic resistance coefficient values (Birkhead et al., 2002).

The values of Manning's n resistance coefficients are required for extending the observed rating data. Manning's n was estimated using experience and coefficients given in the literature (Barnes, 1967; Hicks and Mason, 1991 and Chow, 1959).

The modelled stage-discharge data for each of the EWR sites assessed on a rapid 3 level are given in **Table 4**.

Table 4: Hydraulic data used to extend the measured rating data

EWR site	River	Discharge, *Q* (m3/s)	Manning's resistance, *n*	Max. flow depth, *y* (m)	Surface Slope, *S* (m/m)	Ave. Velocity, V (m/s)
OLI-EWR1	Upper Klein Olifants	0.028	0.09	0.20	0.001	0.08
		22.57	0.035	0.90	0.030	2.70
OLI-EWR2	Upper Steelpoort	0.184	0.075	0.20	0.0033	0.17
		25.435	0.030	1.00	0.0056	2.00
OLI-EWR3	Kranskloofspruit	0.004	0.310	0.15	0.0054	0.03
		3.865	0.100	0.80	0.0054	0.38
OLI-EWR5	Watervals	0.009	0.400	0.20	0.0163	0.05
		5.117	0.045	0.70	0.0163	1.27
OLI-EWR6	Upper Spekboom	0.006	0.200	0.10	0.0167	0.09
		3.385	0.050	0.65	0.0167	1.38
OLI-EWR7	Klaserie	0.009	0.450	0.15	0.0127	0.04
		7.423	0.060	0.75	0.0127	1.02

A general depth-discharge power relationship for open channel flow (Birkhead and James, 1998) is derived by:

$y = aQb + c$ (1)

where:

y is the maximum flow depth (m), *Q* is the discharge rate (m3/s), and *a, b* and *c* are regression coefficients. A continuous rating function given by equation (1) was fitted to the measured and modelled data. The rating relationship coefficients in equation (1) for the EWR sites are given in **Table 5**.

Table 5: Regression coefficient in equation (1)

EWR site	River	Regression coefficients		
		a	b	c
OLI-EWR1	Upper Klein Olifants	0.453	0.224	0
OLI-EWR2	Upper Steelpoort	0.353	0.326	0
OLI-EWR3	Kranskloofspruit	0.584	0.240	0
OLI-EWR5	Watervals	0.512	0.195	0
OLI-EWR6	Upper Spekboom	0.457	0.295	0
OLI-EWR7	Klaserie	0.469	0.238	0

The confidence rating in the hydraulic modeling results per EWR site ranges from 0=none to 5=high and is indicated in **Table 6**.

Table 6: Confidence in modeled results

EWR site	River	Limits of measured discharge range (m3/s)	Confidence rating for discharge range	
		Q measured	Q< Q measured	Q> Q measured
OLI-EWR1	Upper Klein Olifants	0.881	2	2
OLI-EWR2	Upper Steelpoort	1.691	3	3
OLI-EWR3	Kranskloofspruit	0.154	2	2
OLI-EWR5	Watervals	0.848	3	2
OLI-EWR6	Upper Spekboom	0.057	2	2
OLI-EWR7	Klaserie	0.387	2	3

2.3.2 Fish

Fish sampling was undertaken at all the selected EWR sites using electro-narcosis. Electro-narcosis (conducting an electric current into the water, which immobilizes the fish momentarily) was applied at all available biotopes together with a 5mm-mesh scoop-net behind the anode of the electro shocking device. Electro shocking is highly effective and entails the use of an electronic device to rapidly catch fish in rivers. The sampling of fish by using an electro shocker is based on the fact that the flow of direct electric current (DC) in water causes an anode reaction (galvanotaxis) in fish. Under the influence of the electrical current fish are stunned and drawn towards the anode.

Observed fish assemblage diversity and abundance can vary greatly, depending on the season and the integrity of the available habitat. Based on baseline data obtained and available habitat for fish during the survey an Expected and Observed Frequency of Occurrence (FROC) of fish species was compiled. These FROC values were used to interrogate the Fish Response Assessment Index (FRAI) to evaluate changes from reference conditions. The FRAI is a rule-based model recently developed by DWA (Kleynhans et al., 2007) and is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers. These intolerance and preference attributes are categorized into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species. Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements. Usually, the FRAI is based on a combination of fish sample data and available habitat for fish. Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation and to determine the present Ecological Category of the fish assemblage.

Each fish specimen sampled was identified in the field to species level and the standard length noted. Observations were also made on their general health and any anomalies were noted.

2.3.3 Macroinvertebrates

The macroinvertebrate diversity and abundance was measured at all the rapd 2 and rapd 3 EWR sites. The following assessment methods were used:

- Macroinvertebrate diversity and abundance was measured using the South African Scoring System Version 5 (SASS5), (Dickens & Graham, 2002). This index measures aquatic macroinvertebrate presence at the family taxon level. The results are expressed as an index score (SASS score) and the Average Score Per Taxon (ASPT value). According to the method, each taxon is allocated a value between 1 and 15, according to its perceived sensitivity to water quality changes, with 1 being the least sensitive and 15 the most sensitive score allocated. Macroinvertebrate taxa (mostly family level) were identified and these data were entered into the Macroinvertebrate Response Assessment Index (MIRAI).
- The Invertebrate Habitat Assessment System (IHAS) was used to assist in assessing the instream and riparian habitat (McMillan, 1998). Sections of the site characterisation manual (Dallas, 2005) were used to assist in characterising the site and interpreting the data collected at the site. The data were either entered directly into the MIRAI, or were used indirectly to assist with data interpretation.
- The MIRAI is a method that uses SASS data and pre-determined reference conditions to determine the Present Ecological Status (PES) per site assessed. The three main drivers of a river are its flow conditions, geomorphology and water quality. Together, these drivers create certain instream habitat, to which the instream biota responds. The ecological category generated by the MIRAI therefore reflects the integrated driver condition at a site, as well as the response of the macroinvertebrates to the various driver components. Thus the MIRAI ecological category gives an indication of the ecological integrity of the resource at the site assessed.
- Historic sampled data and specialist knowledge were used to obtain the reference conditions. This data was included in the MIRAI along with the data obtained from the field assessments.

2.3.4 Hydrological data

Updated hydrology available from the 2009 Olifants River Water Resources development Project (ORWDP): Phase 1 and 2 (DWA, Directorate National Water Resource Planning, 2009) was used as the basis.

The natural MAR at the various EWR sites were determined using flow data from the above study and the catchment areas at the selected EWR sites. **Table 7** provides the natural MAR at each EWR site.

Table 7: Natural MAR at the selected EWR sites

EWR site	Quaternary catchment	River	MAR (10^6m^3)
OLI-EWR1	B12C	Upper Klein Olifants	44.46
OLI-EWR2	B41B	Upper Steelpoort	63.46
OLI-EWR3	B32A	Kranspoortspruit	4.71
OLI-EWR4	B41F	Klip	5.20
OLI-EWR5	B42G	Watervals	36.39
OLI-EWR6	B42D	Upper Spekboom	28.04
OLI-EWR7	B73A	Klaserie	25.54
OLI-EWR8	B60H	Ohrigstad	65.49
OLI-EWR9	B42B	Dorpspruit	63.19

2.4 Specialist workshop (EcoClassification workshop)

The results of the field assessments of the various habitat and biotic components to obtain the Ecostatus and the recommended ecological category (REC) were compiled after the completion of the site visit. This assessment took place during the ecoclassification workshop on 11 and 12 August 2011 with input from all the specialists. The process included the determination of the following:

Reference conditions:- it is those conditions that occur under natural conditions before anthropogenic impacts.

Present Ecological State (PES) or ecostatus:- the determination of the current state of the resource through rule-based models for the driver components (geomorphology – GAI, hydrology – HAI and water quality – PAI) and for the biological response components (fish – FRAI, macro-invertebrates – MIRAI and vegetation – VEGRAI). A rule-based model is then used to derive the ecostatus or overall/integrated condition/health of the resource by integrating the driver and response status. Only the FRAI and MIRAI models are used during a rapid ecological assessment.

Ecological Importance and Sensitivity (EIS):- the ecological importance is defined by Kleynhans (1999), and is regarded as an expression of the water resource's ability to maintain the ecological diversity and functioning on local and wider scales. The ecological sensitivity refers to the river's ability to recover from disturbance. The EIS model (Kleynhans 1999, updated 2002) was used to determine the EIS.

Habitat Integrity (HI):- the Habitat Integrity model (Kleynhans, 1996) was used to evaluate the habitat integrity of both the instream and riparian components in the vicinity of the EWR sites. This assessment model is based on the qualitative assessment (allocation of scores) for various impact criteria on both the instream and riparian zones.

Recommended ecological category (REC):- the PES and EIS is used in the decision on the REC as well as the feasibility to realistically be able to maintain or improve the current condition of the water resource.

3. RESULTS

The results of the ecological water requirements of the rivers of the Olifants River catchment at the selected EWR sites are presented in this section.

3.1 Upper Klein Olifants River (OLI-EWR1): Rapid 3

3.1.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B12C and is situated just upstream of Middelburg Dam. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by large and small boulder-dominated riffle with some cobbles, sparse marginal vegetation and limited gravel and sand. A run area is downstream of the surveyed cross-section (see **Figure 2**).

Figure 2: Cross-sectional view of the Upper Klein Olifants River

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 8**.

Table 8: Upper Klein Olifants River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	2	• Easy access • One single channel under low flow conditions	• No gauging weir for flow records • Stream bed consists of large rocks and boulders that complicate low flow modelling • Presence of a secondary channel on the left side of the EWR cross-section that will be active under higher flow conditions
Fish	4	• Easy Accessible • Diversity of flow depth classes • Diversity cover and substrate and undercut banks	• Sparse marginal vegetation • High conductivity not conducive to electro fishing • Algal growth reduce ability to sample
Macroinvertebrates	3	Good SIC biotope, as well as SOOC biotope present. The site is accessible and wadeable. A diversity of flows are present. A diversity of instream habitats present, including bedrock, SIC, SOOC, VOOC, GSM.	Dense filamentous algae covering the benthic habitats. Cattle drinking point. No VIC present.

* Confidence scores: 0 = no confidence; 5 = high confidence

3.1.2 Information Availability

The available information for the EWR site is summarized in **Table 9**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 9: Information availability for the Upper Klein Olifants EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						No gauging weir for flow records. Only one survey for hydraulic modeling.
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Several surveys has been conducted at the site since 2000
Macroinvertebrates						Reference conditions provided by C. Thirion; once-off survey during August 2011, historic SASS data from the Rivers Database.

3.1.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Upper Klein Olifants River per specialist component are summarized in **Table 10**.

Table 10: Description of reference conditions for the Upper Klein Olifants River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Amphilius uranoscopus* (was collected upstream of the site) *Barbus anoplus* *Barbus neefi* *Barbus paludinosus* *Barbus trimaculatus* *Chiloglanis pretoriae* (still present below dam) *Clarias gariepinus* *Cyprinus carpio* (Exotic) *Labeo umbratus* (Translocated) *Labeobarbus polylepis* *Pseudocrenilabrus philander* *Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 220 Average Score Per Taxon (ASPT): 6.5 List of taxa expected include: Atyidae, Perlidae, Heptageniidae, Leptophlebiidae, Tricorythidae, Chlorocyphidae, Coenagrionidae, Aeshinidae, Corduliidae, Lebelluliae, Pyralidae, Belostomatidae, Naurcoridae, Corixidae, Pleidae, Ecnomidae, Hydropsychidae, Leptoceridae, Dytiscidae, Elmidae, Gyrinidae, Psephenidae, Athericidae, Ceratopogonidae, Dixidae, Simuliidae, Tabanidae, Lymnaeidae, Corbiculidae, Sphaeridae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus neefi
Clarias gariepinus
Cyprinus carpio (Exotic)
Labeo umbratus (Translocated)
Pseudocrenilabrus philander

Tilapia sparrmanii

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a D (49.5) present state mainly due to the poor water quality at the EWR site. Several of the expected fish species no longer occur in this section of the river and upstream migration from refuge areas for re-establishment no longer available due to Middleburg Dam. The water quality of the Upper Klein Olifants River is also probably no longer suitable for some of the species.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (66.1%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 54.3%, followed by instream habitat at 72.3%, followed closely by the flow modification metric at 72.8%. **Table 11** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include, Baetidae, Coenagrionidae, Hydropsychidae, Dytiscidae, Elmidae and Simuliidae.

Table 11: Macroinvertebrate Ecological Category, MIRAI

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**	72.8	*0.321*	23.404	2	90
HABITAT	**H**	72.3	*0.321*	23.2462	2	90
WATER QUALITY	**WQ**	54.3	*0.357*	19.4062	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				66.0564		
INVERTEBRATE EC CATEGORY				**C**		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for vegetation had been impacted the most from reference, with an allocated rating of 2.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the ASPT score has been impacted the most with an allocated rating of 4. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detailed tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Upper Klein Olifants River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 12** and **Table 13** respectively. The instream integrity is in a D category and the riparian zone integrity in a B/C category. The main impacts on the habitat integrity of the system are the poor water quality and channel modification due to discharges from the upstream mines.

Table 12: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**August 2011 (Upper Klein Olifants EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	6	Removal for mining purposes
EXOTIC VEGETATION (IMPACT 1-25)	6	Sesbania, wattle
BANK EROSION (IMPACT 1-25)	5	Limited at site
CHANNEL MODIFICATION (IMPACT 1-25)	8	Some changes to riparian zone due to increased flows
WATER ABSTRACTION (IMPACT 1-25)	6	Small impact on the riparian zone
INUNDATION (IMPACT 1-25)	2	None
FLOW MODIFICATION (IMPACT 1-25)	4	Some changes to riparian zone due to changes to flow pattern
WATER QUALITY (IMPACT 1-25)	7	Plants sensitive to large changes in water quality not present
TOTAL (OUT OF 200)	44	
RIPARIAN VEGETATION INTEGRITY SCORE *	77.8	
RIPARIAN INTEGRITY CATEGORY	**B/C**	

* Weighted riparian integrity score

Table 13: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	August 2011 (Upper Klein Olifants EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	12	Instream habitats changed due to abstractions in the upper parts of the catchment
FLOW MODIFICATION (IMPACT 1-25)	9	Increased flows
BED MODIFICATION (IMPACT 1-25)	7	Increased sediments due to higher flows
CHANNEL MODIFICATION (IMPACT 1-25)	6	Small changes to the channel due to increased flows
WATER QUALITY (IMPACT 1-25)	25	Critical due to mining discharges
INUNDATION (IMPACT 1-25)	3	None at site
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	5	Presence of Myriophyllum aquaticum
EXOTIC FAUNA (IMPACT 1-25)	4	Presence of CCAR
SOLID WASTE DISPOSAL (IMPACT 1-25)	1	Very little at site
IN STREAM HABITAT INTEGRITY SCORE *	53.5	
INSTREAM INTEGRITY CATEGORY	**D**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 14**. The main impacts on the Upper Klein Olifants River are increased flows as well as the poor water quality due to discharges from mining activities.

Table 14: PES per component for the Upper Klein Olifants River

COMPONENT	PES	EXPLANATION
Fish	D (49.5)	Several of the expected fish species no longer occur in this section of the river and upstream migration from refuge areas for re-establishment no longer available due to Middleburg Dam. Water quality probably no longer suitable for some of the species.
Macro-invertebrates	C (66.1)	The water quality metric is impacted the most from the reference condition, possibly due to discharges from mining and sewage works in the upper catchment. Furthermore, bed modification due to increased sedimentation and cattle trampling the river banks and riparian vegetation serve to reduce the integrity of the system.
Habitat Integrity: Instream	D (53.5)	Upstream water abstraction for agricultural and mining use as well as poor quality return flows from these activities impacts on the instream habitats.
Habitat Integrity: Riparian	B/C (77.8)	Increased flows in the lower reaches of the rivers results in channel modification.

Ecological Importance and Sensitivity (EIS)

The EIS for the Upper Klein Olifants River was determined as low. See **Table 15** for a summary of the EIS of the Upper Klein Olifants River.

Table 15: Ecological Importance and Sensitivity of the Upper Klein Olifants River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	0	
Species/taxon richness	2	27 invertebrate families. ASPT= 4.6 5 of 10 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	
Refugia	1	
Sensitivity to flow changes	3	
Sensitivity to flow related water quality changes	1	
Migration route/corridor (instream and riparian)	0	
Importance of conservation and natural areas	0	
MEDIAN OF DETERMINANTS	**0.5**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**LOW**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Upper Klein Olifants River are shown in **Table 16**.

Table 16: Integrated results for the Upper Klein Olifants River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	D	Low	Stable
Habitat Integrity: Riparian	B/C		Stable
Fish	D		Negative
Macroinvertebrates	C		Stable
ECOSTATUS (overall, integrated score)	**C**		
RECOMMENDED ECOLOGICAL CATEGORY			**C**

3.1.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C for the Upper Klein Olifants River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and January. September is the lowest flow month and January the highest flow month based on the natural time series.

The water level in the Upper Klein Olifants River during the site visit on 8 August 2011 (0.881 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (see **Figure 3**).

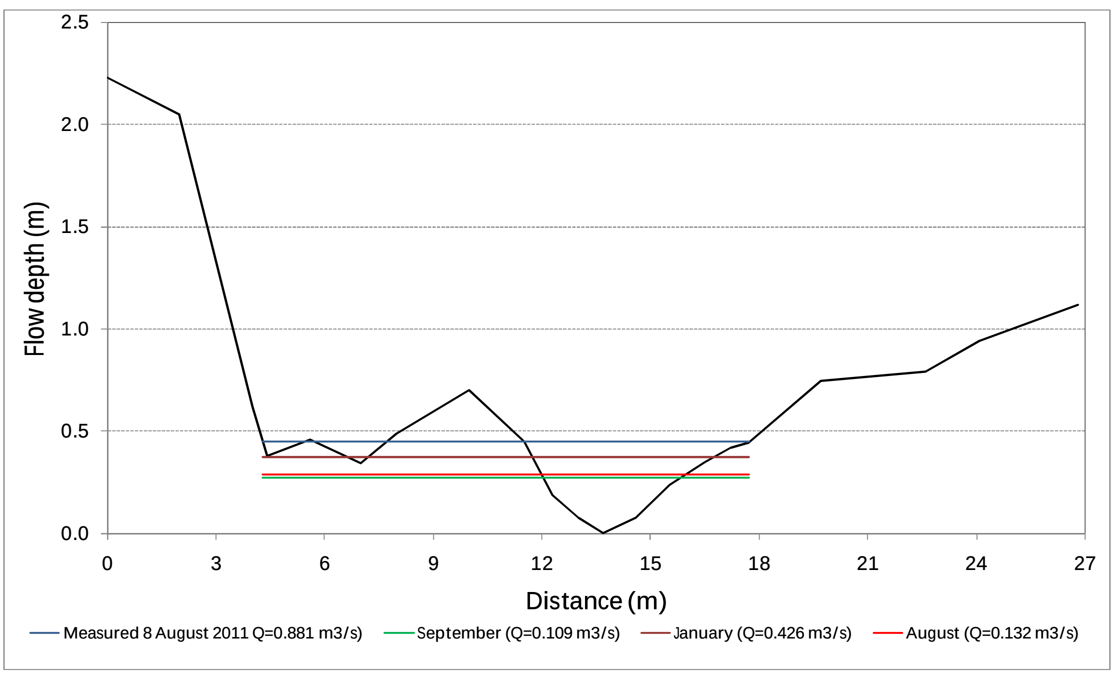

Figure 3: Calibrated cross-sectional profile of the Upper Klein Olifants River at the EWR site

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was not adequate to maintain the system in a C category. The maintenance low flows for September were adjusted from 0.072 m^3/s to 0.109 m^3/s to provide the necessary depths and velocities for fish and macronvertebrates.

Table 17 gives the results of the DRM at the EWR site in the Upper Klein Olifants River in quaternary catchment B12C and **Table 18** provides a summary of the recommended requirements.

Table 17: Results of the DRM for the Upper Klein Olifants River (REC = C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flows	September	0.109	0.28	0.16	0.15
High flows	January	0.426	0.38	0.19	0.37
Datum	August	0.132	0.30	0.17	0.19
Measured discharge at site visit (8 August 2011)		0.881	0.45	0.17	0.55

Table 18: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B12C
EWR Site Co-ordinates	S 25.8169°; E 29.5904°
Recommended Ecological Category	C
VMAR for Quaternary Catchment Area	44.46
Total EWR	12.83 (28.86 %VMAR)
Maintenance Low flows	8.38 (18.85 %VMAR)
Drought Low flows	2.18 (4.90 %VMAR)
Maintenance High flows	4.45 (10.01 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.2 Upper Steelpoort River (OLI-EWR2): Rapid 3

3.2.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B41B and is situated just upstream of the R555. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by boulders and medium cobble-dominated riffle with gravel, marginal vegetation and limited fines. A run area is downstream of the surveyed cross-section (see **Figure 4**).

Figure 4: Cross-sectional view of the Upper Steelpoort River

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 19**.

Table 19: Upper Steelpoort River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	3	• Easy access • Single channel	• No gauging weir for flow records • Stream bed consists of large boulders that complicate low flow modelling
Fish	4	• Easy Accessible • Diversity of flow depth classes • Diversity cover and substrate and undercut banks	• High flows during survey not conducive to sampling
Macroinvertebrates	3	Good diversity of velocities present. Fair habitat diversity present, including SIC, MVIC, GSM, bedrock and boulders. Site is accessible and mostly wadeable (some deeper channels present).	Site adjacent to a settlement, hence potential water quality impacts, due to for example, local people washing clothing upstream of the site, cattle drinking point. Large proportion of the SIC are embedded and difficult to dislodge. Sedimentation visible on instream habitats.

* Confidence scores: 0 = no confidence; 5 = high confidence

3.2.2 Information Availability

The available information for the EWR site is summarized in **Table 20**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 20: Information availability for the Upper Steelpoort EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						No gauging weir for flow records. Only one survey for hydraulic modeling.
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Several surveys since 1970's
Macroinvertebrates						Reference conditions provided by C. Thirion; once-off present day survery, historic SASS data provided by C. Thirion – sourced from the Rivers Database.

3.2.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Upper Steelpoort River per specialist component are summarized in **Table 21**.

Table 21: Description of reference conditions for the Upper Steelpoort River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Amphilius uranoscopus* *Barbus anoplus* *Barbus neefi* *Chiloglanis pretoriae* *Clarias gariepinus* *Labeobarbus polylepis* *Pseudocrenilabrus philander* *Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 250 Average Score Per Taxon (ASPT): 7 List of taxa expected include Perlidae, Baetidae >2spp, Heptageniidae, Leptophlebiidae, Prosopistomatidae, Tricorythidae, Chlorocyphidae, Aeshnidae, Gomphidae, Libellulidae, Corixidae, Notonectidae, Ecnomidae, Hydropsychidae >2spp, Philopotamidae, Leptoceridae, Elmidae, Gyrinidae, Hydraenidae, Psephenidae, Athericidae, Ceratopogonidae, Ancylidae, Planorbinae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus anoplus
Barbus neefi
Chiloglanis pretoriae

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C (68.9) present state mainly due to the poor water quality and sediments at the EWR site. Only three species collected during recent survey. Several species expected has not recently been collected at the site (*Amphilius uranoscopus, Labeobarbus polylepis*) and the abundance of fish in general was very low during the survey. The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (66.7%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 57.5%, followed by instream habitat at 69.6%, with the least impacted driver metric being flow modification, at 73.9%. **Table 22** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include Hydracarina, Coenagrionidae, Gomphidae, Belostomatidae, Naurcoridae, Ecnomidae, Leptoceridae, Simuliidae, Ancylidae.

Table 22: Macroinvertebrate Ecological Category, MIRAI

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**	73.9	*0.321*	23.7556	2	90
HABITAT	**H**	69.6	*0.321*	22.3838	2	90
WATER QUALITY	**WQ**	57.5	*0.357*	20.5465	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				66.6859		
INVERTEBRATE EC CATEGORY				**C**		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for fast flowing water,standing water and abundance and/or frequency of occurrence of taxa with a preference for standing water had the highest rating of 2, thus being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles had been impacted the most from reference, with an allocated rating of 3.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the ASPT score has been impacted the most with an allocated rating of 4. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detail tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Upper Steelpoort River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 23** and **Table 24** respectively. The instream integrity is in a C/D category and the riparian zone integrity in a B category. The main impacts on the habitat integrity of the system are water abstraction for agricultural purposes, flow and bed modification and poor water quality (nutrients).

Table 23: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**August 2011 (Upper Steelpoort EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	4	Small
EXOTIC VEGETATION (IMPACT 1-25)	4	Wattle present in the catchments upstream
BANK EROSION (IMPACT 1-25)	4	Limited at site
CHANNEL MODIFICATION (IMPACT 1-25)	4	Small, bedrock present at site
WATER ABSTRACTION (IMPACT 1-25)	3	Small
INUNDATION (IMPACT 1-25)	2	None
FLOW MODIFICATION (IMPACT 1-25)	2	None
WATER QUALITY (IMPACT 1-25)	5	Small impact, nutrients might have limited impact on increased growth of vegetation
TOTAL (OUT OF 200)	28	
RIPARIAN VEGETATION INTEGRITY SCORE *	85.8	
RIPARIAN INTEGRITY CATEGORY	**B**	

* Weighted riparian integrity score

Table 24: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	**August 2011 (Upper Steelpoort EWR site)**	**COMMENT**
WATER ABSTRACTION (IMPACT 1-25)	14	Irrigation, domestic (Belfast), afforestation and mining use of water upstream
FLOW MODIFICATION (IMPACT 1-25)	10	Low flows impacted by water abstractions
BED MODIFICATION (IMPACT 1-25)	13	Increased sediments due to catchment

		developments
CHANNEL MODIFICATION (IMPACT 1-25)	7	Small due to sediments
WATER QUALITY (IMPACT 1-25)	10	Increased nutrients and sedimentation
INUNDATION (IMPACT 1-25)	5	Small dams upstream and downstream might impact slightly
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	None
EXOTIC FAUNA (IMPACT 1-25)	0	None
SOLID WASTE DISPOSAL (IMPACT 1-25)	2	Some litter present in vicinity of site
IN STREAM HABITAT INTEGRITY SCORE *	61.2	
INSTREAM INTEGRITY CATEGORY	**C/D**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 25**. The main impact on the Upper Steelpoort River is increased nutrients.

Table 25: PES per component for the Upper Steelpoort River

COMPONENT	PES	EXPLANATION
Fish	C (68.9)	Only three species collected during recent survey. Several species expected has not recently been collected at the site (*Amphilius uranoscopus, Labeobarbus polylepis*) and the abundance of fish was low.
Macro-invertebrates	C (66.7)	Water quality is the most impacted driver at this site, with increased nutrients entering the system from adjacent settlements and feedlots in the upper catchment, as well as sedimentation from upstream activities which decreases the available instream habitat for macroinvertebrates.
Habitat Integrity: Instream	C/D (61.2)	Changes to the flow and bed of the river due to upstream water abstractions for agriculture, domestic and mining use.
Habitat Integrity: Riparian	B (85.8)	Small impacts from alien invasive plants, localized bank erosion and increased growth due to nutrients.

Ecological Importance and Sensitivity (EIS)

The EIS for the Upper Steelpoort River was determined as moderate with the presence of the unique Labeobarbus polylepis and the flow and water related water quality sensitive *Chiloglanis pretoriae*, *Amphilius uranoscopus, Heptageniidae* and *Prisopistomatidae*. See **Table 26** for a summary of the EIS of the Upper Steelpoort River.

Table 26: Ecological Importance and Sensitivity of the Upper Steelpoort River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	None
Unique (endemic, isolated)	3	Small population of LPOL
Intolerant (flow and flow related water quality)	3	CPRE, AURA Heptageniidae, Prisopistomatidae
Species/taxon richness	2	23 invertebrate families. ASPT 6.4 2 of 8 expected fish species (water level very high)
RIPARIAN AND INSTREAM HABITATS	**(0-24)**	
Diversity of types	2	Riffle, run, pools, marginal vegetation, some GSM, bedrock, boulders
Refugia	2	LPOL
Sensitivity to flow changes	2	Moderate stream not very sensitive to flow changes
Sensitivity to flow related water quality changes	2	Moderate stream not very sensitive to flow changes
Migration route/corridor (instream and riparian)	2	Limited
Importance of conservation and natural areas	0	None
MEDIAN OF DETERMINANTS	**2**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**MODERATE**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Upper Steelpoort River are shown in **Table 27**.

Table 27: Integrated results for the Upper Steelpoort River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	C/D		Stable
Habitat Integrity: Riparian	B		Stable
Fish	C	**Moderate**	Stable
Macroinvertebrates	C		Stable
ECOSTATUS (overall, integrated score)	**C**		
RECOMMENDED ECOLOGICAL CATEGORY			**C**

3.2.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C for the Upper Steelpoort River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series.

The water level in the Upper Steelpoort River during the site visit on 8 August 2011 (1.691 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (see **Figure 5**).

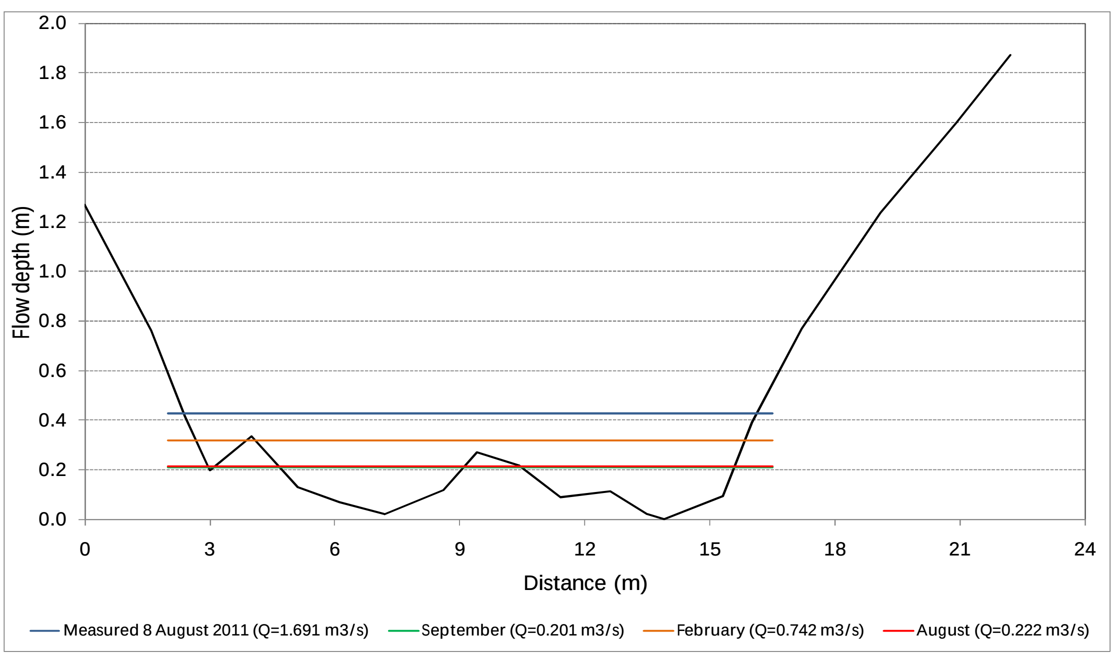

Figure 5: Calibrated cross-sectional profile of the Upper Steelpoort River at the EWR site

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was not adequate to maintain the system in a C category. The maintenance low flows for September were adjusted from 0.129 m^3/s to 0.201 m^3/s to provide the necessary depths and velocities for fish and macroinvertebrates.

Table 28 gives the results of the DRM at the EWR site in the Upper Steelpoort River in quaternary catchment B41B and **Table 29** provides a summary of the recommended requirements.

Table 28: Results of the DRM for the Upper Steelpoort River (REC = C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flows	September	0.201	0.22	0.13	0.16
High flows	February	0.742	0.33	0.20	0.28
Datum	August	0.222	0.23	0.13	0.17
Measured discharge at site visit (8 August 2011)		1.691	0.43	0.28	0.43

Table 29: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B41B
EWR Site Co-ordinates	S 25.3831°; E 29.8383°
Recommended Ecological Category	C
VMAR for Quaternary Catchment Area	63.46
Total EWR	18.90 (29.78 %VMAR)
Maintenance Low flows	13.19 (20.78 %VMAR)
Drought Low flows	4.22 (6.65 %VMAR)
Maintenance High flows	5.71 (9.00 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.3 Kranspoortspruit (OLI-EWR3): Rapid 3

3.3.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B32A and is situated just upstream of Loskop Dam. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by medium cobble-dominated riffle with some larger gravel, with marginal vegetation and limited fines. Instream vegetation is immediately downstream of the surveyed cross-section (see **Figure 6**).

Figure 6: Cross-sectional view of the Kranspoortspruit

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 30**.

Table 30: Kranspoortspruit EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	2	• Easy access	• No gauging weir for flow records • Instream vegetation downstream of the cross-section influences overall flow resistance at higher flows • Survey cross-section does not represent the wide range of hydraulic habitats of the EWR site • The aquatic survey was conducted downstream of the hydraulic cross-section. The aquatic cross-section was not surveyed due to time limitations
Fish	5	• Easy Accessible • Diversity of flow depth classes • Diversity cover and substrate, marginal vegetation and undercut banks	• Near road bridge causing some local loss of habitats downstream of bridge
Macroinvertebrates	3	Good instream habitat diversity present, including good SIC and SOOC. High diversity of flow velocities present at the time of sampling. Multiple channels at the site create a diverse instream structure, with diverse instream habitat. The site is accessible and wadeable. Minimal localized impacts.	Site is situated immediately downstream of a low-flow bridge – causes increased sedimentation on the available instream habitat. Cattle use the site for drinking and trample parts of the available instream habitat.

* Confidence scores: 0 = no confidence; 5 = high confidence

3.3.2 Information Availability

The available information for the EWR site is summarized in **Table 31**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 31: Information availability for the Kranspoortspruit EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						No gauging weir for flow records. Only one survey for hydraulic modeling.
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Several surveys since 2000
Macroinvertebrates						Reference conditions, historic SASS data from the Rivers Database and a once-off assessment of the site during August 2011 were all used as available information.

3.3.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Kranspoortspruit per specialist component are summarized in **Table 32**.

Table 32: Description of reference conditions for the Kranspoortspruit

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Barbus bifrenatus* *Barbus eutaenia* *Barbus lineomaculatus* *Barbus paludinosus* *Barbus trimaculatus* *Barbus unitaeniatus* *Chiloglanis pretoriae* *Clarias gariepinus* *Labeobarbus marequensis* *Oreochromis mossambicus* *Petrocephalus wesselsi* *Pseudocrenilabrus philander* *Tilapia sparrmanii* *Marcusenius macrolepidotus*
Macroinvertebrates	SASS5 scores: 240 Average Score Per Taxon (ASPT): 7.5 List of taxa expected include Atyidae, Potamonautidae, Perlidae, Baetidae, Heptageniidae, Leptophlebiidae, Polymitarcyidae, Prosopistomatidae, Oligoneuridae, Tricorythidae, Lestidae, Gomphidae, Libellulidae, Belostomatidae, Ecnomidae, Hydroptilidae, Psychomyiidae, Leptoceridae, Elmidae, Dytiscidae, Gyrinidae, Helodidae, Hydrophilidae, Psephenidae, Ceratopogonidae, Simuliidae, Tabanidae, Ancylidae, Planorbinae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus bifrenatus
Barbus eutaenia
Barbus lineomaculatus
Barbus paludinosus
Barbus trimaculatus
Barbus unitaeniatus
Chiloglanis pretoriae
Labeobarbus marequensis
Oreochromis mossambicus
Pseudocrenilabrus philander
Tilapia sparrmanii
Marcusenius macrolepidotus

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a B (84.3) present state mainly due to the poor water quality at the EWR site. This site still has a high diversity and abundance of fish. Petrocephalus wesselsi has not recently been collected at the site, possibly as a result of a loss of some marginal vegetation previously present, due to recent high flows. The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a B/C (77.6%). This means the river is in a moderately modified ecological condition to largely natural . The most impacted driver metric is that of water quality at 70.4%, followed by flow modification at 79.8%, with the least impacted driver metric being instream habitat at 82.2%. **Table 33** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include Perlidae, Baetidae >2spp, Heptageniidae, Leptophlebiidae, Philopotamidae, Leptoceridae, Psephenidae, Simuliidae, and Planorbinae.

Table 33: Macroinvertebrate Ecological Category, MIRAI

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	*0.357*	28.5156	1	100
HABITAT	**H**	82.2	*0.321*	26.4286	2	90
WATER QUALITY	**WQ**	70.4	*0.321*	22.6162	2	90
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				77.5604		
INVERTEBRATE EC CATEGORY				**C**		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for standing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for vegetation had been impacted the most from reference, with an allocated rating of 2 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the ASPT score has been impacted the most with an allocated rating of 3. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detail tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Kranspoortspruit was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 34** and **Table 35** respectively. The instream integrity is in an A/B category and the riparian zone integrity in a B category. The main impacts on the habitat integrity of the system are the infestation of exotic plants (wattle, sesbania, poplars), localized bed modification and bank erosion caused by causeways, bridges and cattle trampling and farming activities.

Table 34: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	August 2011 (Kranspoort spruit EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	2	Limited at bridges
EXOTIC VEGETATION (IMPACT 1-25)	7	Wattle, sesbania & poplars
BANK EROSION (IMPACT 1-25)	8	Localised - bridge, cattle watering
CHANNEL MODIFICATION (IMPACT 1-25)	3	Localised at bridge
WATER ABSTRACTION (IMPACT 1-25)	0	None
INUNDATION (IMPACT 1-25)	0	None
FLOW MODIFICATION (IMPACT 1-25)	4	Small due to upstream irrigation
WATER QUALITY (IMPACT 1-25)	2	Some enrichment of nutrients
TOTAL (OUT OF 200)	26	
RIPARIAN VEGETATION INTEGRITY SCORE *	86.7	
RIPARIAN INTEGRITY CATEGORY	**B**	

* Weighted riparian integrity score

Table 35: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	August 2011 (Kranspoort spruit EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	4	Some abstraction for irrigation upstream
FLOW MODIFICATION (IMPACT 1-25)	2	None
BED MODIFICATION (IMPACT 1-25)	3	Localised at bridge, cattle drinking
CHANNEL MODIFICATION (IMPACT 1-25)	2	None
WATER QUALITY (IMPACT 1-25)	5	Small, nutrients
INUNDATION (IMPACT 1-25)	2	None
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	None
EXOTIC FAUNA (IMPACT 1-25)	0	None
SOLID WASTE DISPOSAL (IMPACT 1-25)	1	None
IN STREAM HABITAT INTEGRITY SCORE *	90.1	
INSTREAM INTEGRITY CATEGORY	**A/B**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 36**. The main impacts on the Kranspoortspruit are the presence of exotic plants and localized bank erosion. The erosion is mainly due to bridges and cattle watering. Poor water quality due to increased nutrients.

Table 36: PES per component for the Kranspoortspruit

COMPONENT	PES	EXPLANATION
Fish	B (84.3)	This site still has a high diversity and abundance of fish. Petrocephalus wesselsi has not recently been collected at the site, possibly as a result of a loss of marginal vegetation due to recent high flows.
Macro-invertebrates	B/C (77.6)	Impacts at the site are minimal and include trampling at the site by cattle, impacting the available instream habitat negatively. Silt from the adjacent low-flow bridge and dirt road enter the system and cause increased sedimentation at the site. Some evidence of nutrient enrichment is present, with some algal presence on instream cobbles.
Habitat Integrity: Instream	A/B (90.0)	Abstractions for irrigation and increased nutrients
Habitat Integrity: Riparian	B (86.7)	Alien invasive plants and localized bank erosion

Ecological Importance and Sensitivity (EIS)

The EIS for the Kranspoortspruit was determined as very high due to the following:

- Presence of the rare and endangered BLIN and unique BBIF. The river also serves as refugia for these fish species;
- Intolerant flow and water quality species that are present are CPRE, BEUT, BLIN Heptageniidae and Perlidae;
- Species and taxon richness sampled at the site (30 macroinvertebrates taxa and 10 out of the 14 expected fish species);
- The river is a conservation/protection area for BBIF as this is the only population occurring in Mpumalanga.

Table 37 provides a summary of the EIS of the Kranspoortspruit.

Table 37: Ecological Importance and Sensitivity of the Kranspoortspruit

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	4	BLIN
Unique (endemic, isolated)	3	BBIF
Intolerant (flow and flow related water quality)	4	CPRE, BEUT, BLIN Heptageniidae, Perlidae
Species/taxon richness	4	30 invertebrate families. ASPT= 6.7 10 of14 expected fish species

RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	3	Boulders, rocks, riffles, runs, GSM, marginal vegetation, SOC, SIC
Refugia	4	BBIF, BLIN
Sensitivity to flow changes	4	Small stream sensitive to flow changes
Sensitivity to flow related water quality changes	3	Small stream sensitive to flow related water quality changes
Migration route/corridor (instream and riparian)	2	Local movement of fish
Importance of conservation and natural areas	3	Conservation/protection of BBIF - only population in Mpumalanga
MEDIAN OF DETERMINANTS	**3.5**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**VERY HIGH**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Kranspoortspruit are shown in **Table 38**.

Table 38: Integrated results for the Kranspoortspruit

COMPONENT	**PES**	**EIS**	**TREND**
Habitat Integrity: Instream	A/B	**Very high**	Stable
Habitat Integrity: Riparian	B		Stable
Fish	B		Stable
Macroinvertebrates	B/C		Stable
ECOSTATUS (overall, integrated score)	**B**		
RECOMMENDED ECOLOGICAL CATEGORY	**A/B**		

3.3.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of A/B for the Kranspoortspruit at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series.

The water level in the Kranspoortspruit during the site visit on 9 August 2011 (0.154 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (see **Figure 7**).

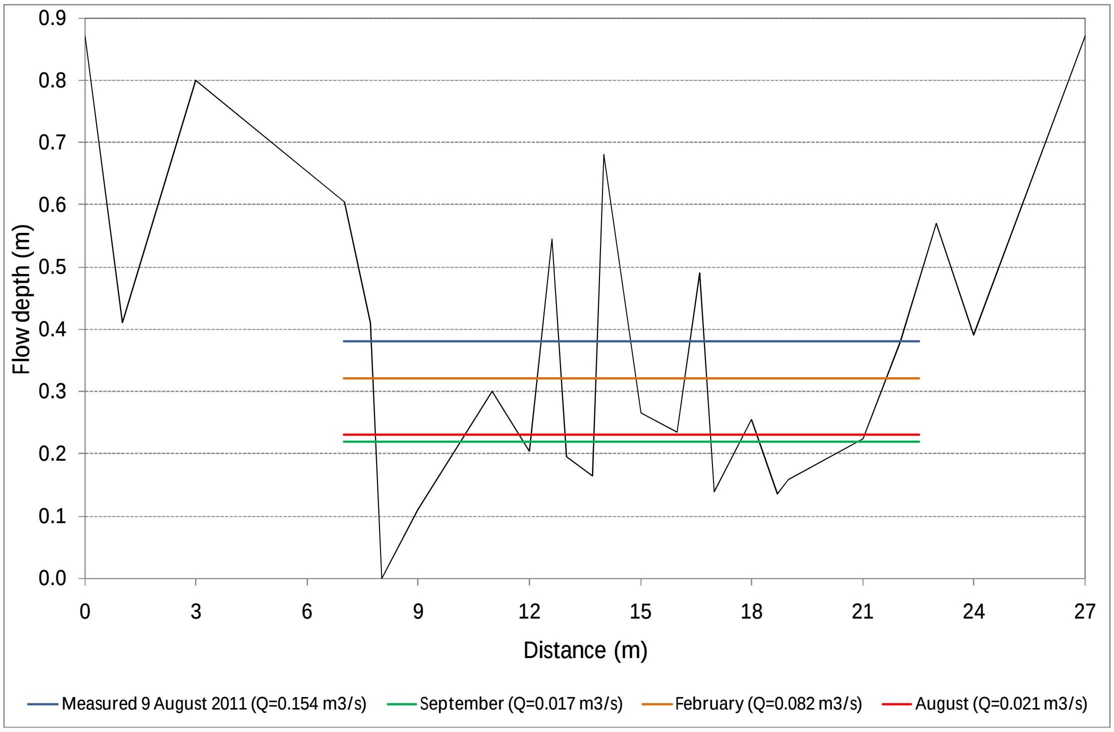

Figure 7: Calibrated cross-sectional profile of the Kranspoortspruit at the EWR site

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was adequate to maintain the system in an A/B category.

Table 39 gives the results of the DRM at the EWR site in the Kranspoortspruit in quaternary catchment B32A and **Table 40** provides a summary of the recommended requirements.

Table 39: Results of the DRM for the Kranspoortspruit (REC = A/B)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flows	September	0.017	0.21	0.06	0.05
High flows	February	0.084	0.32	0.11	0.06
Datum	August	0.021	0.22	0.06	0.05
Measured discharge at site visit (9 August 2011)		0.154	0.38	0.17	0.07

Table 40: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B32A
EWR Site Co-ordinates	S 25.4376°; E 29.4758°
Recommended Ecological Category	A/B
VMAR for Quaternary Catchment Area	4.71
Total EWR	2.17 (46.01 %VMAR)
Maintenance Low flows	1.45 (30.81 %VMAR)
Drought Low flows	0.08 (1.78 %VMAR)
Maintenance High flows	0.72 (15.20 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.4 Klip River (OLI-EWR4): Rapid 1

3.4.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B41F and is situated just downstream of the R577 road from Roossenekal to Lydenburg. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by small gravel and fines with some runs and pools along the reach. Low diversity cover and substrate, marginal vegetation and undercut banks.

Figure 8: View of the Klip River downstream of the EWR site

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 41**.

Table 41: Klip River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Fish	4	• Easy Accessible	• Near road bridge causing some local loss of habitats

			downstream of bridge • Low diversity of flow depth classes • Low diversity cover and substrate, marginal vegetation and undercut banks

* Confidence scores: 0 = no confidence; 5 = high confidence

3.4.2 Information Availability

The available information for the EWR site is summarized in **Table 42**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 42: Information availability for the Klip EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Several recent surveys

3.4.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Klip River per specialist component are summarized in **Table 43**.

Table 43: Description of reference conditions for the Klip River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Amphilius uranoscopus* *Barbus motebensis*

Present Ecological State (PES) or ecostatus

The PES for the fish, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Amphilius uranoscopus
Barbus motebensis

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C (70.2) present state mainly due to the poor water quality at the EWR site. The abundance of both species has recently declined sharply and only a few individuals of both species have been collected. The aquatic plants in the system and sediments have increased notably in recent times.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Habitat Integrity

The habitat integrity assessment for the Klip River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 44** and **Table 45** respectively. Both the instream and riparian zone integrity is in a C category. The main impacts on the habitat integrity of the system are the poor water quality due to upstream agricultural activities and local settlements and bank erosion caused by bridges, roads and cattle trampling.

Table 44: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**August 2011 (Klip EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	8	Settlement in vicinity of river
EXOTIC VEGETATION (IMPACT 1-25)	2	Salix
BANK EROSION (IMPACT 1-25)	11	Bridges, road crossings and cattle drinking
CHANNEL MODIFICATION (IMPACT 1-25)	8	Cattle drinking and crossing
WATER ABSTRACTION (IMPACT 1-25)	1	None
INUNDATION (IMPACT 1-25)	1	None
FLOW MODIFICATION (IMPACT 1-25)	3	Small
WATER QUALITY (IMPACT 1-25)	3	Small, nutrients
TOTAL (OUT OF 200)	37	
RIPARIAN VEGETATION INTEGRITY SCORE *	72.7	
RIPARIAN INTEGRITY CATEGORY	**C**	

* Weighted riparian integrity score

Table 45: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	**August 2011 (Klip EWR site)**	**COMMENT**
WATER ABSTRACTION (IMPACT 1-25)	4	Small for local domestic use
FLOW MODIFICATION (IMPACT 1-25)	2	None

BED MODIFICATION (IMPACT 1-25)	5	Small due to cattle
CHANNEL MODIFICATION (IMPACT 1-25)	7	Cattle crossings
WATER QUALITY (IMPACT 1-25)	11	Increased nutrients
INUNDATION (IMPACT 1-25)	4	Small dams upstream
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	None
EXOTIC FAUNA (IMPACT 1-25)	0	None
SOLID WASTE DISPOSAL (IMPACT 1-25)	5	General littering in vicinity of site
IN STREAM HABITAT INTEGRITY SCORE *	76.6	
INSTREAM INTEGRITY CATEGORY	**C**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 46**. The main impacts on the Klip River are some irrigation upstream and trampling by livestock in the catchment as well as human settlements close to the site.

Table 46: PES per component for the Klip River

COMPONENT	PES	EXPLANATION
Fish	C (70.2)	The abundance of both species has recently declined sharply and on a few individuals of both species has recently been collected. The aquatic plants in the system and sediments have increased notably in recent times.
Habitat Integrity: Instream	C (76.6)	Increased nutrients and some bed modification due to cattle.
Habitat Integrity: Riparian	C (72.7)	Bank erosion and channel modification due to bridges, cattle drinking and crossings.

Ecological Importance and Sensitivity (EIS)

The EIS for the Klip River was determined as moderate. The presence of the unique BMOT, AURA that is intolerant to water and water quality related impacts and the Klip River is a small system that is sensitive to flow related water quality changes contributed to the moderate EIS of the Klip River. See **Table 47** for a summary of the EIS of the Klip River.

Table 47: Ecological Importance and Sensitivity of the Klip River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	

Rare and endangered	0	None
Unique (endemic, isolated)	3	BMOT, *Aponogeton* (possibly new species endemic to the area)
Intolerant (flow and flow related water quality)	3	AURA
Species/taxon richness	2	2 of 2 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	1	Pools, runs
Refugia	2	Provide local refugia for fish
Sensitivity to flow changes	2	Small system sensitive to flow changes
Sensitivity to flow related water quality changes	3	Small system sensitive to flow related water quality changes
Migration route/corridor (instream and riparian)	1	Local movement
Importance of conservation and natural areas	2	Conservation of wetlands and cranes upstream
MEDIAN OF DETERMINANTS	**2**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**MODERATE**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Klip River are shown in **Table 48**. The REC for the Klip River is a B/C category based on the recent declining trend and presence of an isolated population of *Barbus motebensis, Aponogeton* (possibly new aquatic plant species endemic to the area) and because the river downstream flows into an inaccessible wilderness area.

Table 48: Integrated results for the Klip River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	C	**Moderate**	Stable
Habitat Integrity: Riparian	C		Negative
Fish	C		Negative
ECOSTATUS (overall, integrated score)	**C**		
RECOMMENDED ECOLOGICAL CATEGORY	**B/C**		

3.4.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B/C for the Klip River at the EWR site.

No suitable site was present to undertake a hydraulics assessment as the river consists of deep pools. The impacts on the system that resulted in a PES of a C category is mainly non-flow related and the results of the DRM for a REC of a B/C were accepted to provide adequate protection for the system.

Table 49 provides a summary of the recommended requirements of the DRM at the EWR site in the Klip River in quaternary catchment B41F.

Table 49: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B41F
EWR Site Co-ordinates	S 25.2249°; E 30.0523°
Recommended Ecological Category	B/C
VMAR for Quaternary Catchment Area	5.20
Total EWR	1.43 (27.49 %VMAR)
Maintenance Low flows	0.89 (17.18 %VMAR)
Drought Low flows	0.32 (6.18 %VMAR)
Maintenance High flows	0.54 (10.31 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.5 Watervals River (OLI-EWR5): Rapid 3

3.5.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B42G and is situated adjacent to the R37 road from Lydenburg to Burgersfort at S24.8912; E30.3105. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by large cobbles and medium gravel-dominated riffle with some large boulders, marginal vegetation and limited fines. A run is downstream of the surveyed cross-section (see **Figure 9**).

Figure 9: Cross-sectional view of the Watervals River

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 50**.

Table 50: Watervals River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	3	• Single channel	• No gauging weir for flow records • Aquatic survey was conducted upstream of the hydraulic cross-section. The aquatic cross-section was not surveyed due to safety reasons. • Vegetation on both banks may influence overall flow resistance at high flows
Fish	4	• Easy Accessible • Diversity of flow depth classes • Diversity cover and substrate, marginal vegetation and undercut banks	• Near road bridge causing some local loss of habitats downstream of bridge
Macroinvertebrates	3	Excellent diversity of SIC habitat available for sampling. High diversity of instream habitat available for sampling, including SIC, SOOC, GSM, boulders, MVIC, MVOOC. High diversity of flow velocities present. Site is accessible and wadeable. Good MVIC and MVOOC present.	Site situated adjacent to a low-flow bridge. Dense algal growth occurs in slower-flowing areas, impacting the available habitat negatively, including MVIC, MVOOC, some SIC , SOOC and some GSM,

* Confidence scores: 0 = no confidence; 5 = high confidence

3.5.2 Information Availability

The available information for the EWR site is summarized in **Table 51**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 51: Information availability for the Watervals EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics		X				No gauging weir for flow records. Only one survey for hydraulic modeling.
Hydrology		X				Updated monthly hydrology was used for the period 1920-2004.
Fish				X		Few recent surveys in this stretch of river
Macroinvertebrates		X				Reference conditions, Rivers Database historic SASS data, once-off assessment in August 2011.

3.5.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Watervals River per specialist component are summarized in **Table 52**.

Table 52: Description of reference conditions for the Watervals River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Barbus lineomaculatus* *Barbus neefi* *Barbus paludinosus* *Barbus trimaculatus* *Barbus unitaeniatus* *Chiloglanis pretoriae* *Clarias gariepinus* *Labeo cylindricus* *Labeo molybdinus* *Labeobarbus marequensis* *Opsaridium peringueyi* *Oreochromis mossambicus* *Pseudocrenilabrus philander* *Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 250 Average Score Per Taxon (ASPT): 7 List of taxa expected include Atyidae, Perlidae, Baetidae, Caenidae, Heptageniidae, Machadorythidae, Oligoneuridae, Polymitarcyidae, Prosopistomatidae, Chlorolestidae, Lestidae, Libellulidae, Belostomatidae, Naucoridae, Nepidae, Ecnomidae, Hydropsychidae >2spp, Hydroptilidae, Leptoceridae, Elmidae, Dytiscidae, Psephenidae, Ceratopogonidae, SImuliidae, Ancylidae, Bulinae, Thiaridae, Planorbinae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus neefi
Barbus paludinosus
Barbus trimaculatus
Chiloglanis pretoriae
Clarias gariepinus
Labeobarbus marequensis
Oreochromis mossambicus

Labeo cylindricus
Labeo molybdinus
Pseudocrenilabrus philander
Tilapia sparrmanii

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a B/C (80.7) present state mainly due to the reduced water quality at the EWR site. Several species has not been collected recently at this site and movement of fish from the Spekboom into this stretch of river may be impeded by dense growth of reeds close to the confluence of the two rivers.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (72.4%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 69.9%, followed closely by flow modification at 72.2%, with the least impacted driver metric being instream habitat at 75.4%. **Table 53** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include Perlidae, Baetidae >2spp, Heptageniidae, Tricorythidae, Philopotamidae, Hydroptilidae, Leptoceridae, Simuliidae, Planorbinae.

Table 53: Macroinvertebrate Ecological Category, MIRAI

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**	72.2	*0.321*	23.2031	2	90
HABITAT	**H**	75.4	*0.321*	24.2247	2	90
WATER QUALITY	**WQ**	69.9	*0.357*	24.957	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
INVERTEBRATE EC				72.3848		280
INVERTEBRATE EC CATEGORY				C		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water and standing water had the highest rating of 2, being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles and vegetation has been impacted the most from reference, with an allocated rating of 2.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the SASS score as well as taxa with a high requirement, moderate requirement for unmodified physic-chemical conditions and the abundance and/or frequency of occurrence of taxa with a low requirement for unmodified physic-chemical conditions has been impacted the most with an allocated rating of 2. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest. **Annexure 3** provides the detail tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Watervals River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Tables 54** and **55** respectively. Both the instream and riparian zone integrity is in a C category. The main impacts on the habitat integrity of the Watervals River are water abstraction for irrigation, irrigation return flows impacting on water quality. This results in aggressive reed growth that causes channel modification due to encroachment of the reeds.

Table 54: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**August 2011 (Watervals EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	1	None
EXOTIC VEGETATION (IMPACT 1-25)	6	Poplars
BANK EROSION (IMPACT 1-25)	2	None
CHANNEL MODIFICATION (IMPACT 1-25)	7	Localised at bridges, encroachment of reeds
WATER ABSTRACTION (IMPACT 1-25)	2	None
INUNDATION (IMPACT 1-25)	1	None
FLOW MODIFICATION (IMPACT 1-25)	3	None
WATER QUALITY (IMPACT 1-25)	12	Increased nutrients, aggressive reed growth
TOTAL (OUT OF 200)	34	
RIPARIAN VEGETATION INTEGRITY SCORE *	74.5	
RIPARIAN INTEGRITY CATEGORY	**C**	

* Weighted riparian integrity score

Table 55: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	August 2011 (Watervals EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	14	Irrigation upstream
FLOW MODIFICATION (IMPACT 1-25)	10	Low and moderate flows reduced due to abstractions
BED MODIFICATION (IMPACT 1-25)	3	Small
CHANNEL MODIFICATION (IMPACT 1-25)	3	Small
WATER QUALITY (IMPACT 1-25)	13	Increased nutrients from irrigation return flows
INUNDATION (IMPACT 1-25)	1	None
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	5	Exotic watercress
EXOTIC FAUNA (IMPACT 1-25)	0	None
SOLID WASTE DISPOSAL (IMPACT 1-25)	2	General littering in vicinity of site
IN STREAM HABITAT INTEGRITY SCORE *	67.8	
INSTREAM INTEGRITY CATEGORY	**C**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 56**. The main impacts on the Watervals River are abstraction for irrigation and return flows.

Table 56: PES per component for the Watervals River

COMPONENT	PES	EXPLANATION
Fish	B/C (80.7)	Several species has not been collected recently at this site and movement of fish from the Spekboom into this stretch of river may be impeded by dense growth of reeds close to the confluence of the two rivers.
Macro-invertebrates	C (72.4)	Possible nutrient enrichment from upstream irrigation return flows impacts the site negatively. Flow modification due to irrigation abstractions also impacts the site negatively.
Habitat Integrity: Instream	C (68.8)	Water abstractions for irrigation and nutrient rich return flows
Habitat Integrity: Riparian	C (74.5)	Channel modification and nutrients that lead to excessive reed growth

Ecological Importance and Sensitivity (EIS)

The EIS for the Watervals River was determined as moderate. The presence of the rare and endangered BLIN and unique OPER and the intolerant CPRE, BLIN, Perlidae, Psephenidae and Tricorythidae contributes to the moderate EIS of the Watervals River. See **Table 57** for a summary of the EIS of the Watervals River.

Table 57: Ecological Importance and Sensitivity of the Watervals River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	4	BLIN
Unique (endemic, isolated)	2	OPER
Intolerant (flow and flow related water quality)	3	CPRE, BLIN, Perlidae, Psephenidae, Tricorythidae
Species/taxon richness	3	21 invertebrate families. ASPT= 6.3 7 of 13 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	Rapids, riffles, runs, marginal vegetation, bedrock, boulders, GSM
Refugia	2	Limited refugia
Sensitivity to flow changes	2	Moderately sensitive
Sensitivity to flow related water quality changes	2	Moderately sensitive
Migration route/corridor (instream and riparian)	2	Local movement
Importance of conservation and natural areas	0	None
MEDIAN OF DETERMINANTS	**2**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**MODERATE**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Watervals River are shown in **Table 58**.

Table 58: Integrated results for the Watervals River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	C		Negative
Habitat Integrity: Riparian	C		Stable
Fish	B/C	**Moderate**	Negative
Macroinvertebrates	C		Stable
ECOSTATUS (overall, integrated score)	**C**		
RECOMMENDED ECOLOGICAL CATEGORY			**C**

3.5.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C for the Watervals River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series.

The water level in the Watervals River during the site visit on 9 August 2011 (0.848 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (see **Figure 10**).

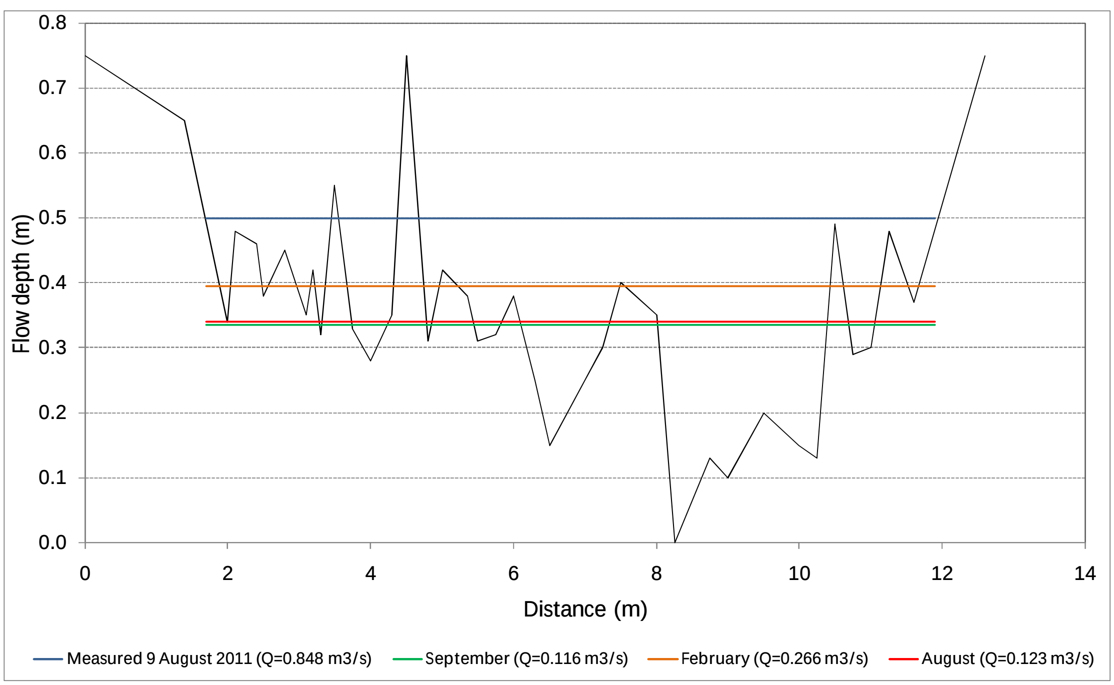

Figure 10: Calibrated cross-sectional profile of the Watervals River at the EWR site

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was adequate to maintain the system in a C category.

Table 59 gives the results of the DRM at the EWR site in the Watervals River in quaternary catchment B42G and **Table 60** provides a summary of the recommended requirements.

Table 59: Results of the DRM for the Watervals River (REC = C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flows	September	0.116	0.34	0.13	0.17
High flows	February	0.266	0.40	0.14	0.26
Datum	August	0.123	0.35	0.13	0.18
Measured discharge at site visit (9 August 2011)		0.848	0.50	0.19	0.45

Table 60: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B42G
EWR Site Co-ordinates	S 24.8912°; E 30.3105°
Recommended Ecological Category	C
VMAR for Quaternary Catchment Area	36.39
Total EWR	8.54 (23.48 %VMAR)
Maintenance Low flows	5.63 (15.47 %VMAR)
Drought Low flows	2.98 (8.20 %VMAR)
Maintenance High flows	2.91 (8.01 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.6 Upper Spekboom River (OLI-EWR6): Rapid 3

3.6.1 EWR site evaluation

The selected EWR site falls at the outlet of quaternary catchment B42D and is situated just upstream of the R36 road from Lydenburg to Ohrigstad. Gauging weir B4H007 is situated at the EWR site.

The site is characterised by bedrock and large boulder-dominated riffle, with some large cobbles at the toe of the riffle, with some marginal vegetation and limited fines. A run area is downstream of the surveyed cross-section (see **Figure 11**).

Figure 11: Cross-sectional view of the Upper Spekboom River

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 61**.

Table 61: Upper Spekboom River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	2	• Single channel. • Gauging weir for flow records	• River bed consists of large bedrock and large boulders that will complicate low flow modeling.
Fish	4	• Easy Accessible • Moderate diversity of flow depth classes • Moderate diversity cover and substrate, marginal vegetation and undercut banks	• Near road bridge causing some local loss of habitats downstream of bridge • Bedrock dominated
Macroinvertebrates	3	Good SOOC and GSM habitat available for sampling. A fair diversity of velocities present. Site is accessible and wadeable.	Minimal MVIC available for sampling. Site is bedrock-dominated, with some pockets of SIC available for sampling. Instream weir present at site.

* Confidence scores: 0 = no confidence; 5 = high confidence

3.6.2 Information Availability

The available information for the EWR site is summarized in **Table 62**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 62: Information availability for the Upper Spekboom EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics						Only one survey for hydraulic modeling.
Hydrology						Updated monthly hydrology was used for the period 1920-2004. Gauged flow data from B4H007
Fish						Several recent surveys
Macroinvertebrates						Reference conditions, Rivers Database historic SASS data, once-off assessment in August 2011.

3.6.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Upper Spekboom River per specialist component are summarized in **Table 63**.

Table 63: Description of reference conditions for the Upper Spekboom River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Amphilius uranoscopus* *Barbus motebensis* *Barbus neefi* *Pseudocrenilabrus philander* *Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 250 Average Score Per Taxon (ASPT): 7 List of taxa expected include Atydiae, Perlidae, Baetidae >2spp, Machadorythidae, Heptageniidae, Tricorythidae, Chlorolestidae, Lestidae, Libellulidae, Belostomatidae, Naucoridae, Nepidae, Ecnomidae, Hydropsychidae >2spp, Hydroptilidae, Leptoceridae, Elmidae, Dytiscidae, Psephenidae, Ceratopogonidae, SImuliidae, Ancylidae, Bulinae, Thiaridae, Planorbinae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Amphilius uranoscopus
Barbus motebensis
Barbus neefi
Pseudocrenilabrus philander

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a B (82.4) and is mainly influenced by reduced water quality at the EWR site. This is mainly as a result of upstream fly-fishing activities and impoundments. Some of the upper reaches of the Spekboom feeding into this site can be regarded as near pristine.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (77.0%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 75.2%, followed closely by flow modification at 77.2%, with the least impacted driver metric being instream habitat, at 78.7%. **Table 64** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterizing this site include Hydracarina, Perlidae, Baetidae >2spp, Simuliidae, Hydropsychidae >2spp and Leptoceridae.

Table 64: Macroinvertebrate Ecological Category, MIRAI

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**	77.2	*0.321*	24.8103	2	90
HABITAT	**H**	78.7	*0.321*	25.2845	2	90
WATER QUALITY	**WQ**	75.2	*0.357*	26.8718	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				76.9665		
INVERTEBRATE EC CATEGORY				**C**		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for standing water had the highest rating of 2, being impacted the most from the reference condition.

The occurrence of taxa with a preference for vegetation had been impacted the most from reference, with an allocated rating of 2 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, the abundance and/or frequency of occurrence of taxa with a low requirement for unmodified physico-chemical conditions has been impacted the most with an allocated rating of 2. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detail tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Upper Spekboom River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 65** and **Table 66** respectively. Both the instream and riparian zone integrity is in a C category. The main impacts on the habitat integrity of the system are upstream abstractions and small dams and the presence of poplars in the system.

Table 65: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	August 2011 (Upper Spekboom EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	3	Small
EXOTIC VEGETATION (IMPACT 1-25)	11	Poplars, brambles
BANK EROSION (IMPACT 1-25)	1	None
CHANNEL MODIFICATION (IMPACT 1-25)	1	None
WATER ABSTRACTION (IMPACT 1-25)	3	Abstraction upstream of site for irrigation
INUNDATION (IMPACT 1-25)	2	None
FLOW MODIFICATION (IMPACT 1-25)	6	Small impact on the low flows
WATER QUALITY (IMPACT 1-25)	6	Some nutrient enrichment
TOTAL (OUT OF 200)	33	
RIPARIAN VEGETATION INTEGRITY SCORE *	75.9	
RIPARIAN INTEGRITY CATEGORY	**C**	

* Weighted riparian integrity score

Table 66: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	August 2011 (Upper Spekboom EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	11	Upstream irrigation abstractions
FLOW MODIFICATION (IMPACT 1-25)	11	Upstream dams impact on low and moderate flows
BED MODIFICATION (IMPACT 1-25)	2	None
CHANNEL MODIFICATION (IMPACT 1-25)	2	None
WATER QUALITY (IMPACT 1-25)	6	Some nutrient enrichment
INUNDATION (IMPACT 1-25)	3	Small impact
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	None
EXOTIC FAUNA (IMPACT 1-25)	0	None

SOLID WASTE DISPOSAL (IMPACT 1-25)	5	Littering in vicinity of site
IN STREAM HABITAT INTEGRITY SCORE *		
INSTREAM INTEGRITY CATEGORY	**C**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 67**. The main impacts on the Upper Spekboom River are reduced flows due to upstream dams and abstractions for irrigation. This also results in poor water quality due to return flows.

Table 67: PES per component for the Upper Spekboom River

COMPONENT	PES	EXPLANATION
Fish	B (82.4)	Mainly influenced by reduced water quality at the EWR site. This is mainly as a result of fly-fishing developments and impoundments. Some of the upper reaches of the Spekboom feeding into this site can be regarded as near pristine.
Macro-invertebrates	C (77.0)	Some nutrient enrichment from upstream activities, impact negatively on the site. Flow modification due to upstream abstractions and small, instream dams impacting on the low and moderate flows. Localized impacts include sedimentation and littering at the picnic site. Instream weir acts as a barrier to movement of aquatic biota.
Habitat Integrity: Instream	C (71.6)	Upstream water abstraction for irrigation and flow modification due to small dams
Habitat Integrity: Riparian	C (75.9)	Presence of alien invasive plants, mainly poplars

Ecological Importance and Sensitivity (EIS)

The EIS for the Upper Spekboom River was determined as high. The EIS is high due to the following:

- Presence of the unique BMOT and the flow and water quality intolerant AURA, Heptageniidae and Tricorythidae;
- Species and taxon richness (33 macroinvertebrate taxa and 5 of 5 of the expected fish species;
- High diversity of habitat types (Bedrock, SOC, SIC, GSM, shutes, cascades, pools, waterfalls); and
- It’s a small system that is sensitive to flow and flow related water quality changes.

See **Table 68** for a summary of the EIS of the Upper Spekboom River.

Table 68: Ecological Importance and Sensitivity of the Upper Spekboom River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	None
Unique (endemic, isolated)	3	BMOT
Intolerant (flow and flow related water quality)	3	AURA, Heptageniidae, Tricorythidae
Species/taxon richness	3	33 invertebrate families. ASPT= 6.72 5 of 5 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	3	Bedrock, SOC, SIC, GSM, chutes, cascades, pools, waterfalls
Refugia	2	Local refugia
Sensitivity to flow changes	3	Small system sensitive to flow changes
Sensitivity to flow related water quality changes	3	Small system sensitive to flow related water quality changes
Migration route/corridor (instream and riparian)	2	Local migration
Importance of conservation and natural areas	0	None
MEDIAN OF DETERMINANTS	**3**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**HIGH**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Upper Spekboom River are shown in **Table 69**.

Table 69: Integrated results for the Upper Spekboom River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	C	High	Stable
Habitat Integrity: Riparian	C		Stable
Fish	B		Stable
Macroinvertebrates	C		Stable
ECOSTATUS (overall, integrated score)	**C**		
RECOMMENDED ECOLOGICAL CATEGORY			**B/C**

3.6.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B/C for the Upper Spekboom River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series.

The water level in the Upper Spekboom River during the site visit on 11 August 2011 (0.057 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (see **Figure 12**).

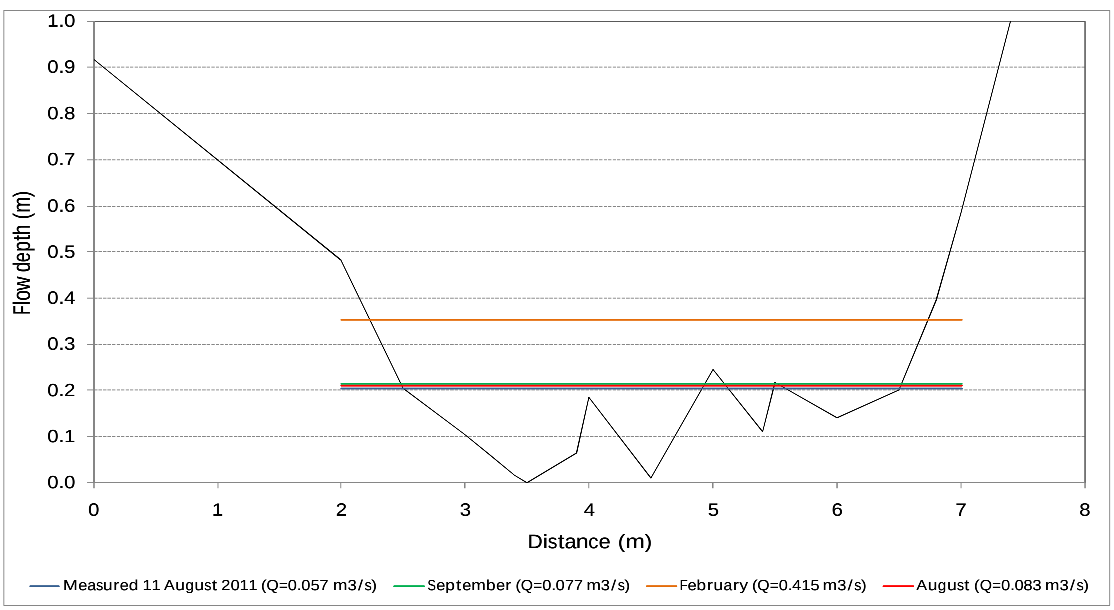

Figure 12: Calibrated cross-sectional profile of the Upper Spekboom River at the EWR site

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates.

The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was not adequate to maintain the system in a B/C category. The maintenance low flows for September were adjusted from 0.059 m^3/s to 0.077 m^3/s to provide the necessary depths and velocities for fish and macronvertebrates.

Table 70 gives the results of the DRM at the EWR site in the Upper Spekboom River in quaternary catchment B42D and **Table 71** provides a summary of the recommended requirements.

Table 70: Results of the DRM for the Upper Spekboom River (REC = B/C)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flows	September	0.077	0.22	0.10	0.21
High flows	February	0.415	0.35	0.21	0.42
Datum	August	0.083	0.22	0.10	0.21
Measured discharge at site visit (11 August 2011)		0.057	0.20	0.08	0.19

Table 71: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B42E
EWR Site Co-ordinates	S 25.0094°; E 30.5003°
Recommended Ecological Category	B/C
VMAR for Quaternary Catchment Area	28.04
Total EWR	9.40 (33.52 %VMAR)
Maintenance Low flows	6.64 (23.67 %VMAR)
Drought Low flows	6.74 (6.74 %VMAR)
Maintenance High flows	2.76 (9.85 %VMAR)
Overall confidence	Low to medium

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.7 Klaserie River (OLI-EWR7): Rapid 3

3.7.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B73A and is situated just upstream of the R40 road from Hoedspruit. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by bedrock, large boulders and sand-dominated riffle, with limited marginal vegetation. A run area is further downstream of the surveyed cross-section (see **Figure 13**).

Figure 13: Cross-sectional view of the Klaserie River

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 72**.

Table 72: Klaserie River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Hydraulics	2	• Easy access • Good uniform downstream section for flow measurement	• No gauging weir for flow records • Large-scale river bed substrates result in non-uniform flow with potential for non-horizontal water profile at low flows
Fish	4	• Easy Accessible • Diversity of flow depth classes • Diversity cover and substrate, marginal vegetation and undercut banks	• Water abstraction point causing some disturbance downstream
Macroinvertebrates	3	Fair diversity of velocities present at the site. Fair instream habitat available for sampling. Good GSM biotope available. Fair SIC biotope available for sampling. Site is accessible and wadeable.	Boulder/bedrock and sand dominated site. MVIC limited. Localized water abstraction impacts negatively at the site, including diesel film visible on surface of water.

* Confidence scores: 0 = no confidence; 5 = high confidence

3.7.2 Information Availability

The available information for the EWR site is summarized in **Table 73**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 73: Information availability for the Klaserie EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydraulics		X				No gauging weir for flow records. Only one survey for hydraulic modeling.
Hydrology		X				Updated monthly hydrology was used for the period 1920-2004.
Fish				X		Few surveys since 2000
Macroinvertebrates		X				Reference conditions, Rivers Database historic SASS data, once-off assessment in August 2011.

3.7.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Klaserie River per specialist component are summarized in **Table 74**.

Table 74: Description of reference conditions for the Klaserie River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Amphilius uranoscopus* *Barbus eutaenia* *Barbus lineomaculatus* *Barbus paludinosus* *Barbus trimaculatus* *Barbus unitaeniatus* *Chiloglanis pretoriae* *Clarias gariepinus* *Labeobarbus marequensis* *Marcusenius macrolepidotus* *Petrocephalus wesselsi* *Pseudocrenilabrus philander* *Tilapia sparrmanii*
Macroinvertebrates	SASS5 scores: 200 Average Score Per Taxon (ASPT): 7 List of taxa expected include Hydracarina, Perlidae, Baetidae >2spp, Oligoneuridae, Polymitarcyidae, Tricorythidae, Aeshnidae, Corduliidae, Gomphidae, Corixidae, Notonectidae, Ecnomidae, Hydropsychidae >2spp., Leptoceridae, Elmidae, Gyrinidae, Ceratopogonidae, SImuliidae, Ancylidae, Corbiculidae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus eutaenia
Barbus trimaculatus
Chiloglanis pretoriae
Clarias gariepinus
Labeobarbus marequensis
Marcusenius macrolepidotus
Pseudocrenilabrus philander

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a B/C (79.9%) present state mainly due to increased sediments and reduced water quality at the EWR site. The absence of *Amphilius uranoscopus* during the recent survey can be indicative of reduced water quality. The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (75.8%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 74.1%, followed closely by instream habitat at 76.6%, with the least impacted driver metric being flow modification, at 77.0%. **Table 75** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include Porifera, Hydracarina, Baetidae >2spp, Heptageniidae, Leptophlebidae, Hydropsychidae >2spp, Leptoceridae, Simuliidae, Corbiculidae.

Table 75: Macroinvertebrate Ecological Category, MIRAI

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**	77.0	*0.321*	24.76	2	90
HABITAT	**H**	76.6	*0.321*	24.625	2	90
WATER QUALITY	**WQ**	74.1	*0.357*	26.463	1	100
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						280
INVERTEBRATE EC				75.848		
INVERTEBRATE EC CATEGORY				**C**		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a vegetation preference and the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles have been impacted the most from reference, with an allocated rating of 2.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, taxa with a moderate requirement for unmodified physic-chemical conditions, as well as the abundance and/or frequency of taxa with a moderate and low requirement for modified physic-chemical conditions has been impacted the most with an allocated rating of 2. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detail tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Klaserie River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 76** and **Table 77** respectively. The instream integrity is in a B/C category and the riparian zone integrity in a B category. The main impacts on the habitat integrity of the system are impacts on water quantity due to upstream afforestation (reduced low flows), vegetation clearing (sediments) and settlements (nutrients). The presence of exotic vegetation (Mauritius thorn, guava and jacaranda) impacts on the riparian zone of the Klaserie River.

Table 76: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**August 2011 (Klaserie EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	8	Localised removal of vegetation, cattle grazing
EXOTIC VEGETATION (IMPACT 1-25)	10	Mauritius thorn, guava, jacaranda
BANK EROSION (IMPACT 1-25)	7	Limited at bridges and water abstraction sites
CHANNEL MODIFICATION (IMPACT 1-25)	2	None
WATER ABSTRACTION (IMPACT 1-25)	1	None
INUNDATION (IMPACT 1-25)	0	None
FLOW MODIFICATION (IMPACT 1-25)	3	Small impact
WATER QUALITY (IMPACT 1-25)	3	Small impact, sediments
TOTAL (OUT OF 200)	34	
RIPARIAN VEGETATION INTEGRITY SCORE *	82.6	
RIPARIAN INTEGRITY CATEGORY	**B**	

* Weighted riparian integrity score

Table 77: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	August 2011 (Klaserie EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	6	Afforestation, settlements upstream
FLOW MODIFICATION (IMPACT 1-25)	9	Afforestation and vegetation clearing upstream
BED MODIFICATION (IMPACT 1-25)	7	Some due to sediments
CHANNEL MODIFICATION (IMPACT 1-25)	7	Some due to sediments, water abstraction activities at site
WATER QUALITY (IMPACT 1-25)	8	Increased sediments and nutrients
INUNDATION (IMPACT 1-25)	1	None
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	None
EXOTIC FAUNA (IMPACT 1-25)	0	None
SOLID WASTE DISPOSAL (IMPACT 1-25)	3	General littering in vicinity of site
IN STREAM HABITAT INTEGRITY SCORE *	78.4	
INSTREAM INTEGRITY CATEGORY	**B/C**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 78**. The main impacts on the Klaserie River are reduced flows, sediments and nutrients due to afforestation, vegetation clearing and settlements upstream of the site.

Table 78: PES per component for the Klaserie River

COMPONENT	PES	EXPLANATION
Fish	B/C (79.9)	Mainly due to increased sediments and reduced water quality at the EWR site. The absence of *Amphilius uranoscopus* during the recent survey can be indicative of reduced water quality.
Macro-invertebrates	C (75.8)	Some nutrient enrichment due to upstream settlements, as well as some bed modification due to sedimentation.
Habitat Integrity: Instream	B/C (78.4)	Vegetation removal and afforestation in upstream catchment result in flow modification
Habitat Integrity: Riparian	B (82.6)	Presence of alien invasive plants in riparian zone and vegetation removal in upstream catchment

Ecological Importance and Sensitivity (EIS)

The EIS for the Klaserie River was determined as high. The high EIS is due to the following:

- The presence of intolerant flow and water quality species (CPRE, BJUT, AURA
- Perlidae, Heptageniidae and Hydropsychidae);
- Species/taxon richness (25 macroinvertebrate taxa and 9 of the 9 expected fish species);
- Diversity of habitat types (Chutes, bedrock, riffles, runs, SIC, SOC, marginal vegetation, GSM);
- Serves as refugia for CPRE, BJUT and AURA);
- Small system that is intolerant to flow and flow related changes; and
- Part of the Kruger to Canyon conservation initiative.

See **Table 79** for a summary of the EIS of the Klaserie River.

Table 79: Ecological Importance and Sensitivity of the Klaserie River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	None
Unique (endemic, isolated)	0	None
Intolerant (flow and flow related water quality)	3	CPRE, BJUT, AURA Perlidae, Heptageniidae, Hydropsychidae
Species/taxon richness	3	25 invertebrate families. ASPT= 6.4 9 of 9 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	3	Chutes, bedrock, riffles, runs, SIC, SOC, marginal vegetation, GSM
Refugia	3	Provides refugia on a provincial scale for fish
Sensitivity to flow changes	3	Small system sensitive to flow changes
Sensitivity to flow related water quality changes	3	Small system sensitive to flow related water quality changes
Migration route/corridor (instream and riparian)	2	Local movement due to dam downstream
Importance of conservation and natural areas	3	Part of the Kruger to Canyon initiative
MEDIAN OF DETERMINANTS	**3**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**HIGH**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Klaserie River are shown in **Table 80**.

Table 80: Integrated results for the Klaserie River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	B/C	**High**	Stable
Habitat Integrity: Riparian	B		Stable
Fish	B/C		Stable
Macroinvertebrates	C		Stable
ECOSTATUS (overall, integrated score)	**B/C**		
RECOMMENDED ECOLOGICAL CATEGORY	**B**		

3.7.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of B for the Klaserie River at the EWR site.

The EWR flow data were converted to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series.

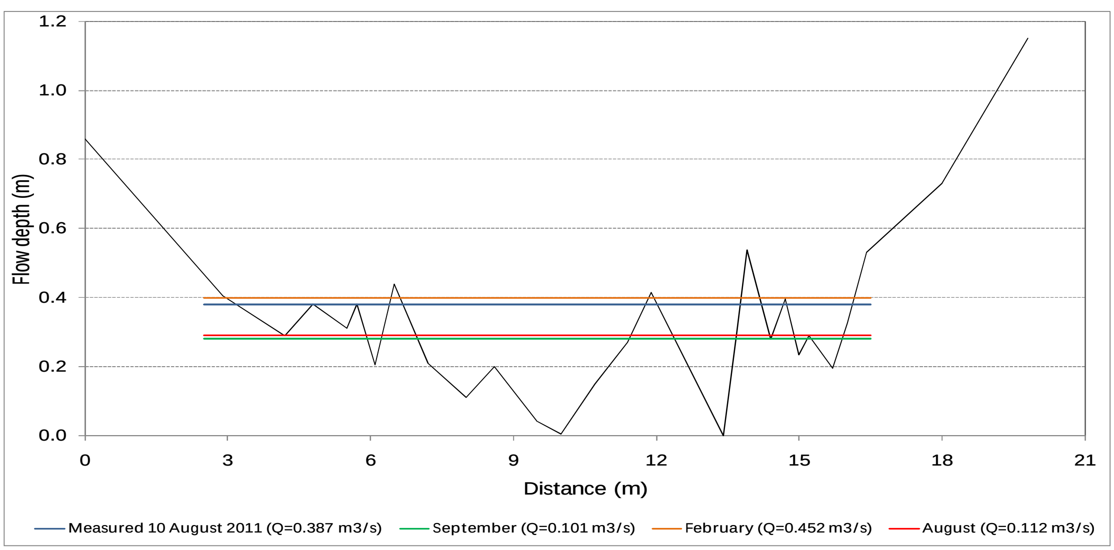

Figure 14: Calibrated cross-sectional profile of the Klaserie River at the EWR site

The water level in the Klaserie River during the site visit on 10 August 2011 (0.387 m^3/s) was used as a datum. Together with the site photographs and the rating relationships (flow depth versus discharge) from the hydraulic model, the water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements (see **Figure 14**).

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical riffle habitat, recommended by the DRM model during the critical low flow month of September was not adequate to maintain the system in a B category. The maintenance low flows for September were adjusted from 0.079 m^3/s to 0.101 m^3/s to provide the necessary depths and velocities for fish and macroinvertebrates.

Table 81 gives the results of the DRM at the EWR site in the Klaserie River in quaternary catchment B73A and **Table 82** provides a summary of the recommended requirements.

Table 81: Results of the DRM for the Klaserie River (REC = B)

	Month	Discharge (m^3/s)	Depth (m)		Velocity (m/s)
			Maximum	Average	Average
Maintenance low flows					
Low flows	September	0.101	0.28	0.13	0.12
High flows	February	0.452	0.40	0.16	0.24
Datum	August	0.112	0.29	0.13	0.13
Measured discharge at site visit (10 August 2011)		0.387	0.38	0.16	0.22

Table 82: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B73A
EWR Site Co-ordinates	S 24.5427°; E 31.0349°
Recommended Ecological Category	B
VMAR for Quaternary Catchment Area	25.54
Total EWR	9.95 (38.95 %VMAR)
Maintenance Low flows	7.07 (27.69 %VMAR)
Drought Low flows	1.44 (5.63 %VMAR)
Maintenance High flows	2.88 (11.26 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.8 Ohrigstad River (OLI-EWR8): Rapid 2

3.8.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B60H and is situated on the R532 road to Blyde River Canyon. The site falls within the Blyde Nature Reserve. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by medium cobbles and sand, with marginal vegetation (see **Figure 15**).

Figure 15: View of the Ohrigstad River

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 83**.

Table 83: Ohrigstad River EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Fish	4	• Easy Accessible	• Near road bridge causing some local loss of habitats downstream of bridge • Low diversity of flow depth classes • Low diversity cover and substrate, marginal vegetation and undercut banks
Macroinvertebrates	3	Site is accessible and wadeable.	Low diversity of instream habitats available. Low diversity of velocities present. Cobbles very embedded due instream sedimentation.

* Confidence scores: 0 = no confidence; 5 = high confidence

3.8.2 Information Availability

The available information for the EWR site is summarized in **Table 84**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 84: Information availability for the Ohrigstad EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Few surveys since 2000
Macroinvertebrates						Reference conditions, Rivers Database historic SASS data, once-off assessment in August 2011.

3.8.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Ohrigstad River per specialist component are summarized in **Table 85**.

Table 85: Description of reference conditions for the Ohrigstad River

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: Anguilla mossambica Barbus eutaenia Barbus neefi Barbus paludinosus Barbus trimaculatus Barbus unitaeniatus Chiloglanis pretoriae Labeo molybdinus Labeobarbus marequensis Oreochromis mossambicus Tilapia sparrmanii
Macroinvertebrates	SASS5 scores: 200 Average Score Per Taxon (ASPT): 6.5 List of taxa expected include Hydracarina, Baetidae >2spp, Heptageniidae, Leptophlebiidae, Polymitarcyidae, Tricorythidae, Gomphidae, Libellulidae, Pyralidae, Corixidae, Gerridae, Philopotamidae, Hydroptilidae, Leptoceridae, Dytiscidae, Elmidae, Psephenidae, Athericidae, Dixidae, Simuliidae, Tipulidae, Ancylidae, Planoribinae, Corbiculidae.

Present Ecological State (PES) or ecostatus

The PES for the fish, macroinvertebrates, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus eutaenia
Barbus neefi
Barbus trimaculatus
Chiloglanis pretoriae
Labeo molybdinus
Labeobarbus marequensis

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a C (76.5%) present state mainly due to the poor water quality and flow at the EWR site. Excessive sediments were present at the site indicating that high flows are not sufficient to remove sediments and more likely contributes towards sediment load. The detail FRAI tables are presented in **Annexure 2**.

(ii) Macroinvertebrates

The three modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The Ecological Category for the site was then derived by the model.

The macroinvertebrate Ecological Category is a C (65.9%). This means the river is in a moderately modified ecological condition. The most impacted driver metric is that of water quality at 62.0%, followed by flow modification at 66.7%, with the least impacted driver metric being instream habitat at 68.8%. **Table 86** provides the summary of the data interpretation and the PES for the macroinvertebrates.

Taxa characterising this site include Hydracarina, Heptageniidae, Leptophlebiidae, Gomphidae, Leptoceridae, Gyrinidae, Athericidae, Tipulidae, Corbiculidae.

Table 86: Macroinvertebrate Ecological Category, MIRAI

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**	66.7	*0.296*	19.7685	3	80
HABITAT	**H**	68.8	*0.370*	25.4815	1	100
WATER QUALITY	**WQ**	62.0	*0.333*	20.679	2	90
CONNECTIVITY & SEASONALITY	**CS**	60.0	*0.000*	0		
						270
INVERTEBRATE EC				65.929		
INVERTEBRATE EC CATEGORY				C		

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

According to the flow modification metric group, presence of taxa and abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water are ranked the most important, with taxa with a preference for standing water ranked the least important. The presence of taxa with a preference for very fast flowing water, slow flowing water and standing water had the highest rating of 2.5, being impacted the most from the reference condition.

The occurrence of taxa with a preference for loose cobbles and vegetation had been impacted the most from reference, with an allocated rating of 3.5 for the habitat modification metrics. The occurrence, abundance and/or frequency of occurrence of loose cobbles has been ranked as the most important instream habitat for this site, with water column ranked as the least important instream habitat for this site.

According to the water quality metrics, taxa with a moderate requirement for unmodified physic-chemical conditions have been impacted the most with an allocated rating of 3.5. The SASS and ASPT scores were ranked the highest, while the number of taxa and abundance and/or frequency of occurrence of taxa with a very low requirement for unmodified physic-chemical conditions ranked the lowest.

Annexure 3 provides the detail tables for the flow, habitat and water quality modification metrics.

(iii) Habitat Integrity

The habitat integrity assessment for the Ohrigstad River was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 87** and **Table 88** respectively. The instream integrity is in a D category and the riparian zone integrity in a C category. The main impacts on the habitat integrity of the system are water abstraction for irrigation, dams that impacts on all the flow components and irrigation return flows that leads to increased nutrients. The nutrients also lead to excessive weed growth in the riparian zone of the river.

Table 87: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	**August 2011 (Ohrigstad EWR site)**	**COMMENT**
VEGETATION REMOVAL (IMPACT 1-25)	1	None
EXOTIC VEGETATION (IMPACT 1-25)	1	None
BANK EROSION (IMPACT 1-25)	2	Hippo paths
CHANNEL MODIFICATION (IMPACT 1-25)	2	None
WATER ABSTRACTION (IMPACT 1-25)	5	Reduced floods due to dams upstream
INUNDATION (IMPACT 1-25)	1	None
FLOW MODIFICATION (IMPACT 1-25)	3	Small impact on riparian zone
WATER QUALITY (IMPACT 1-25)	13	Sedimentation and increased nutrients lead to weed growth
TOTAL (OUT OF 200)	28	
RIPARIAN VEGETATION INTEGRITY SCORE *	76.5	
RIPARIAN INTEGRITY CATEGORY	**C**	

* Weighted riparian integrity score

Table 88: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	**August 2011 (Ohrigstad EWR site)**	**COMMENT**
WATER ABSTRACTION (IMPACT 1-25)	21	Extensive water abstraction for irrigation
FLOW MODIFICATION (IMPACT 1-25)	20	All flow components impacted due to upstream dams and irrigation abstractions
BED MODIFICATION (IMPACT 1-25)	10	Increased sediments
CHANNEL MODIFICATION (IMPACT 1-25)	10	Sedimentation and increased vegetation

WATER QUALITY (IMPACT 1-25)	11	Irrigation return flows
INUNDATION (IMPACT 1-25)	1	None
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	0	None
EXOTIC FAUNA (IMPACT 1-25)	0	None
SOLID WASTE DISPOSAL (IMPACT 1-25)	0	None
IN STREAM HABITAT INTEGRITY SCORE *	43.5	
INSTREAM INTEGRITY CATEGORY	**D**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 89**. The main impacts on the Ohrigstad River are decreased flows due to dams and irrigation abstractions as well as poor water quality due to irrigation return flows.

Table 89: PES per component for the Ohrigstad River

COMPONENT	PES	EXPLANATION
Fish	C (76.5)	Mainly due to the poor water quality and flow at the EWR site. Excessive sediments were present at the site indicating that high flows are not sufficient to remove sediments and is more likely contributing towards sediment load.
Macro-invertebrates	C (65.9)	Increased nutrients due to irrigation return flows impact this site negatively, as well as bed modification due to increased sedimentation. Flow modification due to upstream abstractions and instream dams impact this site negatively.
Habitat Integrity: Instream	D (43.5)	All flow components have been impacted by upstream irrigation abstractions and dams. This lead to channel and bed modifications due to sediments
Habitat Integrity: Riparian	C (76.5)	Reduced floods with increased levels of sediment. Nutrients due to irrigation return flows

Ecological Importance and Sensitivity (EIS)

The EIS for the Ohrigstad River was determined as moderate with the flow and flow related water quality AURA, BEUT and Heptageniidae present in the river. The Ohrigstad River is a small system that is sensitive to flow related water quality changes and forms part of the Blyde Nature Reserve. See **Table 90** for a summary of the EIS of the Ohrigstad River.

Table 90: Ecological Importance and Sensitivity of the Ohrigstad River

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT SCORE**	**COMMENT**
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	None
Unique (endemic, isolated)	0	None
Intolerant (flow and flow related water quality)	3	AURA, BEUT, Heptageniidae
Species/taxon richness	2	20 invertebrate families. ASPT= 5.6 4 of 6 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	2	Pools, runs, riffles, marginal vegetation, mud
Refugia	2	Provide local refugia
Sensitivity to flow changes	2	Moderately sensitive
Sensitivity to flow related water quality changes	3	System sensitive to flow related water quality changes
Migration route/corridor (instream and riparian)	1	Local
Importance of conservation and natural areas	3	Site is situated in Blyde Nature Reserve
MEDIAN OF DETERMINANTS	**2**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**MODERATE**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Ohrigstad River are shown in **Table 91**.

Table 91: Integrated results for the Ohrigstad River

COMPONENT	PES	EIS	TREND
Habitat Integrity: Instream	D	**Moderate**	Negative
Habitat Integrity: Riparian	C		Stable
Fish	C		Negative
Macroinvertebrates	C		Stable
ECOSTATUS (overall, integrated score)	**C**		
RECOMMENDED ECOLOGICAL CATEGORY			**C**

3.8.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C for the Ohrigstad River at the EWR site. No hydraulic cross-section were surveyed as the sampling area were covered by reeds and only small pools of water were present during the site visit. Discharge was however measured at the site to provide some indication of the flow.

Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series.

The discharge level in the Ohrigstad River during the site visit on 10 August 2011 (0.79 m^3/s) was used as a datum. Together with the site photographs the water requirements proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements.

The site-specific flow requirements were based mainly on the depths required for fish passage, as well as the velocity requirements of flow-sensitive aquatic macroinvertebrates. The consensus reached by the ecologists was that the water depths and velocities at the critical habitat, recommended by the DRM model during the low flow month of September was not adequate to maintain the system in a C category. The maintenance low flows for September were adjusted from 0.125 m^3/s to 0.178 m^3/s to provide the necessary depths and velocities for fish and macronvertebrates.

Table 92 gives the results of the DRM at the EWR site in the Ohrigstad River in quaternary catchment B60H and **Table 93** provides a summary of the recommended requirements.

Table 92: Results of the DRM for the Ohrigstad River (REC = C)

	Month	**Discharge (m^3/s)**
Maintenance low flows		
Low flows	September	0.178
High flows	February	0.663
Datum	August	0.198
Measured discharge at site visit (10 August 2011)		0.79

Table 93: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B60H
EWR Site Co-ordinates	S 24.5403°; E 30.7223°
Recommended Ecological Category	C
VMAR for Quaternary Catchment Area	65.49
Total EWR	17.26 (26.35 %VMAR)
Maintenance Low flows	10.87 (16.59 %VMAR)
Drought Low flows	3.72 (5.68 %VMAR)
Maintenance High flows	6.39 (9.76 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

3.9 Dorpspruit (OLI-EWR9): Rapid 1

3.9.1 EWR site evaluation

The selected EWR site falls in quaternary catchment B42B and is situated just outside of Lydenburg on the R37 road to Burgersfort. No gauging weirs are present in the vicinity of the selected site.

The site is characterised by bedrock-dominated riffle with some cobbles. Moderate diversity cover and substrate, marginal vegetation and undercut banks (see **Figure 16**).

Figure 16: View of the Dorpspruit

The chosen site was evaluated by the various specialists in terms of advantages and disadvantages as well as given a confidence score to provide clues for undertaking field verification. The scores allocated were from 0 to 5, with 0 = no confidence and 5 = high confidence that the EWR site provides sufficient indicators. The results of this evaluation are given in **Table 94**.

Table 94: Dorpspruit EWR site evaluation

Component	Confidence Score*	Advantages	Disadvantages
Fish	4	• Easy Accessible • Moderate diversity of flow depth classes • Moderate diversity cover	• Sewage pollution reduce water quality • Bedrock dominated

		and substrate, marginal vegetation and undercut banks	

* Confidence scores: 0 = no confidence; 5 = high confidence

3.9.2 Information Availability

The available information for the EWR site is summarized in **Table 95**. Data availability is scored from 0 to 4 with 0 = no confidence 4 = high confidence.

Table 95: Information availability for the Dorpspruit EWR site

COMPONENT	INFORMATION AVAILABILITY					DESCRIPTION OF INFORMATION
	0	1	2	3	4	
Hydrology						Updated monthly hydrology was used for the period 1920-2004.
Fish						Several recent surveys

3.9.3 Ecoclassification

Reference conditions

Reference conditions usually reflect the natural, un-impacted/pre-development conditions and are used as a baseline against which surveyed data can be compared to reflect the degree of change from the natural/un-impacted state of a resource. Reference conditions for EWR sites are usually derived from un-impacted rivers in the same catchment area, aerial photographs, knowledge of the catchment and historical information, where available. The reference conditions for the EWR site in the Dorpspruit per specialist component are summarized in **Table 96**.

Table 96: Description of reference conditions for the Dorpspruit

COMPONENT	DESCRIPTION OF REFERENCE CONDITIONS
Fish	Expected fish species: *Anguilla mossambica* *Barbus motebensis* *Barbus neefi* *Clarias gariepinus* *Labeobarbus polylepis* *Pseudocrenilabrus philander* *Tilapia sparrmanii*

Present Ecological State (PES) or ecostatus

The PES for the fish, instream habitat integrity and riparian habitat integrity were derived from the various available models. The details are provided below:

(i) Fish

During the August 2011 survey the following fish species were present at the site:

Barbus neefi
Clarias gariepinus
Pseudocrenilabrus philander

Based on these results, the PES was determined using the Fish Response Assessment Index (FRAI). The FRAI results indicated that fish is in a D (54.9) present state mainly due to the poor water quality as a result of sewage pollution at the EWR site.

The detail FRAI tables are presented in **Annexure 2**.

(ii) Habitat Integrity

The habitat integrity assessment for the Dorpspruit was conducted utilizing the procedure described by Kleynhans 1996. The habitat integrity was evaluated taking into consideration the flow and water quality related impacts of the upstream catchment.

The results of the assessment of the riparian and instream zones are presented in **Table 97** and **Table 98** respectively. The instream integrity is in a D category and the riparian zone integrity in a C category. The main impacts on the habitat integrity of the system are water abstraction for the town of Lydenburg, poor water quality due to discharges from the sewage works and increase of exotic plants (wattles, blue gums, poplars).

Table 97: Habitat Integrity assessment scores for the riparian zone

RIPARIAN ZONE HABITAT INTEGRITY	August 2011 (Dorpspruit EWR site)	COMMENT
VEGETATION REMOVAL (IMPACT 1-25)	10	Clearing of vegetation next to river
EXOTIC VEGETATION (IMPACT 1-25)	15	Wattle, blue gum, poplars
BANK EROSION (IMPACT 1-25)	10	Bridges, causeways
CHANNEL MODIFICATION (IMPACT 1-25)	4	Small impact
WATER ABSTRACTION (IMPACT 1-25)	2	None
INUNDATION (IMPACT 1-25)	2	None
FLOW MODIFICATION (IMPACT 1-25)	2	None
WATER QUALITY (IMPACT 1-25)	10	Increased nutrients lead to excessive growth
TOTAL (OUT OF 200)	55	
RIPARIAN VEGETATION INTEGRITY SCORE *	63.9	
RIPARIAN INTEGRITY CATEGORY	**C**	

* Weighted riparian integrity score

Table 98: Habitat Integrity assessment scores for the instream zone

IN STREAM HABITAT INTEGRITY	August 2011 (Dorpspruit EWR site)	COMMENT
WATER ABSTRACTION (IMPACT 1-25)	11	Abstraction for domestic use of

		Lydenburg
FLOW MODIFICATION (IMPACT 1-25)	5	Small impact due to abstraction of low and moderate flows
BED MODIFICATION (IMPACT 1-25)	5	Small modification due to changes in flow
CHANNEL MODIFICATION (IMPACT 1-25)	6	Small modification of the bed due to bridges
WATER QUALITY (IMPACT 1-25)	21	Nutrient enrichment due to sewage discharges
INUNDATION (IMPACT 1-25)	2	None
SECONDARY		
EXOTIC MACROPHYTES (IMPACT 1-25)	3	Exotic watercress
EXOTIC FAUNA (IMPACT 1-25)	5	Presence of carp
SOLID WASTE DISPOSAL (IMPACT 1-25)	15	Extensive due to settlements and urban development
IN STREAM HABITAT INTEGRITY SCORE *	54.5	
INSTREAM INTEGRITY CATEGORY	**D**	

* Weighted instream integrity score

A summary of the PES per component as derived from the various available models and the rationale is provided in **Table 99**. The main impacts on the Dorpspruit are decreased flows as well as the poor water quality due to discharges from the sewage works.

Table 99: PES per component for the Upper Klein Olifants River

COMPONENT	PES	EXPLANATION
Fish	D (54.9)	Very few of the expected species was present mainly due to the poor water quality as a result of sewage pollution at the EWR site
Habitat Integrity: Instream	D (54.5)	Nutrient enrichment due to sewage discharges. Extensive solid waste present due to settlements and urban development. Upstream abstractions for the town of Lydenburg.
Habitat Integrity: Riparian	C (63.9)	Presence of alien invasive plants, clearing of indigenous vegetation on banks and nutrient enrichment

Ecological Importance and Sensitivity (EIS)

The EIS for the Dorpspruit was determined as low. See **Table 100** for a summary of the EIS of the Dorpspruit.

Table 100: Ecological Importance and Sensitivity of the Dorpspruit

ECOLOGICAL IMPORTANCE AND SENSITIVITY		
DETERMINANTS	**PRESENT**	**COMMENT**

	SCORE	
BIOTA (RIPARIAN AND INSTREAM)	**(0-4)**	
Rare and endangered	0	
Unique (endemic, isolated)	0	
Intolerant (flow and flow related water quality)	2	BPOL
Species/taxon richness	1	3 of 7 expected fish species
RIPARIAN AND INSTREAM HABITATS	**(0-4)**	
Diversity of types	3	Riffles, runs, chutes, pools, marginal vegetation
Refugia	1	Local refugia for fish
Sensitivity to flow changes	2	Moderately sensitive
Sensitivity to flow related water quality changes	2	Moderately sensitive
Migration route/corridor (instream and riparian)	1	Local scale
Importance of conservation and natural areas	0	None
MEDIAN OF DETERMINANTS	**1**	
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**LOW**	

4 – Very high; 3 – High; 2 – Moderate; 1 – Marginal/Low; 0 - None

Integration of results and Recommended Ecological Category (REC)

The assessments of the various biophysical components impacting on the present ecological status of the river can be integrated, with the overall classification given as an ecostatus score. This ecostatus score can be modified, if necessary, by the ecological importance and sensitivity (EIS) assessment to give the final attainable REC.

During the final allocation of the EC, if the resource is degraded but has a high ecological importance and sensitivity, the REC can be upgraded if it is potentially feasible to do so. The integrated results for the Dorpspruit are shown in **Table 101**.

Table 101: Integrated results for the Dorpspruit

COMPONENT	**PES**	**EIS**	**TREND**
Habitat Integrity: Instream	D	**Low**	Stable
Habitat Integrity: Riparian	C		Negative
Fish	D		Negative
ECOSTATUS (overall, integrated score)	**C/D**		
RECOMMENDED ECOLOGICAL CATEGORY	**C/D**		

3.9.4 Ecological Water Requirements

The Desktop Reserve Model (DRM) (SPATSIM, version 2.12) was used to calculate the Ecological Water Requirements (EWR) for a recommended ecological category of C/D for the Dorpspruit at the EWR site.

Maintenance flows were examined for September and February. September is the lowest flow month and February the highest flow month based on the natural time series. The requirements proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements.

The site-specific flow requirements were based mainly on the requirements for fish. The consensus reached by the ecologists was that the requirements at the critical riffle habitat, recommended by the DRM model during the low flow month of September was adequate to maintain the system in a C/D category.

Table 102 provides a summary of the recommended requirements at the EWR site in the Dorpspruit in quaternary catchment B42B.

Table 102: Summary of the EWR results (flows in million m^3 per annum)

Quaternary Catchment	B42B
EWR Site Co-ordinates	S 25.0758°; E 30.4399°
Recommended Ecological Category	C/D
VMAR for Quaternary Catchment Area	63.19
Total EWR	12.19 (19.28 %VMAR)
Maintenance Low flows	7.57 (11.99 %VMAR)
Drought Low flows	5.20 (8.23 %VMAR)
Maintenance High flows	4.61 (7.30 %VMAR)
Overall confidence	Low

The EWR results are used to produce the final Ecological Reserve quantity results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the defined maintenance and drought flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

4. CONCLUSIONS

The PES, EIS, REC and EWRs for all the EWR sites are summarized in **Table 103**.

Table 103: Summary of results for the EWR sites in the Olifants catchment

EWR site	Quaternary catchment	River	PES	EIS	REC	%EWR	MAR ($10^6 m^3$)
OLI-EWR1	B12C	Upper Klein Olifants	C	Low	C	28.86	44.46
OLI-EWR2	B41B	Upper Steelpoort	C	Moderate	C	29.78	63.46
OLI-EWR3	B32A	Kranspoortspruit	B	Very high	A/B	46.01	4.71
OLI-EWR4	B41F	Klip	C	Moderate	B/C	27.49	5.20
OLI-EWR5	B42G	Watervals	C	Moderate	C	23.48	36.39
OLI-EWR6	B42D	Upper Spekboom	C	High	B/C	33.52	28.04
OLI-EWR7	B73A	Klaserie	B/C	High	B	38.95	25.54
OLI-EWR8	B60H	Ohrigstad	C	Moderate	C	26.35	65.49
OLI-EWR9	B42B	Dorpspruit	C/D	Low	C/D	19.28	63.19

Most of the systems are currently in a C present state with the main impacts being abstraction for irrigation, poor water quality and alien invasive plants. The poor water quality is mainly from mining activities (sediments, salts) in the Upper Klein Olifants, irrigation return flows and sewage discharges.

The EIS for the rivers range from low to very high with some rare and unique fish species present in the Kranspoortspruit, Klip, Watervals, Steelpoort and Spekboom Rivers. These are *Labeobarbus polylepis, Barbus lineomaculatus, Barbus bifrenatus, Barbus motebensis and Opsoridium peringueyi*.

The diversity of habitat types were high at most of the selected EWR sites with bedrock, gravel, mud and sand, marginal vegetation, riffles, pools and runs available.

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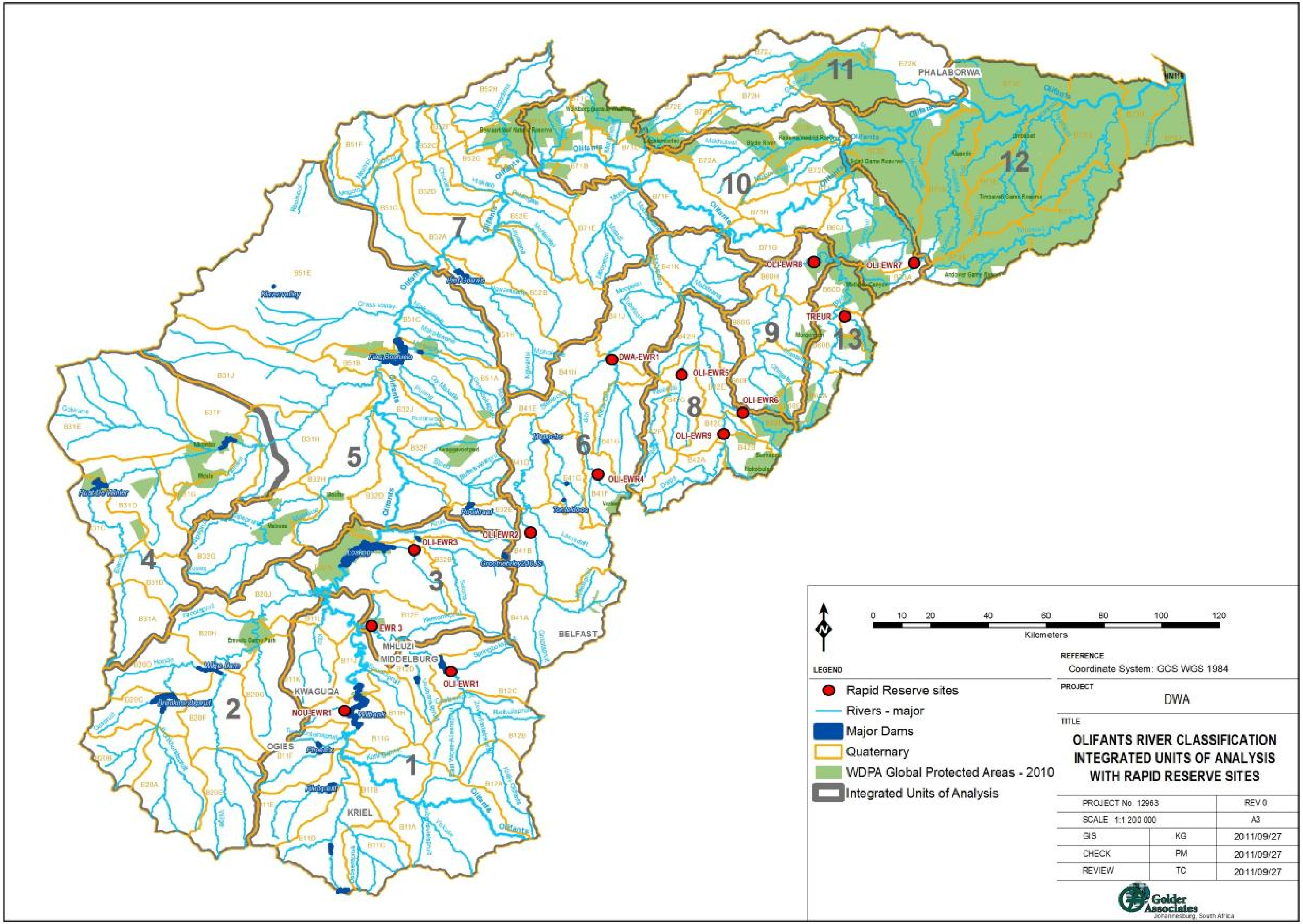
ANNEXURE 1

MAP OF STUDY AREA



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ANNEXURE 2

FISH: FRAI TABLES

Annexure 2.1: Upper Klein Olifants River

Summary of the metric group weighting for the Klein Olifants River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Klein Olifants River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	49.52
EC: FRAI	D
ADJUSTED	
FRAI (%)	49.52
EC: FRAI	D

Summary of Frequency of Occurrence of Fish species for reference and present conditions for the Klein Olifants River

Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Amphilius uranoscopus	5	0
Barbus anoplus	5	0
Barbus neefi	5	3
Barbus paludinosus	5	0
Barbus trimaculatus	4	0
Chiloglanis pretoriae	5	0
Clarias gariepinus	4	3
Labeobarbus polylepis	5	3
Pseudocrenilabrus philander	5	5
Tilapia sparrmanii	4	3

Annexure 2.2: Upper Steelpoort River

Summary of the metric group weighting for the Upper Steelpoort River **FRAI EC calculation**	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Upper Steelpoort River **showing the automated EC and the adjusted EC**	
AUTOMATED	
FRAI (%)	68.9
EC: FRAI	C
ADJUSTED	
FRAI (%)	68.9
EC: FRAI	C

Frequency of Occurrence of Fish species for reference and present conditions for the Upper Steelpoort River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Barbus anoplus	5	5
Labeobarbus polylepis	5	2
Chiloglanis pretoriae	5	4
Amphilius uranoscopus	5	2
Tilapia sparrmanii	4	2
Clarias gariepinus	4	3
Pseudocrenilabrus philander	5	3
Barbus neefi	5	3

Annexure 2.3: Kranspoort Spruit

Summary of the metric group weighting for the Kranspoort Spruit FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Kranspoort Spruit showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	84.3
EC: FRAI	B
ADJUSTED	
FRAI (%)	84.3
EC: FRAI	B

Frequency of Occurrence of Fish species for reference and present conditions for the Kranspoort Spruit		
Scientific names: reference species (introduced species excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Barbus trimaculatus	5	5
Barbus bifrenatus	3	2
Barbus lineomaculatus	3	2
Labeobarbus marequensis	5	5
Barbus paludinosus	4	2
Barbus eutaenia	4	3
Petrocephalus wesselsi	4	4
Marcusenius macrolepidotus	4	3
Clarias gariepinus	4	4
Pseudocrenilabrus philander	5	5
Chiloglanis pretoriae	5	5
Barbus unitaeniatus	4	3
Oreochromis mossambicus	4	3
Tilapia sparrmanii	4	4

Annexure 2.4: Klip River

Summary of the metric group weighting for the Klip River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Klip River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	49.52
EC: FRAI	D
ADJUSTED	
FRAI (%)	49.52
EC: FRAI	D

Frequency of Occurrence of Fish species for reference and present conditions for the Klip River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Amphilius uranoscopus	5	3
Barbus motebensis	5	4

Annexure 2.5: Watervals River

Summary of the metric group weighting for the Watervals River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Watervals River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	80.7
EC: FRAI	B/C
ADJUSTED	
FRAI (%)	80.7
EC: FRAI	B/C

Frequency of Occurrence of Fish species for reference and present conditions for the Watervals River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Barbus lineomaculatus	3	0.5
Barbus neefi	5	5
Barbus paludinosus	3	2
Barbus trimaculatus	4	4
Barbus unitaeniatus	3	2
Chiloglanis pretoriae	5	5
Clarias gariepinus	4	4
Labeo cylindricus	3	2
Labeo molybdinus	5	5
Labeobarbus marequensis	5	5
Opsaridium peringueyi	2	0.5
Oreochromis mossambicus	4	3
Pseudocrenilabrus philander	4	2
Tilapia sparrmanii	3	2

Annexure 2.6: Klaserie River

Summary of the metric group weighting for the Klaserie River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Klaserie River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	79.9
EC: FRAI	B/C
ADJUSTED	
FRAI (%)	79.9
EC: FRAI	B/C

Frequency of Occurrence of Fish species for reference and present conditions for the Klaseri River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Barbus trimaculatus	5	5
Barbus eutaenia	5	5
Barbus lineomaculatus	3	1
Labeobarbus marequensis	5	5
Barbus paludinosus	4	3
Amphilius uranoscopus	4	3
Petrocephalus wesselsi	3	2
Marcusenius macrolepidotus	5	5
Clarias gariepinus	5	5
Pseudocrenilabrus philander	3	2
Chiloglanis pretoriae	5	4
Barbus unitaeniatus	4	3
Tilapia sparrmanii	3	2

Annexure 2.7: Ohrigstad River

Summary of the metric group weighting for the Ohrigstad River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Ohrigstad River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	76.5
EC: FRAI	C
ADJUSTED	
FRAI (%)	76.5
EC: FRAI	C

Frequency of Occurrence of Fish species for reference and present conditions for the Ohrigstad River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Anguilla mossambica	1	0
Barbus eutaenia	5	4
Barbus neefi	5	4
Barbus paludinosus	3	2
Barbus trimaculatus	5	4
Barbus unitaeniatus	3	2
Chiloglanis pretoriae	5	4
Labeo molybdinus	5	4
Labeobarbus marequensis	5	4
Oreochromis mossambicus	4	3
Tilapia sparrmanii	3	2

Annexure 2.8: Spekboom River

Summary of the metric group weighting for the Spekboom River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Spekboom River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	82.4
EC: FRAI	B
ADJUSTED	
FRAI (%)	82.4
EC: FRAI	B

Frequency of Occurrence of Fish species for reference and present conditions for the Spekboom River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes:Observed & Habitat Derived Frequency Of Occurrence**
Barbus motebensis	5	4
Amphilius uranoscopus	5	4
Tilapia sparrmanii	4	2
Pseudocrenilabrus philander	4	2
Barbus neefi	5	4

Annexure 2.9: Dorps River

Summary of the metric group weighting for the Dorps River FRAI EC calculation	
WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	95.71
COVER	78.57
FLOW MODIFICATION	87,14
PHYSICO-CHEMICAL	100
MIGRATION	48.57
IMPACT OF INTRODUCED	12.86

Summary of the FRAI EC for the Dorps River showing the automated EC and the adjusted EC	
AUTOMATED	
FRAI (%)	54.9
EC: FRAI	D
ADJUSTED	
FRAI (%)	54.9
EC: FRAI	D

Frequency of Occurrence of Fish species for reference and present conditions for the Dorps River		
Scientific Names: Reference Species (Introduced Species Excluded)	**Reference Frequency Of Occurrence**	**Pes: Observed & Habitat Derived Frequency Of Occurrence**
Barbus motebensis	5	3
Barbus neefi	5	3
Tilapia sparrmanii	4	2
Pseudocrenilabrus philander	4	2
Labeobarbus polylepis	4	2
Anguilla mossambica	2	0
Clarias gariepinus	2	2

ANNEXURE 3

MACROINVERTEBRATES : MIRAI TABLES

Annexure 3.1 Upper Klein Olifants River

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	2.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	90
Presence of taxa with a preference for moderately fast flowing water	2	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	0.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	3	80
Presence of taxa with a preference for standing water	2	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	50
Overall % change in flow dependance of assemblage			27

<u>HABITAT MODIFICATION METRICS.</u> **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	4	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	0.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2.5	3	85
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	3	85
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	4	75
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	4	75
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	2	5	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	5	70
Overall % change in flow dependanceof assemblage			28

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	3.5	3	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	3	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	3.5	2	95
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	0.5	2	95
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	2.5	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	2	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	5	60
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	4	1	100
Overall change to indicators of modified water quality			46

Annexure 3.2 Upper Steelpoort River

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	2	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	0.5	2	90
Presence of taxa with a preference for moderately fast flowing water	1	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	2	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	2	4	50
Overall % change in flow dependance of assemblage			26

<u>HABITAT MODIFICATION METRICS.</u> **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	3.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	2	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	3	3	85
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	3	85
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	4	70
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	4	70
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1	5	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	1	5	70
Overall % change in flow dependanceof assemblage			30

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	2	3	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	1	3	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	3.5	2	95
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	2	95
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	4	1	100
Overall change to indicators of modified water quality			42

Annexure 3.3 Kranspoortspruit

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	1.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	2	90
Presence of taxa with a preference for moderately fast flowing water	1	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	0.5	1	100
Presence of taxa with a preference for slow flowing water	1	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	2.5	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	0.5	4	50
Overall % change in flow dependance of assemblage			20

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	%WEIGHT
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	4	70
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	4	70
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	1.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	0.5	3	85
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0.5	3	85
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1	5	60
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	5	60
Overall % change in flow dependanceof assemblage			18

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	1.5	3	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	3	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	2	2	95
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	2	95
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	5	60
How does the total SASS score differ from expected?	2	1	100
How does the total ASPT score differ from expected?	3	1	100
Overall change to indicators of modified water quality			30

Annexure 3.4 Watervals River

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	2	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1.5	2	90
Presence of taxa with a preference for moderately fast flowing water	0.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1.5	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	3	80
Presence of taxa with a preference for standing water	2	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1.5	4	50
Overall % change in flow dependance of assemblage			28

HABITAT MODIFICATION METRICS. **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	3	80
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	3	80
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	2.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	4	75
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	4	75
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0.5	5	65
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	5	65
Overall % change in flow dependanceof assemblage			25

<u>WATER QUALITY METRICS.</u> **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	2	3	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	1	3	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	2	2	95
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	2	95
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
How does the total SASS score differ from expected?	2	1	100
How does the total ASPT score differ from expected?	1	1	100
Overall change to indicators of modified water quality			30

Annexure 3.5 Upper Spekboom River

FLOW MODIFICATION METRICS. **WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% Weight**
Presence of taxa with a preference for very fast flowing water	1.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1.5	2	90
Presence of taxa with a preference for moderately fast flowing water	0.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	1.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	2	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	50
Overall % change in flow dependance of assemblage			23

<u>HABITAT MODIFICATION METRICS.</u> **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	1.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	1.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2	3	85
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	3	85
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	4	80
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	4	80
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1	5	75
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	5	75
Overall % change in flow dependanceof assemblage			21

<u>WATER QUALITY METRICS.</u> **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	1	3	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	1.5	3	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	1.5	2	95
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	2	95
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	5	60
How does the total SASS score differ from expected?	1	1	100
How does the total ASPT score differ from expected?	1	1	100
Overall change to indicators of modified water quality			25

Annexure 3.6 Klaserie River

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	2.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1	2	90
Presence of taxa with a preference for moderately fast flowing water	0.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1.5	1	100
Presence of taxa with a preference for slow flowing water	1	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	0.5	3	80
Presence of taxa with a preference for standing water	1.5	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	0.5	4	50
Overall % change in flow dependance of assemblage			23

HABITAT MODIFICATION METRICS. **WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	2	95
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	2	95
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	1.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	2.5	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	2.5	4	85
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	1	4	85
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	1	3	90
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	1	3	90
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	0.5	5	80
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	5	80
Overall % change in flow dependanceof assemblage			23

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	1	3	90
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	3	90
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	2	2	95
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	2	2	95
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	1	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1.5	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
How does the total SASS score differ from expected?	1	1	100
How does the total ASPT score differ from expected?	1	1	100
Overall change to indicators of modified water quality			26

Annexure 3.7 Ohrigstad River

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight
Presence of taxa with a preference for very fast flowing water	2.5	2	90
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water	1.5	2	90
Presence of taxa with a preference for moderately fast flowing water	1.5	1	100
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water	1	1	100
Presence of taxa with a preference for slow flowing water	2.5	3	80
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water	1	3	80
Presence of taxa with a preference for standing water	2.5	4	50
Abundance and/or frequency of occurrence of taxa with a preference for standing water	1	4	50
Overall % change in flow dependance of assemblage			33

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	**RATING**	**RANKING OF METRICS**	**%WEIGHT**
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?	0.5	5	30
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?	0.5	5	30
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?	3.5	1	100
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?	2	1	100
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?	3.5	2	90
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?	0.5	2	90
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?	0.5	3	80
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	0.5	3	80
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?	1.5	4	75
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?	0.5	4	75
Overall % change in flow dependanceof assemblage			31

WATER QUALITY METRICS. **WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?**	**RATING**	**RANKING OF METRICS**	**% WEIGHT**
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?	3	3	85
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical conditions changed?	0.5	3	85
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?	3.5	2	90
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical conditions changed?	1	2	90
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?	2	4	70
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical conditions changed?	1.5	4	70
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?	1	5	60
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical conditions changed?	0.5	5	60
How does the total SASS score differ from expected?	3	1	100
How does the total ASPT score differ from expected?	2	1	100
Overall change to indicators of modified water quality			38