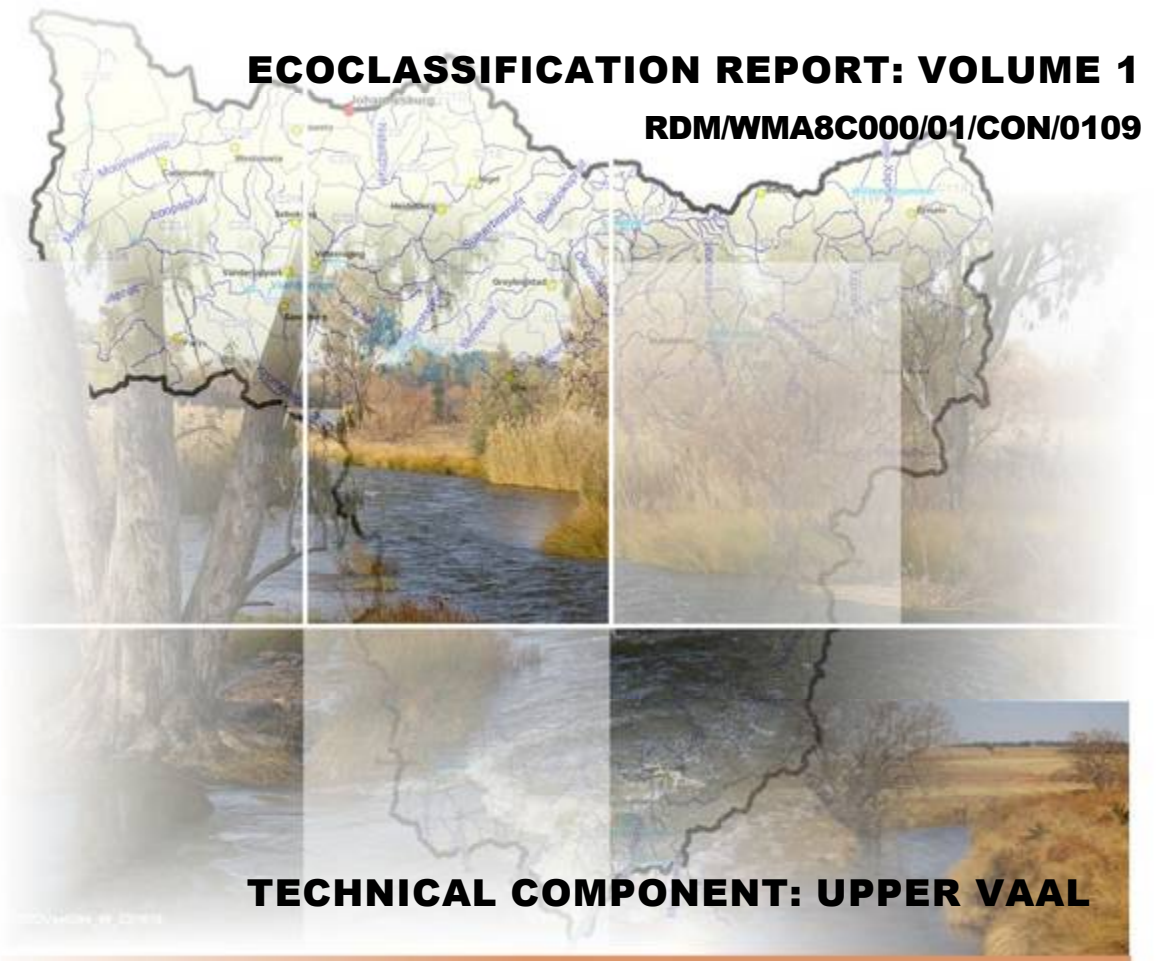
COMPREHENSIVE RESERVE DETERMINATION

INTEGRATED VAAL RIVER SYSTEM

SURFACE WATER

ECOCLASSIFICATION REPORT: VOLUME 1

RDM/WMA8C000/01/CON/0109



TECHNICAL COMPONENT: UPPER VAAL

JULY 2010

REPORT NO.: RDM/WMA8C000/01/CON/0109
PROJECT NO.: 8829/1

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

COMPREHENSIVE RESERVE DETERMINATION STUDY OF THE INTEGRATED VAAL RIVER SYSTEM

UPPER VAAL WATER MANAGEMENT AREA
TECHNICAL COMPONENT: ECOCLASSIFICATION REPORT – VOLUME 1

Report number: RDM/WMA8C000/01/CON/0109

JULY 2010

This report should be cited as:
Department of Water Affairs (DWA), 2010. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: EcoClassification Report: Volume 1. Report produced by Koekemoer Aquatic Services and Rivers for Africa. Edited by Louw, D and Koekemoer, S. Report no: RDM/ WMA8 C000/01/CON/0109.

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Bold indicates this report

APPROVAL

TITLE:	Comprehensive Reserve determination study of the Integrated Vaal River System, Upper Vaal River Management Area. EcoClassification Report: Volume 1
DATE:	July 2010
EDITORS:	S Koekemoer and MD Louw
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FILE NO.:	26/8/3/10/10
FORMAT:	MSWord and PDF
WEB ADDRESS:	www.dwaf.gov.za

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ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

INTRODUCTION

In order for the Department of Water Affairs (DWA) to make informed decisions regarding the authorization of future water use and the magnitude of the impacts of the present and proposed developments in the Vaal River System, higher levels of confidence is needed for the Reserve Determination within this study area. Therefore a Comprehensive Reserve determination study within Water Management Area (WMA) 8 has been undertaken to provide input to the Reconciliation studies and the integrated water quality management plan recently undertaken by the National Water Resources Planning Directorate (D: NWRP) of the DWA.

STUDY AREA

The Upper Vaal WMA is one of three WMAs in the Vaal River catchment, which is the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers (DWAF, 2004).

The Upper Vaal WMA includes the Vaal, Klip, Wilge, Liebenbergsvlei and Mooi Rivers and extends to the confluence of the Mooi and Vaal Rivers. It covers a catchment area of 55 565 km^2. The locality and characteristics of the Ecological Water Requirement (EWR) sites are provided in the Table below.

THIS REPORT

This report describes the results of the EcoClassification assessments that were undertaken for each EWR Site as part of the Upper Vaal Comprehensive Reserve Determination Study.

EWR site number	EWR site name	River	National RHP site	Co-ordinates		EcoRegion (Level II)	Geomorphic Zone	Altitude (m)	RU	Quaternary	Hydrological gauge
				Latitude	Longitude						
EWR 1	Uitkoms	Vaal	C1Geel_Unspe	-26.8728	29.61384	11.05	Lowland	1570	MRU Vaal B	C11J	C1H007
EWR 2	Grootdraai	Vaal	C1Vaal Braks	-26.9211	29.27929	11.03	Lowland	1537	MRU Vaal C	C11L	C1H019
EWR 3	Gladdedrift	Vaal	C1Vaal-Villie	-26.99087	28.72971	11.03	Lowland	1487	MRU Vaal C	C12H	C1H012
EWR 4	De Neys	Vaal	C2Vaal-Deny	-26.84262	28.1123	11.03	Lower Foothills	1445	MRU Vaal D	C22F	C2H122
EWR 5	Skandinavia	Vaal		-26.93243	27.01367	11.08	Lowland	1309	MRU Vaal E	C23L	C2H018
EWR 6	Klip	Klip	C1Klip-Unspe2	-27.36166	29.48503	11.06	Lower Foothills	1593	MRU Klip C	C13D	
EWR 7	Upper Wilge	Wilge		-28.20185	29.55827	11.03	Lowland	1692	MRU Wilge A	C81A	Redmans Werf 319
EWR 8	Bavaria	Wilge	C8Wilg-Belwh	-27.80017	28.76778	11.03	Lowland	1573	MRU Wilge B	C82C	C8H028
EWR 9	Suikerbos US	Suikerbosrand	C2Suik-Dehoe	-26.6467	28.38197	11.01	Lower Foothills	1509	RU Suiker A	C21C	
EWR 10	Suikerbos DS	Suikerbosrand	Close to C2Suik-Badfo	-26.68137	28.16798	11.01	Lowland	1453	RU Suiker B	C21G	
EWR 11	Blesbokspruit	Blesbokspruit	C2Bles-Marai (locality incorrect)	-26.47892	28.42488	11.03	Lower Foothills	1528	RU Bles A	C21F	
Rapid Level sites											
RE-EWR 1	Klein Vaal	Klein Vaal	C1KVaal-unspe	-26.9128	30.17497	11.02	Lower Foothills	1620	MRU Kvaal A	C11C	
RE-EWR 2	Mooi	Mooi	Close to C2Mooi-Klerk	-26.2587	27.15973	11.01	Lower Foothills	1457	RU Mooi B	C23G	

METHODOLOGY

EcoClassification forms step 3 of the 8-step Reserve process (Louw and Hughes, 2002) (Figure 1.1).

EWR 1 – 11

The procedure for the EcoClassification that was followed during the Upper Vaal Comprehensive Reserve determination was according to the revised methods for rivers as outlined in the EcoClassification manual version 2 (Kleynhans and Louw, 2007). The physico-chemical assessment was according to Kleynhans (2005) and all subsequent updates which are still being documented (these updates will be included in the current RDM method Revision project that are being undertaken through the Water Research Commission). Different levels of EcoClassification exist and the Level 4 method, required for the Comprehensive Ecological Reserve Methodology, was applied. The EcoClassification steps are summarised as follows:

- Determine reference conditions for each component.
- Determine the Present Ecological State (PES) for each component[1] as well as the EcoStatus[2].
- Determine the trend for each component.
- Determine reasons for PES and whether these are flow or non-flow related.
- Determine the Ecological Importance and Sensitivity (EIS) for the biota and habitat.
- Considering the PES and the EIS, suggest a realistic Recommended Ecological Category (REC) for each component as well as for the EcoStatus.
- Determine Alternative Ecological Categories (AECs) for each component as well as for the EcoStatus.

RE – EWR 1 and 2

Two Rapid III sites were identified; Klein Vaal (RE - EWR 1) and Mooi River (RE - EWR 2). For RE - EWR 1 the Level 4 EcoClassification method was followed and applied. RE-EWR 2 would naturally have been a wetland with a badly defined channel. Therefore Wetland tools (WETLAND – Index of Habitat Integrity) (WETLAND – IHI, DWAF, 2007)) were used to represent the driver state and the river tools used to assess the responses. The section of the river examined for the Wetland-IHI is between the Klerkskraal and Boskop Dam.

Habitat assessments provide information on the quality, quantity and suitability of the physical environment that supports biota and the WETLAND – IHI assesses four components of a floodplain, namely:

- Alteration to vegetation due to landuse activities on the floodplain surface.
- Alteration to the natural hydrology (flooding regime) due to catchment as well as on-site activities.
- Alteration to the geomorphology of the site due to catchment as well as on-site activities.
- Alteration to the water quality aspects of the river due to upstream catchment activities.

RESULTS

The detailed explanations for each of the below summaries are provided in subsequent sections of this report as well as in the various specialist reports (EcoClassification Report: Volume 2).

[1]**Components:** Driver components (Hydrology, Geomorphology, Physico-chemical variables) and Response components (Riparian vegetation, Fish, Macroinvertebrates)

[2]**EcoStatus:** *'The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services'.*
In essence the EcoStatus represents an ecologically integrated state representing the driver and response components

EWR 1: UITKOMS (VAAL RIVER)

EIS: HIGH
Presence of rare and endangered *Labeobarbus kimberleyensis* and diversity of habitat.
PES: B/C
Combination of flow and non-flow related impacts. Flow related impacts are mainly due to interbasin transfers (Heysope and Zaaihoek). Mining and agricultural activities in area has caused water quality deterioration and erosion.
REC: B/C
The EIS at EWR 1 is **HIGH** and the PES warrants an improvement. An improvement in the PES EcoStatus would mean that fish and macroinvertebrates must improve from a C to a B EC. No improvement in riparian vegetation is needed as the current EC is an A/B. An improvement in the biotic component EC is dependent on **water quality** changes and not flow related issues. It seems that the water quality at this site is problematic as the fish show signs of serious bacterial infection and quality sensitive macroinvertebrates are absent. Diatoms also indicate that water quality is impaired; however, it is not certain what the water quality problems are. To improve the EC therefore, the water quality problems must be identified to determine how it can be addressed. As no improvement in flow is required, no EWR for the REC will be undertaken.
AEC down 1: C
A hydrological regime with **increased** base flows for longer periods of time in the winter (longer than present transfer) as well as fluctuations in temperature.
AEC down 2: C
A hydrological regime with **decreased** base flows below natural (no transfers) with potential for some low flows.
Decreased moderate floods.
Deteriorated water quality due to increased impacts of mining.

IHI			Driver Components	PES and REC Category	Trend	AEC↓1	AEC↓2
INSTREAM	C	RIPARIAN B	HYDROLOGY	C			
			WATER QUALITY	C	Stable	C	C
			GEOMORPHOLOGY	B/C	Negative	C	C
			Response Components	PES Category	Trend	AEC↓1	AEC↓2
			FISH	C (B)	Negative	D	D
			MACRO INVERTEBRATES	C (B)	Stable	C	D
			INSTREAM	C		C	D
			RIPARIAN VEGETATION	A/B	Stable	B/C	B/C
			ECOSTATUS	B/C (B)		C	C

IHI Hydro	Diatoms
E	C

Note: Categories in red relates to a REC based on water quality improvements.

EWR 2: GROOTDRAAI (VAAL RIVER)

EIS: MODERATE
PES: C
Combination of flow and non-flow related impacts. Impacts mostly related to changes in flow regime due to Grootdraai Dam.
REC: C
Maintain the PES due to the **MODERATE** EIS rating. However note that there is rare and endangered *Labeobarbus kimberleyensis* present which warrants improvement of the fish EC.
AEC up: B
This ecological scenario is important due to the presence of *L. kimberleyensis*.
Change in the operation of Grootdraai dam, which includes the release of flows (base flows) with more natural seasonal patterns and the release of moderate floods to remove fines and no bottom releases.
AEC down: C/D
Less spilling (i.e. less floods) and decreased base flows.
Increased bottom releases.

IHI			Driver Components	PES and REC Category	Trend	AEC↑	AEC↓
INSTREAM	D	RIPARIAN C	HYDROLOGY	D			
			WATER QUALITY	B/C	Negative	B	B/C
			GEOMORPHOLOGY	D	Stable	D	D/E
			Response Components	PES Category	Trend	AEC↑	AEC↓
			FISH	C	Stable	B	D
			MACRO INVERTEBRATES	C	Stable	B/C	C/D
			INSTREAM	C		B/C	C/D
			RIPARIAN VEGETATION	B/C	Stable	B	C
			ECOSTATUS	C		B	C/D

IHI Hydro	Diatoms
E	C

EWR 3: GLADDEDRIFT (VAAL RIVER)

EIS: MODERATE
PES: C
Combination of flow and non-flow related impacts. Impacts mostly related to changes in flow regime due to Grootdraai Dam, illegal irrigation, livestock farming and vegetation removal.
REC: C
Maintain the PES due to the **MODERATE** EIS rating. However note that there is rare and endangered *Labeobarbus kimberleyensis* present which warrants improvement of the fish EC.
AEC Up: B
Improved base flows (no zero flows), and increased frequency of moderate floods.
Improved water quality due to improved flow regime.
Removal of cattle grazing in the marginal zone.
AEC Down: C/D
Increased duration of zero flow periods.
Decreased frequency of floods.
Very low base flows in the dry season when flowing.
Associated water quality deterioration.

IHI			Driver Components	PES and REC Category	Trend	AEC↑	AEC↓
INSTREAM	C	RIPARIAN C	HYDROLOGY	C			
			WATER QUALITY	C	Stable	B/C	D
			GEOMORPHOLOGY	C	Stable	C	D
			Response Components	PES Category	Trend	AEC↑	AEC↓
			FISH	C	Stable	B	D
			MACRO INVERTEBRATES	C	Stable	B/C	D
			INSTREAM	C		B	D
			RIPARIAN VEGETATION	C	Stable	B	C
			ECOSTATUS	C		B	C/D

IHI Hydro	Diatoms
C	C

EWR 4: DE NEYS (VAAL RIVER)

EIS: HIGH
The presence of the rare and endangered *Labeobarbus kimberleyensis*.
The Vaal River being a large river, which is rare in South Africa.
The diversity of riparian and instream habitats which include runs, rocky outcrops and rapids as well as pools.
Important refugia such as pools.
Being the only area between the Vaal Dam and barrage where yellowfish can breed.

PES: C
Impacts are mostly due to flow related problems, especially the presence of Vaal Dam and lack of flow variability. Increased base flows (dry season) occur as well as reduced frequencies of moderate floods due to releases from the Vaal Dam to maintain a target TDS concentration of 600 mg/l downstream of Vaal Barrage. .

REC: B/C
Improvement of PES due to **HIGH** EIS rating. A B EcoStatus could not be attained due to the limited operational possibilities from the Vaal Dam. Scenario includes improvement of seasonal variability (decreased base flows during the dry season and increased wet season flows above the current base flows).

AEC Down: D
Increased constant base flows if salinity problems are exacerbated leading to a loss of variability.
Decreased frequency of floods.

IHI			Driver Components	PES Category	Trend	REC	AEC↓	IHI Hydro	Diatoms
INSTREAM	D	RIPARIAN D	HYDROLOGY	D/E				E	C
			WATER QUALITY	C	Stable	C	C/D		
			GEOMORPHOLOGY	D	Stable	D	D		
			Response Components	PES Category	Trend	REC	REC		
			FISH	C	Stable	B	D		
			MACRO INVERTEBRATES	C/D	Stable	C	C/D		
			INSTREAM	C		B/C	D		
			RIPARIAN VEGETATION	C	Negative	B/C	D		
			ECOSTATUS	C		B/C	D		

EWR 5: SCANDINAVIA (VAAL RIVER)

EIS: HIGH
Presence of rare and endangered *Labeobarbus kimberleyensis,* and Rand Highveld Grassveld vegetation type. Most importantly, this site falls within the Vredefort Dome World Heritage Site and the river is an important feature within this World Heritage Site.

PES: C/D
Combination of flow and non-flow related impacts. Flow related impacts include increased base flows and reduced frequency of moderate floods due to Vaal Dam and Barrage and releases to regulated TDS levels. Non-flow related impacts include agriculture, and urban sewage and industrial waste and the occurrence of gauges, weirs and dams in the system.

REC: C
Improvement of the PES due to **HIGH** EIS rating. A B/C EcoStatus could not be attained due to the limited operational possibilities from the Vaal Dam. Scenario includes decreased base flows for 3 days (during winter) (to improve macroinvertebrates EC) and increased moderate floods in the wet season.

AEC down: D
Increased base flows.
Possibility of further decrease of floods due to the development in tributaries and increased return flows.

IHI			Driver Components	PES Category	Trend	REC	AEC↓	IHI Hydro	Diatoms
INSTREAM	D	RIPARIAN D	HYDROLOGY	D		C/D	D	C	C/D
			WATER QUALITY	E	Negative	D/E	E		
			GEOMORPHOLOGY	C	Negative	C	C/D		
			Response Components	PES Category	Trend	REC	AEC↓		
			FISH	C	Stable	B	D		
			MACRO INVERTEBRATES	C	Stable	C	C/D		
			INSTREAM	C		B/C	D		
			RIPARIAN VEGETATION	D	Negative	C	-D		
			ECOSTATUS	C/D		C	D		

EWR 6: KLIP (KLIP RIVER)

EIS: MODERATE

PES: B/C
Combination of flow and non-flow related impacts. Flow related impacts include reduced base flows and moderate floods due to weirs and farm dams. Non-flow related impacts include agriculture, cattle grazing, and alien vegetation. The sole reason for the PES not being a B EcoStatus is the current vegetation EC (B/C EC) due to the high proportion of exotic species

REC: B/C
The EIS at EWR 6 is **MODERATE** and the REC is to maintain the PES.

AEC up: B
A B EC can be achieved by removal of alien vegetation. Improving flows will not improve the vegetation.

AEC down: C
The scenario includes decreased low flows and zero flows and decreased moderate floods and deteriorated water quality.

IHI			Driver Components	PES and REC Category	Trend	AEC ↓	IHI Hydro	Diatoms
INSTREAM	C	RIPARIAN C	HYDROLOGY	C			B/C	B/C
			WATER QUALITY	B/C	Negative	C		
			GEOMORPHOLOGY	B	Stable	C		
			Response Components	PES Category	Trend	AEC↓		
			FISH	B	Stable	C		
			MACRO INVERTEBRATES	B	Stable	C		
			INSTREAM	B		C		
			RIPARIAN VEGETATION	B/C	Stable	C		
			ECOSTATUS	B/C		C		

EWR 7: UPPER WILGE (WILGE RIVER)

EIS : HIGH
There are rare and endangered species i.e. the flufftail crowned crane, bald ibis, and 11 red data vegetation species. There is a good diversity of habitats that include wetlands, flood plains, oxbow lakes and peat lands.
PES: A/B
Non-flow related impacts that include small dams for agriculture and exotic fish species (MSAL).
REC A/B
As the PES is also relatively high, the attainable and realistic objective is to maintain the PES even though a **HIGH** EIS would normally warrant improvement.
AEC Down: C
The scenario includes decreased low flows, some periods of zero flows and decreased moderate floods.

IHI		Driver Components	PES and REC Category	Trend	AEC↓	IHI Hydro	Diatoms
INSTREAM B	RIPARIAN B	HYDROLOGY	A			A/B	B
		WATER QUALITY	B	Negative B/C	-B		
		GEOMORPHOLOGY	A	Negative B/C	B/C		
		Response Components	PES Category	Trend	AEC↓		
		FISH	B (D)	Negative D/E	C		
		MACRO INVERTEBRATES	B	Stable	C/D		
		INSTREAM	B		C		
		RIPARIAN VEGETATION	A/B	Stable	B/C		
		ECOSTATUS	A/B		C		

EWR 8: BAVARIA (WILGE RIVER)

EIS: MODERATE
PES: C
Flow related impacts include alteration of hydrological regime due to interbasin transfers from Sterkfontein Dam, abstraction and agriculture. Non-flow related impacts include water quality problems, erosion and exotic species invasion.
REC: C.
Maintain the PES due to the **MODERATE** EIS rating.
AEC Up: B/C
Dry season base flow increase and no zero flows.
Ongoing improved management of the Sterkfontein Dam releases.
Reduced grazing, burning and removal of debris.
Removal of MSAL (although highly impractical, without this removal, the fish EC will not improve).
AEC Down: D
Further decrease of base flows (e.g. an additional dam).
Decrease in small moderate floods.
Associated water quality deterioration.

IHI		Driver Components	PES and REC Category	Trend	AEC ↑	AEC↓	IHI Hydro	Diatoms
INSTREAM C/D	RIPARIAN C	HYDROLOGY	D				C	C/D
		WATER QUALITY	C	Stable	B/C	C/D		
		GEOMORPHOLOGY	C	Positive	+C	C/D		
		Response Components	PES Category	Trend	AEC ↑	AEC↓		
		FISH	C	Stable	B	D		
		MACRO INVERTEBRATES	C/D	Stable	C	D		
		INSTREAM	C		B/C	D		
		RIPARIAN VEGETATION	C	Stable	B/C	D		
		ECOSTATUS	C		B/C	D		

EWR 9: SUIKERBOS US (SUIKERBOSRAND RIVER)

EIS: HIGH
There are endangered species at this site, which includes *Labeobarbus kimberleyensis* and the Soweto Highveld grassland vegetation type (conservation status: endangered).
PES: C
Combination of flow and non-flow related impacts. Flow related impacts include altered flow regime due to Balfour and Harhoff Dams and non-flow related impacts include deteriorated water quality due to WWTW and agriculture, erosion and alien species (fish and vegetation).
REC: B/C
Improvement of the PES due to **HIGH** EIS rating.
An improvement is based on increased base flows (released from upstream dams) as well as erosion control measures in the tributaries to address erosion and increased sediment loads in the reach and alien woody vegetation control.
AEC Down: D
This scenario was not developed as the macroinvertebrates and fish are already in a D EC. A D AEC would involve the maintenance of the current ECs of fish and macroinvertebrates and a deterioration of the riparian vegetation EC. Any flow related changes will however cause deterioration in the riparian vegetation EC and would result in the instream and biota ECs to drop to an E.

IHI		Driver Components	PES Category	Trend	REC	IHI Hydro	Diatoms
INSTREAM C	RIPARIAN B	HYDROLOGY	E			B	C
		WATER QUALITY	C/D	Negative D	C		
		GEOMORPHOLOGY	B/C	Negative C	B		
		Response Components	PES Category	Trend	REC		
		FISH	D	Stable	C		
		MACRO INVERTEBRATES	D	Stable	C		
		INSTREAM	D		C		
		RIPARIAN VEGETATION	B/C	Negative C/D	B		
		ECOSTATUS	C		B/C		

EWR 10: SUIKERBOS DS (SUIKERBOSRAND RIVER)

EIS: MODERATE
PES: C/D
Combination of flow and non-flow related impacts. Flow related impacts include elevated base flow and increased floods due to mining, SAPPI, urban runoff and Blesbokspruit input. Non-flow related impacts include deteriorated water quality due to industries, agriculture and urban activities; erosion, and exotic alien invasion (fish and vegetation).
REC: C/D
Maintain the PES due to the **MODERATE** EIS rating.
AEC up: C
Improved water quality management in the Blesbokspruit catchment. The biotic condition of the biota will improve under this scenario although no improvement will be evident in the riparian vegetation component. The riparian vegetation EC is associated with increased flows rather than water quality. **NOTE:** The recommendations at EWR 9 are to improve the low flows in the dry season. This could increase flows to the level that is problematic at EWR 10. This will have to be treated as a scenario in a systems context and evaluated.
AEC down: D
The scenario is increased base flows.

IHI			Driver Components	PES and REC Category	Trend	AEC ↑	AEC↓	IHI Hydro	Diatoms
INSTREAM	C	RIPARIAN C	HYDROLOGY	D				B	C/D
			WATER QUALITY	D/E	Negative	D	D/E		
			GEOMORPHOLOGY	C	Negative C	C	-C		
			Response Components	PES Category	Trend	REC	AEC↓		
			FISH	C/D	Stable	C	D		
			MACRO INVERTEBRATES	C/D	Stable	C	D		
			INSTREAM	C/D		C	D		
			RIPARIAN VEGETATION	C	Negative D	C	D		
			ECOSTATUS	C/D		C	D		

EWR 11: BLESBOKSPRUIT (BLESBOKSPRUIT RIVER)

EIS: LOW
Site is characterised by water quality problems and elevated flows.
PES: D
Mainly non-flow related impacts that include increased base flows and floods due to mine water decants, urban runoff, agriculture and return flows from WWTW. Water quality is also heavily impacted due to these activities and erosion has increased. Alien fish species occur.
REC: D
Maintain the PES due to the **LOW** EIS rating, **with invertebrates improving to D.**

An improved EcoStatus based on a hypothetical flow regime is not feasible at this site. Decreased flows as a scenario is unattainable and will result in deteriorated water quality.

The improvement of the macroinvertebrate EC is only possible with improved water quality. Improved water quality is only possible with better water quality management, which is unlikely, but feasible at a cost. Due to the huge amount of salts in the system, this improvement will only be a long term option.

The implications for setting flows are the following:
Flow requirements to maintain the present state would be based on present flows. Only increased flows can be evaluated as a scenario to determine whether increased flows (with either improved or the same water quality) will maintain the EcoStatus.

IHI			Driver Components	PES Category	Trend	REC	IHI Hydro	Diatoms
INSTREAM	D/E	RIPARIAN C	HYDROLOGY	D/E			E	C/D
			WATER QUALITY	D/E	Negative D/E	D		
			GEOMORPHOLOGY	C	Negative C/D	C		
			Response Components	PES Category	Trend	REC		
			FISH	D	Stable	C		
			MACRO INVERTEBRATES	D/E	Stable	D		
			INSTREAM	D/E		C/D		
			RIPARIAN VEGETATION	D	Negative D/E	D		
			ECOSTATUS	D		D		

RE-EWR 1: KLEIN VAAL

EIS: MODERATE
PES: C
Flow related impacts include interbasin transfer and abstraction altering hydrological regime. Non-flow related impacts include deterioration in water quality, increased erosion due to cattle and agricultural activities. Loss of habitat due to farm dams.
REC: C
Maintain the PES due to the **MODERATE** EIS rating.
The C EcoStatus is due to the riparian vegetation EC of a D as the instream EC is an A/B. The riparian vegetation PES is due to non-flow related impacts (grazing and trampling) and highly likely a very localised impact.
AEC down: C/D
A hydrological regime with decreased base flows.
Increased periods of zero flows during dry season.

IHI			Driver Components	PES and REC Category	AEC↓	IHI Hydro	Diatoms
INSTREAM	B	RIPARIAN B	HYDROLOGY	A/B		A/B	B
			WATER QUALITY	B/C	B/C		
			GEOMORPHOLOGY	B/C	B/C		
			Response Components	PES Category	REC		
			FISH	B	C		
			MACRO INVERTEBRATES	A/B	C		
			INSTREAM	A/B	C		
			RIPARIAN VEGETATION	D	D		
			ECOSTATUS	C	C/D		

RE-EWR 2: MOOI RIVER

EIS: LOW
PES: D

This naturally would have been a wetland with a badly defined channel. Wetland tools were used to represent the driver state and the river tools used to assess the responses.

Some very rare constricted areas with small riffles occur. This site is downstream of the dam and about the only one with remnants of wetland intact. This is a short section. The rest of the MRU is very badly degraded and would be in a lower category. Downstream of the Wonderfontein inflow, the bad water quality would be the overriding concern. The PES is in a D and the rest of the MRU would be in an E or even lower. It will not be possible to improve the category by improving flows as the fish is already in a C EC and the riparian vegetation EC is due to non-flow related impacts. However, the macroinvertebrate EC might improve to at least a D with some improved flow.

Driver Components	PES Category
HYDROLOGY	E
WATER QUALITY	C/D
WETLAND HABITAT INTEGRITY	E
Response Components	**PES Category**
FISH	C
MACRO INVERTEBRATES	E
INSTREAM	D
RIPARIAN VEGETATION	D
ECOSTATUS	D

Diatoms
C

A summary of confidences for all the sites are given below. Red cells indicate low confidence, yellow cells indicate medium confidence and green cells indicate high confidence.

EWR site	EWR 1		EWR 2		EWR 3		EWR 4		EWR 5		EWR 6		EWR 7		EWR 8		EWR 9		EWR 10		EWR 11		RE – EWR 1		RE – EWR 2	
Confidence	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification
Hydrology	3	4	4	4	4	4	4	4	3	3	1	2	2	4	1	1	1	2	2	4	2	5	1	3		
Physico-chemical	2	1.7	4	1.5	1.5	2.3	4	3	4	3.9	3.6	3.6	1.5	3.5	2.3	2.3	2.5	2.5	3	3	2.6	3	1.5	1.7		
Geomorphology	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	3.5	4	4.5	3.5	3.5	3	3	3.5	3	3.5	3.5	2	2	3	4
IHI (instream & riparian	4	3	4	4	4	3.6	4	3.5	4	3.5	4	2.9	4	3.4	4	3.2	4	2.9	4	2.7	4	2.5	4	2.8		
Fish	3.5	4	3.5	4	3.5	4	4	4	4	4	3.5	3	3.5	3	4	4	4	3.5	4	3.5	4	4	2.5	2	2.5	2
Macroinvertebrates	3	4	3	3	3	3	3	3	3	3	3	4	3	2	3	3	3	3	4	3.5	4	5	2	4	1	3
Vegetation	4.5	4	4.5	3.7	4.5	3.6	4.5	3.2	4.5	3.2	4.5	3.1	4.5	4	4.5	3.4	4.5	3.3	4.5	3.3	4.5	3.4	2	3.4	2	2
Average	3.36	3.46	3.79	3.39	3.43	3.43	3.86	3.46	3.71	3.44	3.37	3.16	3.21	3.49	3.19	2.91	3.14	2.89	3.57	3.29	3.51	3.77	2.14	2.70	2.13	2.75
Median	3.50	4.00	4.00	3.70	3.50	3.60	4.00	3.50	4.00	3.50	3.60	3.10	3.50	3.50	3.50	3.20	3.00	3.00	4.00	3.30	4.00	3.50	2.00	2.80	2.25	2.50

CONCLUSIONS

Comprehensive Reserve Sites: Data availability

The results indicate **MEDIUM TO HIGH** data availability at all the sites with **HIGH** data availability for EWR 4, 5 and 10. Driver information was particularly good at EWR 4 and 5. The present modelled hydrology did not reflect the observed hydrology and the monthly format could not be used, therefor the available observed daily data was used at EWR 4 and 5. There was good data and long data records available from the water quality stations at the respective sites as well as Rand Water data.

In general, the only low confidence in data availability was in the hydrology and physico-chemical variable information. Hydrology issues are mainly due to the fact that the modelled present hydrology is only relevant up to 1994, and that the present uses were aggregated for large areas.

Comprehensive Reserve Sites: EcoClassification Results

The results in indicate **MEDIUM TO HIGH** confidence in EcoClassification results at all the sites with **HIGH** data availability for EWR 1 and 11. Even though data availability is poor at EWR 11, there is no uncertainty about the state of the poor hydrology and there is a good understanding of the biotic components especially fish and macroinvertebrates.

The major issues were the following:

- EWR 1: Limited data record from water quality station. There are fish kills and fish diseases which apparently relate from water quality issues. The links and causes are however unknown.
- EWR 2: There is uncertainty in the water quality data as there is uncertainty regarding the impact of Leeuspruit and Blesbokspruit water quality on the trophic status of Grootdraai Dam.
- EWR 3: Water quality measuring station is far from site and downstream of the Waterval River confluence. Data is therefore not representative of the EWR site.
- EWR 4: There was a discrepancy between modelled hydrology and actual releases being made for dilution purposes. This resulted in observed hydrology being used rather than the modelled hydrology.
- EWR 5: See above. The available gauge is also far from the EWR site and does not measure low flows accurately.
- EWR 6: The hydrological gauge is situated far from the site. The modelled present hydrology did not match observations of flow at the site, i.e. modelled present day hydrology predicted more flows than natural with actual observations of dry season flows being more common. The good aquatic invertebrate state was also in contradiction with the hydrology information observed and available.
- EWR 7: Lack of water quality measuring station and hydrological gauge. C8H002 was far from the site and a 10-year intermittent data base exists. Low confidence in macroinvertebrates data due to limited sampling opportunities.
- EWR 8: Limited data available from water quality measuring station. There were discrepancies between modelled hydrological data and observed flows, and the gauge does not measure low and zero flows accurately.
- EWR 9: Limited data available from water quality measuring station. Hydrological data did not include impact of Balfour and Harrhoff Dams. Biological responses were therefore difficult to interpret, as there was no correlation between the hydrology provided, and observations on site.
- EWR 10: The two hydrological gauges used for the assessment does not measure low and zero flows accurately and there is a 18-year gap in the data. The hydrology of EWR 9 and associated problems affects this site. There are however uncertainties regarding the hydrology due to the complexities of all the urban and industrial upstream activities. The higher than natural flows are difficult to interpret.
- EWR 11: There was only a 4-year flow record available. There are however uncertainties regarding the hydrology due to the complexities of all the urban and industrial upstream activities. The higher than natural flows are difficult to interpret.

Rapid Reserve sites

Data availability in the driver components for RE-EWR 1 was **LOW**. There was no hydrological data available and limited physico-chemical data. The confidence in the EcoClassification results for RE-EWR 1 was **LOW-MEDIUM** due to limited driver information on which biotic responses are based as well as one instream biota survey only.

The confidence at RE-EWR 2 was **LOW** for data availability and EcoClassification. Although there was a good understanding of the driver components, the biotic responses were poor. The situation is complex as this site used to be a wetland and now consists of a very disturbed area, with some small sections of artificial river channel due to anthropogenic changes.

RECOMMENDATIONS

In general, it does not seem to be practical to undertake any more detailed work to improve confidence in the EcoClassification results. Ecological Water Resource Monitoring should be initiated as quickly as possible. The surveys results undertaken for EcoClassification should be valid for a baseline.

Specific aspects that require attention as part of Ecological Water Resource Monitoring are the following:

- Due to the lack of a nearby water quality monitoring stations at EWR 1, 2, 3, 8, 9 diatom assessments should be undertaken. This will provide good indication of the trend of the physico-chemical variables and if problems are indicated, more detailed physico-chemical analysis can be undertaken; however only based on available data. This is also relevant for 4, 5, 10 and 11.
- EWR 4: It is proposed that TDS levels and flow releases are monitored comprehensively.
- EWR 7: It is assumed that ESKOM will initiate ecological monitoring as part of the EIA recommendations designed for the Braamhoek pump storage scheme and according to Regulations. This should in any case improve base line information and overall confidence in the site evaluation.
- EWR 8, 10 and 11: Inaccurate gauges near these sites need to be serviced and maintained. EWRM will not be successful without the hydrological information being available.
- EWR 9: The impact of Balfour and Harhoff Dams must be included in the system model to ensure that the EWR assessment and specifically the design of operational scenarios include this. This therefore must still be undertaken within the latter phases of this study.
- Water quality management plans are proposed for EWR 1, 10 and 11 as the problems associated with these sites are water quality related and not flow related.
- Alien eradication programme is required at EWR 6.

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ACRONYMS

AEC	Alternative Ecological Category
AMD	Acid Mine Drainage
ASPT	Average Score Per Taxon
CD: RDM	Chief Directorate: Resource Directed Measures
Conf	Confidence
D: NWRP	Directorate: National Water Resources Planning
DO	Dissolved Oxygen
D:RQS	Directorate: Resource Quality Services
DWA	Department Water Affairs (Name change applicable after April 2009
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EC	Electrical conductivity
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
F	Flow related
FD	Fast Deep fish habitat
FRAI	Fish Response Assessment Index
FROC	Fish Frequency of occurrence
FS	Fast Shallow fish habitat
Geom	Geomorphology
GSM	Gravel, sand, mud habitat
Hydro	Hydrology
IIHI	Instream Index of Habitat Integrity
Inverts	Macroinvertebrates
MCM	Million Cubic Metres
MIRAI	Macro Invertebrate Response Assessment Index
MRU	Management Resource Unit
MV	Marginal Vegetation
NF	Non Flow related
NRHP	National River Health Programme
NRU	Natural Resource Unit
PES	Present Ecological State
Physico-chem	Physico chemical
Quat	Quaternary catchment
RAU	Resource Assessment Unit
RC	Reference Condition
REC	Recommended Ecological Category
RHP	River Health Programme
RIHI	Riparian Index of Habitat Integrity
Rip Veg	Riparian vegetation
RU	Resource Unit
SAIAB	South African Institute of Aquatic Biodiversity
SASS5	South African Scoring System version 5
SD	Slow Deep fish habitat
SIC	Stones-in-current habitat
SOOC	Stones-out-of-current habitat
SPI	Specific Pollution Index
SRP	Soluble Reactive Phosphate

SS	Slow Shallow fish habitat
TDS	Total Dissolved Salts
TEACHA	Tool for Ecological Aquatic Chemical Habitat Assessment
TIN	Total Inorganic Nitrogen
TP	Total Phosphorous
VRSAU	Vaal River System Analysis Update
WETLAND – IHI	Wetland Index of Habitat Integrity
WMA	Water Management Area
WQSU	Water Quality Sub Unit
WWTW	Waste Water Treatment Works

1 BACKGROUND AND INTRODUCTION

1.1 BACKGROUND

In order for the Department of Water Affairs (DWA) to make informed decisions regarding the authorization of future water use and the magnitude of the impacts of the present and proposed developments in the Vaal River System, higher levels of confidence is needed for the Reserve Determination within this study area. Therefore a Comprehensive Reserve determination study within Water Management Area (WMA) 8 has been undertaken to provide input to the Reconciliation studies and the integrated water quality management plan recently undertaken by the National Water Resources Planning Directorate (D: NWRP) of the DWA.

The Comprehensive Ecological Reserve Methodology followed the 8 - step Ecological Reserve process (Figure 1.1). This report summarizes step 3 of the process.

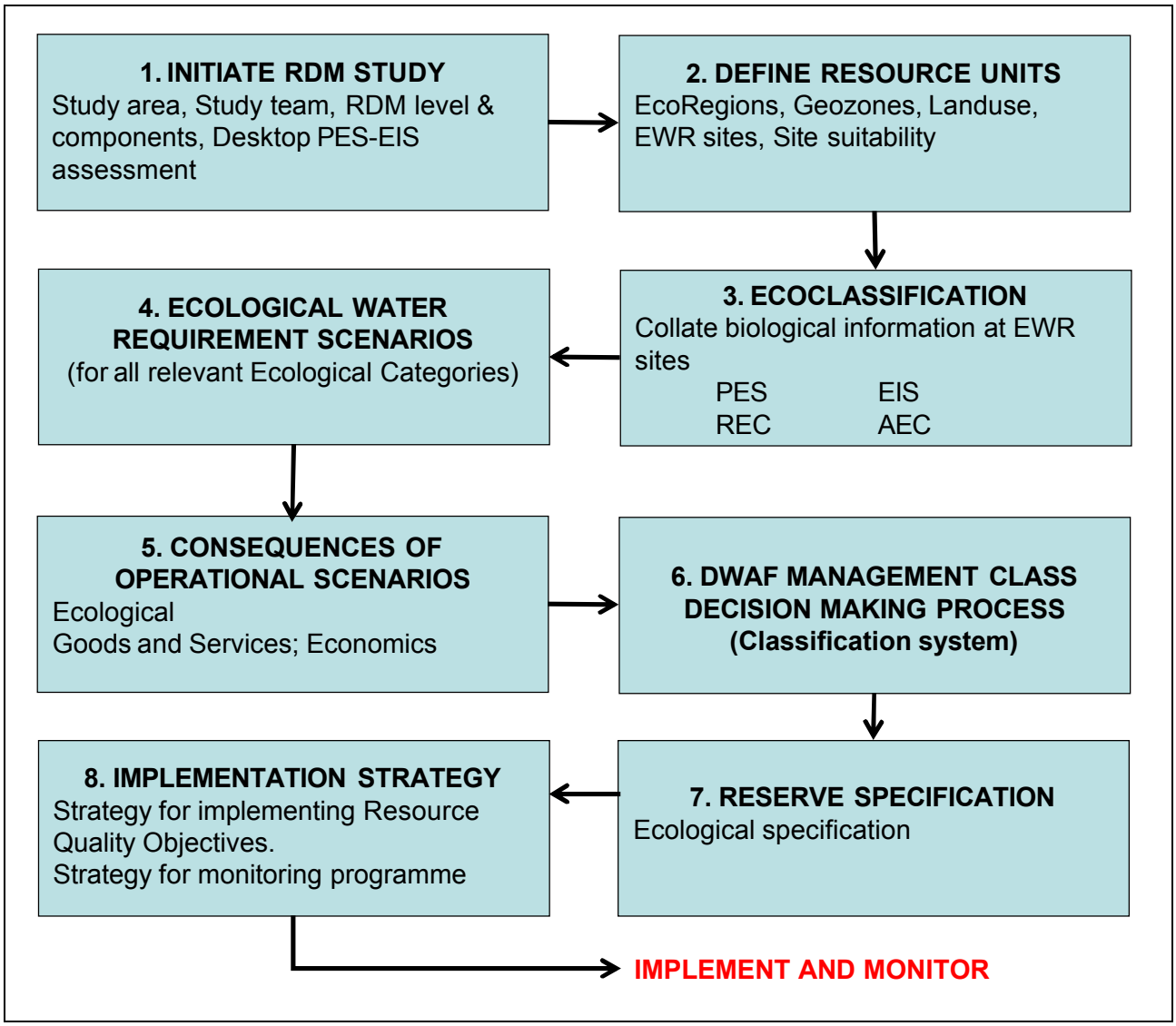


Figure 1-1 The 8-step Ecological Reserve procedure (DWAF, 1999)

1.2 STUDY AREA

The Upper Vaal WMA is one of three WMAs in the Vaal River catchment, which is the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers (DWAF, 2004).

The major tributaries in the Upper Vaal WMA include the Vaal, Klip, Watervals, Wilge, Liebenbergsvlei, Suikerbosrand, Klipspruit and Mooi Rivers and extend to the confluence of the Mooi and Vaal Rivers. It covers a catchment area of 55 565 km^2. The locality and characteristics of the Ecological Water Requirement (EWR) sites are provided in Table 1.1 and Figure 1.2. Information on site selection and the Management Resource Units (MRUs) are provided in DWAF (2008).

EWR site number	EWR site name	River	National RHP site	Co-ordinates		EcoRegion (Level II)	Geomorphic Zone	Altitude (m)	RU	Quaternary	Hydrological gauge
				Latitude	Longitude						
EWR 1	Uitkoms	Vaal	C1Geel_Unspe	-26.8728	29.61384	11.05	Lowland	1570	MRU Vaal B	C11J	C1H007
EWR 2	Grootdraai	Vaal	C1Vaal Braks	-26.9211	29.27929	11.03	Lowland	1537	MRU Vaal C	C11L	C1H019
EWR 3	Gladdedrift	Vaal	C1Vaal-Villie	-26.99087	28.72971	11.03	Lowland	1487	MRU Vaal C	C12H	C1H012
EWR 4	De Neys	Vaal	C2Vaal-Deny	-26.84262	28.1123	11.03	Lower Foothills	1445	MRU Vaal D	C22F	C2H122
EWR 5	Skandinavia	Vaal		-26.93243	27.01367	11.08	Lowland	1309	MRU Vaal E	C23L	C2H018
EWR 6	Klip	Klip	C1Klip-Unspe2	-27.36166	29.48503	11.06	Lower Foothills	1593	MRU Klip C	C13D	
EWR 7	Upper Wilge	Wilge		-28.20185	29.55827	11.03	Lowland	1692	MRU Wilge A	C81A	Redmans Werf 319
EWR 8	Bavaria	Wilge	C8Wilg-Belwh	-27.80017	28.76778	11.03	Lowland	1573	MRU Wilge B	C82C	C8H028
EWR 9	Suikerbos US	Suikerbosrand	C2Suik-Dehoe	-26.6467	28.38197	11.01	Lower Foothills	1509	RU Suiker A	C21C	
EWR 10	Suikerbos DS	Suikerbosrand	Close to C2Suik-Badfo	-26.68137	28.16798	11.01	Lowland	1453	RU Suiker B	C21G	
EWR 11	Blesbokspruit	Blesbokspruit	C2Bles-Marai (locality incorrect)	-26.47892	28.42488	11.03	Lower Foothills	1528	RU Bles A	C21F	
Rapid Level sites											
RE-EWR 1	Klein Vaal	Klein Vaal	C1KVaal-unspe	-26.9128	30.17497	11.02	Lower Foothills	1620	MRU Kvaal A	C11C	
RE-EWR 2	Mooi	Mooi	Close to C2Mooi-Klerk	-26.2587	27.15973	11.01	Lower Foothills	1457	RU Mooi B	C23G	

1 River Health Programme 2 Resource Unit 3 Quaternary catchment

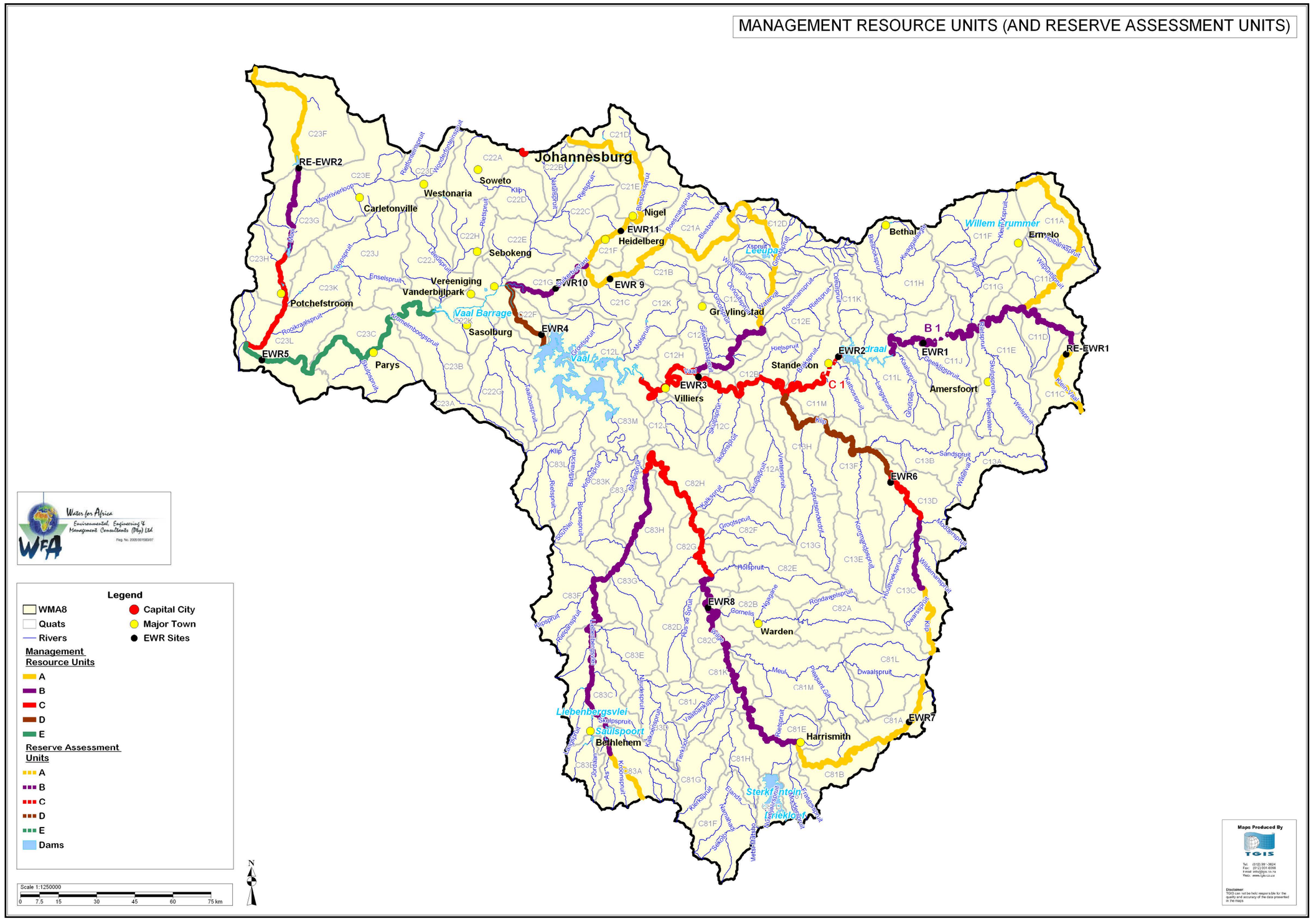


Figure 1.2 Locality of EWR sites and Management Resource Units

1.3 METHODOLOGY

EcoClassification forms step 3 of the 8-step Reserve process (Louw and Hughes, 2002) (Figure 1.1).

1.3.1 EWR 1 – 11

The procedure for the EcoClassification that was followed during the Upper Vaal Comprehensive Reserve determination was according to the revised methods for rivers as outlined in the EcoClassification manual version 2 (Kleynhans and Louw, 2007). The physico-chemical assessment was according to Kleynhans (2005) and all subsequent updates which is still being documented (these updates will be included in the current RDM method Revision project that are being undertaken through the Water Research Commission). Different levels of EcoClassification exist and the Level 4 method, required for the Comprehensive Ecological Reserve Methodology, was applied. The EcoClassification steps are summarised as follows:

- Determine reference conditions for each component.
- Determine the Present Ecological State (PES) for each component[3] as well as the EcoStatus[4].
- Determine the trend for each component.
- Determine reasons for PES and whether these are flow or non-flow related.
- Determine the Ecological Importance and Sensitivity (EIS) for the biota and habitat.
- Considering the PES and the EIS, suggest a realistic Recommended Ecological Category (REC) for each component as well as for the EcoStatus.
- Determine Alternative Ecological Categories (AECs) for each component as well as for the EcoStatus.

1.3.2 RE – EWR 1 and 2

Two Rapid III sites were identified; Klein Vaal (RE - EWR 1) and Mooi River (RE - EWR 2). For RE - EWR 1 the Level 4 EcoClassification method was followed and applied. RE-EWR 2 would naturally have been a wetland with a badly defined channel. Therefore Wetland tools (WETLAND – Index of Habitat Integrity) (WETLAND – IHI, DWAF, 2007)) were used to represent the driver state and the river tools used to assess the responses. The section of the river examined for the Wetland-IHI is between the Klerkskraal and Boskop Dam.

Habitat assessments provide information on the quality, quantity and suitability of the physical environment that supports biota and the WETLAND – IHI assesses four components of a floodplain, namely:

- Alteration to vegetation due to landuse activities on the floodplain surface.
- Alteration to the natural hydrology (flooding regime) due to catchment as well as on-site activities.
- Alteration to the geomorphology of the site due to catchment as well as on-site activities.
- Alteration to the water quality aspects of the river due to upstream catchment activities.

[3] **Components:** Driver components (Hydrology, Geomorphology, Physico-chemical variables) and Response components (Riparian vegetation, Fish, Macroinvertebrates)

[4] **EcoStatus:** *'The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services'.*
In essence the EcoStatus represents an ecologically integrated state representing the driver and response components.

1.4 PURPOSE OF THE REPORT

This report serves to document the results of the EcoClassification process which were finalised at two specialist meetings held during 26 – 30 May and 30 June – 4 July 2008. The final results consist of the following:

- EIS scores.
- Reference conditions.
- PES for each component and the EcoStatus.
- REC for each component and the EcoStatus.
- AEC/s for each component and the EcoStatus.
- Confidences for all of the above and conclusions and recommendations based on the confidences.
- Conclusions and recommendations.

Note: The REC and AECs together form the range of EWR scenarios for which EWRs will be set in the latter part of this study.

1.5 OUTLINE OF THE REPORT

The report consists of the main EcoClassification report (this report) which is outlined below. Specialist appendices are provided in a separate (Volume 2) report together with the suite of EcoStatus models and component assessment models applied to this study in electronic format (RDM/WMA8C000/01/CON/0810) (DWA, 2010a) which will accompany the main report (RDM/WMA8C000/01/CON/0710) (DWA, 2010b) of this study.

Chapter 1: Introduction and Background
This chapter.

Chapter 2 - 14: EcoClassification for the Vaal River system
The results are provided for each EWR site.

Chapter 15: Summary of Results and Conclusions
The results are summarised and recommendations are made.

Chapter 16: References

2 EWR 1: UITKOMS (VAAL RIVER)

2.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 2.1.

Table 2.1 EWR 1: Summary of data availability

Component	Data availability	Conf[1]
Hydrology	C1H007 is the nearest gauge. It has a 36 year flow record.	3
Physico-chemical	Limited data with 69 data points was available from 1999 to 2007 from VS4 GDDC11 Vaal River at R35 Bloukop bridge.	2
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site and catchment was available. Ecological reports and specialist assessments for this study.	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Two site visits and fish sampling during September 2007 and December 2007. Rivers Data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. South African Institute of Aquatic Biodiversity (SAIAB) data base (2006). Kleynhans *et al.* (2007): FROC data base.	3.5
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	3

1 Confidence

2.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 2.2) was rated as **HIGH** (present). The rare and endangered fish, *Labeobarbus kimberleyensis* is present. The Vaal River is a relatively large river in South Africa, and the variety of riparian and instream habitats in this reach include rapids, wetlands, riffles, floodplain, and islands as well as pools which is scares habitat types and important refugia habitat. The anastomosing rapid section is scarce habitat in a pool-run dominated Vaal River and the isolated upper reaches are important migration corridors for birds and yellowfish.

Table 2.2 EWR 1: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING (0 - 4)	CONF	
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	*Labeobarbus kimberleyensis.*
Unique (endemic, isolated, etc.)	2	4	*Austroglanis sclateri*, *Labeo capensis.*
Intolerant (flow & flow related water quality)	2.5	4	*L. kimberleyensis*, *L. aeneus*, *L. capensis*, *A. sclateri*, Heptageniidae.
Species/taxon richness	3	3	9 fish species, 18 macroinvertebrate taxa.
RIPARIAN & INSTREAM HABITATS			

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Diversity of types	3.5	4	Large river (rare in SA), rapid, wetlands, riffles floodplain, islands.
Refugia	2	3	Pools.
Sensitivity to flow changes	2	3	Wide river, but riffle sensitive.
Sensitivity to flow related water quality changes	2	3	
Migration route/corridor (instream & riparian)	2	2.5	Birds, yellowfish, in isolated upper river reaches and tributaries.
Importance of conservation & natural areas	2.5	3	Large riffle, rapid area. Soweto Highveld Grassland (conservation status of endangered).
MEDIAN	2.25		
EIS EVALUATION	**HIGH**		

2.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 2.3. Additional information on physico-chemical variables, fish and macroinvertebrate reference conditions are also provided.

Table 2.3 EWR 1: Reference conditions

Component	Reference conditions	Conf
Hydrology	A 36 year gauge record was available from C1H007. Natural hydrology was scaled to EWR site which may have cause a reduction in accuracy. Virgin MAR: 288.79 MCM	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al.* (2005). Refer to Table 2.4.	3
Geomorphology	Single thread sinuous channel with fewer cut banks.	2
Riparian vegetation	Marginal zone Sedge dominated zone with minor herbaceous component. *Salix mucronata* and *Gomphostigma virgatum* could also form a minor woody component, but distribution is expected to be patchy, even in the reference condition. Lower zone Sedge dominated zone with minor herbaceous component. *S. mucronata* and *G. virgatum* could also form a minor woody component. Grasses (especially *Miscanthus junceus*) also expected to occur where lateral alluvia occur, especially along pools and lateral bars. Upper portion of lower zone expected to be colonised by terrestrial grasses (adjacent to grassland biome). Upper zone Grass dominated (mainly terrestrial grasses), with woody component where substrate becomes rocky and steep (*Diospyros lyceoides* mainly).	3
Fish	Nine species present. Refer to Table 2.5.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 2A and 3 (Chutter, 1967: Table 11). The reference South African Scoring System version 5 (SASS5) score is 176 and the Average Score Per Taxon (ASPT) is 6.3.	4

2.3.1 Physico-chemical variables

The quality component of the comprehensive Reserve determination study for the Integrated Vaal River System is a separate study and detailed information regarding the water quality of the Vaal River system is available in report RDM/WMA8/9/10C000/01/CON/0207. Physico-chemical variable information for this report was provided by Dr Ralph Heath (Golder and Associates) during the EcoClassification specialist workshops held in 2008. The approach to determine reference conditions for the physico-chemical variables in the Upper Vaal WMA (WMA 8) is outlined below and in Appendix C – Volume 2. The reference conditions provided in Table 2.4 is applicable to all EWR sites within the study area.

Approach

Due to the Vaal River main stem being highly impacted over the past century it was difficult to find Reference Condition (RC) water quality data per EWR site.

After discussions with Drs Jooste, and Scherman it was also agreed that the default benchmarks in the Tool for Ecological Aquatic Chemical Habitat Assessment (TEACHA) model were not appropriate for the Vaal River. In order to find an appropriate RC for the Vaal River, a reference site in WMA 8 in the Upper reaches of the Vaal River in Water Quality Sub-Unit 1 (WQSU 1) was selected. This water quality monitoring site (VS2 Vaal River at R29/N2 bridge at Camden) has no major upstream activities that could impact on the water quality.

The DWAF (2006) was used as a reference guide for this water quality assessment. The water quality database was updated from DWA up to 2008.

Table 2.4 Physico-chemical reference condition values for EWR sites in WMA 8

Water Quality Constituents		RC Value	Category/Comment
Inorganic salts (mg/L)	$MgSO_4$	32.9	D
	Na_2SO_4	4.96	A
	$MgCl_2$	6.79	A
	$CaCl_2$	16.3	A
	NaCl	22.7	A
	$CaSO_4$	0.734	A
Nutrients (mg/L)	Soluble Reactive phosphate (SRP)	0.075	C
	TIN (Total Inorganic nitrogen)	0.11	A
Physical variables	pH (pH units)	6.5 – 8.44	A
	Temperature (° C)		Natural and not impacted.
	Dissolved oxygen (DO) (mg/L)		
	Turbidity (NTU)		Clear water with minimal upstream impacts.
Toxics	Fluoride (mg/L)	0.325	A
	Ammonia (mg/L)	0.1	C
Overall site classification (estimate)		**A/B**	

2.3.2 Fish

Reference conditions broadly refer to “expectations on the state of aquatic biological communities in the absence of human disturbance and pollution”. In the context of this report, it refers specifically to the fish species present in a particular river reach and their frequency of occurrence (FROC) under reference habitat conditions (Kleynhans *et al.,* 2007).

Reference conditions set should be valid for the entire Natural Resource Unit (NRU) D and Management Resource Unit (MRU) B. Reference conditions as set for the National River Health Programme (NRHP) site, C1Geel-Unspe, (Kleynhans *et al.,* 2007), which is 14,5 km upstream of the EWR site and falls within the same EcoRegion, NRU and MRU, was used as starting point for setting reference conditions. Based on the latest available information and professional judgement the following alterations were made for the purpose of this site:

- The FROC of *Barbus anoplus* and *Pseudocrenilabrus philander* was reduced to 2. There is strong evidence (Scott *et al*., 2006) that this species mainly occur in the tributaries of the Vaal River and very seldom in the main stem, although this reach is relatively high up

in the catchment, and may have been able, under natural conditions, to provide suitable habitat[5] (slow deep (SD) and slow shallow (SS)) for the maintenance of populations of this species.

- *Barbus pallidus* was removed from the expected species list. According to Scott *et al.* (2006) this species mainly occurs in the tributaries of the Vaal River.
- *Barbus paludinosus* was added to the expected species list as it has been recorded previously in this WMA and also recently directly below the Grootdraai Dam, which is a possible indication that if the migration barriers were not present, this species may well have occurred in the upper reaches of the Vaal River.
- *Tilapia sparmanii* was excluded from the expected species list as there is no evidence that this species has been recorded upstream of the Grootdraai Dam (main stem of tributaries).

Nine indigenous fish species are expected under reference conditions and are listed in Table 2.5.

Table 2.5 EWR 1: Reference fish species

Expected Reference and Habitat derived Frequency of Occurrence (FROC) of fish at EWR 1 (Values used in Fish Response Assessment Index (FRAI)). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	2	2
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	4	4
Barbus anoplus	Chubbyhead barb	BANO	2	1
Barbus paludinosus	Straightfin barb	BPAU	2	1
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	2	1
Clarias gariepinus	Sharptooth catfish	CGAR	2	2
Labeo capensis	Orange River labeo	LCAP	4	4
Labeo umbratus	Moggel	LUMB	3	3
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	2	1

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

2.3.3 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Perlidae, Hydropsychidae (>2 spp.), Heptageniidae, Baetidae (>2 spp.), Tricorythidae, Elmidae/Dryopidae, Atyidae, Leptophlebiidae, Hydracarina, Simuliidae, Coenagrionidae, Naucoridae, Hydroptilidae, Tipulidae, Corbiculidae, Caenidae, Gerridae, Veliidae/ M...veliidae, Dytiscidae/Noteridae, Gyrinidae, Ceratopogonidae, Porifera, Hydrophilidae, Turbellaria, Potamonautidae, Corixidae, Chironomidae, Sphaeriidae, Oligochaeta, and Hirudinea.

2.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

[5] Habitat guilds are detailed in Kleynhans (2007).

2.4.1 Hydrology (C EC)

There has been a significant increase in base flow volumes during the dry months (October – May). The increase in the dry months is mainly due to the transfers from Heyshope and Zaaihoek dams to maintain Grootdraai Dam at 90% of its Full Storage Level. Grootdraai Dam supplies water to Standerton, SASOL and Eskom. There has been no change in the frequency of floods from natural condition.

2.4.2 Geomorphology (B/C EC, 79.3%)

The Resource Assessment Unit (RAU) consists of an anastamosing rapid section with off-channel pools and backwaters, making this a very critical habitat within this very homogenous MRU of the Vaal River. Wetlands (pools) are located in the bed of a seasonal channel at this site. The permanent nature of these pools appears to be unique in the reach. Very high base flows are present due to interbasin transfers and this may account for the cut banks on both banks upstream of the site. Google Earth images indicate an absence of bars and islands in the reach which may also be a result of the elevated base flows. No change in moderate or large floods is evident from the available hydrological data, although there are several farm dams in the upper catchment area.

2.4.3 Physico chemical variables (C EC, 70%)

Three diatom samples were taken at the site (September and December 2007, and April 2008) and 2003 diatom data was also available (Taylor, 2004). Data from VS4 GDDC11 for 1999 - 2007 (n = 69) was used for the physico-chemical PES assessment.

The overall biological[6] water quality EC is a C, but there are indications that the water quality deteriorates markedly during the months of March and September – November. The Specific Pollution Index (SPI[7]) during these months indicates an increase in nutrient load, ionic concentrations and organic pollution. Due to the transfer schemes (Heysope and Zaaihoek) that cause elevated base flows there seems to be a dilution effect on the water quality.

Physico-chemical variables indicate that the water quality is fairly good, although some impacts are detected. Increased Total Dissolved Salts (TDS) could be diffuse impacts originating from coal mines. Witpuntspruit tributary is impacted (low pH, high sulphates) by Acid Mine Drainage (AMD) and there are temperature changes due to the interbasin transfer from the Usutu River to the Perdewaterspruit which also raise the base flow from April to October. Occasional fish kills occur in the MRU that could be related to water quality problems. Cattle grazing also occur in the river. PES values for the physico-chemical variables are provided in Table 2.6 and in Volume 2 - Appendix C of this report.

Table 2.6 EWR 1: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	41.6
	Na_2SO_4	6.34
	$MgCl_2$	5.53
	$CaCl_2$	20.2

[6] Diatoms are primary producers and form the base of the aquatic foodweb. Within the EcoClassification process diatoms are used as an additional response variable to physico-chemical information and therefore reference is made to biological water quality.

[7] A diatom based water quality index. The index evaluates organic and inorganic pollution based on the sensitivity of each taxon, while taking into account the response of the whole diatom community (Almeida, 2001). The index is used to indicate general water quality.

Water Quality Constituents		Value: PES
	NaCl	27.4
	$CaSO_4$	0.73
Nutrients (mg/L)	SRP	0.05
	TIN	0.25
Physical variables	pH (5^{th}+95^{th} percentiles)	7 – 8.56
Toxics	Fluoride (mg/L)	0.05
	Ammonia (mg/L)	0.03

2.4.4 Index of Habitat Integrity (IIHI: C EC, 70.4%; RIHI: B EC, 82.1%)

The Instream Index of Habitat Integrity (IIHI) is a C (70.4%). This is mostly due to changes in hydrology due to interbasin transfers and deteriorating water quality. The Riparian Index of Habitat Integrity (RIHI) is a B (82.1%) with the main impacts being substrate exposure due to trampling and the presence of exotic vegetation.

2.4.5 Fish (C EC, 71%)

All the expected fish species are still present within this Resource Unit (RU) although the FROC of some species have been reduced from reference conditions. The FROC of *L. kimberleyensis* has been altered potentially as a result of water quality deterioration as well as habitat deterioration (increased siltation and benthic algae). The FROC of *B. anoplus*, *B. paludinosus* and *Pseudocrenilabrus philander* have also been reduced and relates to loss of cover (vegetation loss as result of bank erosion and sedimentation of substrates) and especially due to the presence of the aggressive alien predator *Micropterus salmoides* (MSAL).

2.4.6 Macroinvertebrates (C EC, 74.6%)

September 2007:	SASS5 score: 104	No of Taxa: 18	ASPT: 5.8
April 2008:	SASS5 score: 89	No of Taxa: 17	ASPT: 5.2

Key taxa expected but not observed were generally those that are sensitive to water quality changes, such as Perlidae, Leptophlebiidae, Heptageniidae, Gerridae, *Centroptiloides bifasciata,* Hydracarina, *Caridina nilotica a*nd *Hydropsyche longifurca.* Tricorythidae were more abundant than expected, while Hydropsychidae were less abundant than expected.

2.4.7 Riparian vegetation (A/B EC, 87.5%)

This site occurs within the Soweto Highveld Grassland vegetation type, which has an endangered conservation status with 52.7% of the type remaining and only 0.2% protected.

2.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 2.7.

CAUSE: A stressor that occurs at an intensity, duration and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor into the waterbody (EPA, 2000).

Table 2.7 EWR 1: Causes and sources

	PES	Conf	Causes	Sources	F[1]/NF[2]	Conf
Hydro[3]	C	4	Elevated base flows. Higher than natural for months May to Oct (dry season).	Interbasin transfer.	F	4
Physico-chem[4]	C	1.7	Increased TDS.	Diffuse impacts originating from coal mines. Cattle grazing.	NF	3
			Some indication of phosphate contamination.	Agriculture.		
			Temperature changes.	Interbasin transfer and Perdewaterspruit.	F	
Geom[5]	B/C	3.5	Elevated base flows are causing river bank cutting and likely decreased beds and bars.	Interbasin transfers.	F	3.5
			Reduced sediment supply.	Small dams.		
Rip veg[6]	A/B	4	Vegetation removal.	Some trampling/grazing pressure, but minimal impact.	NF	4
			Exotic invasion.	<10%, *Salix babylonica* and non-woody weeds mainly.		
			Water quantity.	Reduced sedge cover in marginal zone due to increased dry season base flows, but the same cause has increased sedge cover and vigour in the lower zone.	F	
Fish	C	4	Loss of habitat (decreased SS and SD) diversity as a result of flow modification (especially during natural low flow periods).	Interbasin transfer.	F	3.6
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming activities.	NF	
			Increased sedimentation results in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and dryland crops.		
			Decreased substrate quality related to increased benthic growth.	Effluents from mines and agricultural areas.		
			Decreased water quality affect species with requirement for high water quality.			
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL).	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation / angling.		
			Increased turbidity and disturbed bottom substrates.	Erosion and presence of bottom feeding alien CCAR.		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Grootdraai Dam and other major downstream dams as well as weirs. Also farm dams in tributaries reduce refuge areas.		
Inverts[7]	C	4	Increased flows during dry season.	Interbasin transfer.	F	2
			Water temperature shocks.			
			Water quality and associated benthic growth.	Agriculture and mining.	NF	

1 Flow related 2 Non Flow related 3 Hydrology
4 Physico chemical variables 5 Geomorphology 6 Riparian vegetation
7 Macroinvertebrates

2.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 2.8.

Table 2.8 EWR 1: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	C	Stable	C		Stable trend in phosphate and other nutrients as well as salt and pH concentrations.	3
Geom	B/C	Negative	Lower C	5 years	Site and reach is continuing to adjust to the highly elevated baseflows.	2.5
Rip veg	A/B	Stable	A/B		The vegetation has already responded to flow changes, and alien vegetation (non-aggressive) is unlikely to increase so as to affect the current EC.	3
Fish	C	Negative	C/D	Long term	As extreme fish kills were observed and reports from concerned residents indicate more frequent occurrence of such events in recent times, there is a definite indication that some alteration is responsible for the consistent degradation of this river reach.	3
Inverts	C	Stable	C		The macroinvertebrates have already reacted to the current conditions.	3

2.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 2.9. The Instream EC is a C (72.8%).

Table 2.9 EWR 1: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	**12**	**330**	**71.0**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	1	100		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	30		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	2	70		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**6**	**200**	**74.6**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		**530**	**72.5**	**C**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	4	0.50	35.50	
Confidence rating for macroinvertebrate information	4	0.50	37.30	
	8	1	72.80	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**	

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence is included in the EcoStatus assessment index (Table 2.10). The EcoStatus EC is a B/C (80.06%).

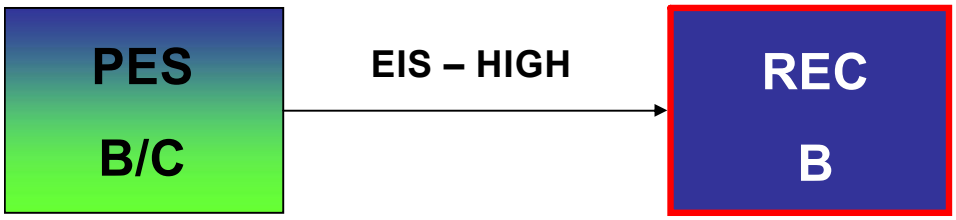
Table 2.10 EWR 1: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	87.5	A/B	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	4	0.50	36.40
Confidence rating for riparian vegetation zone information	4	0.50	43.75
	8	1.00	80.15
ECOSTATUS	EC		B/C

2.7 RECOMMENDED ECOLOGICAL CATEGORY (REC): B/C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 1 is **HIGH** and the PES warrants an improvement. An improvement in the PES EcoStatus would mean that fish and macroinvertebrates must improve from a C to a B EC. No improvement in riparian vegetation is needed as the current EC is an A/B. An improvement in the biotic component EC is dependent on **water quality** changes and not flow related issues. It seems that the water quality at this site is problematic as the fish show signs of serious bacterial infection and quality sensitive macroinvertebrates are absent. Diatoms also indicate that water quality is impaired; however, it is not certain what the water quality problems are. To improve the EC therefore, the water quality problems must be identified to determine how it can be addressed. As no improvement in flow is required, no EWR for the REC will be undertaken and the REC will thereore be to maintain the PES.



Note: The red indicates that improvement is based on water quality changes.

2.8 ALTERNATIVE ECOLOGICAL CATEGORIES (AECs) TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

Two alternative scenarios were designed based on the implementation of different hydrological regimes. Both scenarios result in an Alternative Ecological Category (AEC) of a C and are discussed below.

2.8.1 AEC down 1: C (increased base flows)

The hypothetical scenario is designed and includes the following:

- A hydrological regime with **increased** base flows for longer periods of time in the winter (longer than present transfer) as well as fluctuations in temperature.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are available electronically and summarised in Table 2.11.

Table 2.11 EWR 1: C AEC – Increased base flows

	PES	AEC	Comments	Conf
Physico -chem	C	C	Greater fluctuations in temperatures due to interbasin transfers. This in effect will dilute any of the other water quality variables but increase turbidity due to higher erosion.	3
Geom	B/C	C	There will be some increase in the extent of cut banks and further reduction of the extent of islands (due to inundation and erosion). This will not cause a change in the current Ecological Category (EC). However, the meandering alluvial floodplain sections in the upper sections of the Vaal (approx. 20 km upstream of this site) will be much more sensitive to the increases in baseflow. The active channels in these areas are likely to incise further, reducing overtopping and the activation (flooding) of the floodplain, ox-bow lakes and secondary channels.	2.5
Rip veg	A/B	B/C	Due to increased inundation levels the marginal zone will reduce as sedge and woody habitat is lost. Species composition will also change as the marginal zone pushes into the lower zone where grasses occur. The lower zone will also have reductions in sedge cover and abundance. No change will occur in the upper zone.	2.5
Fish	C	D	As the temperatures decrease in winter, the metabolism of the fish species decrease significantly, and they go into an "over wintering" phase, where they would seek refuge in areas with limited diurnal temperature fluctuations (generally deep pools). Should the pools be altered (SD>Fast Deep (FD)), and transfer scheme water furthermore results in increased fluctuations in temperature, oxygen and other water quality variables, the FROC of some indigenous species may be reduced (especially species such as BAEN, LCAP, and LUMB). During spring and summer increased base flows may also result in alteration of adequate spawning habitats for species such as BAEN, BKIM and LCAP. The increased base flows may also result in a reduced sedge component, which may have an impact on species with a preference for aquatic vegetation as cover (especially as protection against the existing impact of the alien predator, *Micropterus salmoides* (MSAL)).	2.5
Inverts	C	C	There will be an increase in the abundance of flow-dependent species, particularly pest blackflies such as *Simulium chutteri* and *S. damnosum* and a reduction in the abundance of taxa with a preference for slow-flowing water, such as Turbellaria, and Leptophlebiidae. These changes are not expected to change the current EC.	3

2.8.2 AEC down 2: C (decreased base flows)

A hypothetical scenario is designed and includes the following:

- A hydrological regime with **decreased** base flows below natural (no transfers) with potential for some low flows.
- Decreased moderate floods.
- Deteriorated water quality due to increased impacts of mining.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are available electronically and summarised in Table 2.12.

Table 2.12 EWR 1: C AEC – Decreased base flows

	PES	AEC	Comments	Conf
Physico -chem	C	C	There will be no dilution of mining impacts.	3
Geom	B/C	C	The impact upon the morphology will be to reduce the cutting of the banks and promote the reinstatement of bars and islands, but the reduction of the moderate events and reduced overbank flooding will cause a net decrease in the EC to a C category.	2
Rip veg	A/B	B/C	Marginal zone will migrate, but will remain in similar condition, while the upper zone will also remain unchanged. The lower zone will have reduced woody cover and abundance. While the non-woody cover will remain as is, the species composition is likely to change from sedge dominated to grass dominated.	2
Fish	C	D	During summer this scenario will impact on the semi-rheophilic species with a requirement for flow during this period (for spawning, migration, etc.). It can therefore be expected that the FROC of ASCL, BAEN, BKIM and LCAP will be reduced under such conditions. The deterioration in water quality associated with the decreased flows may further influence species such as BKIM. Reduced moderate events will lead to decreased condition of substrates if the silt is not flushed from the sediment, and benthic algal growth increases. This will further impact on species such as ASCL, BAEN, LCAP and even LUMB.	2.5
Inverts	C	D	This scenario will have detrimental impacts on taxa that prefer high or moderate flows, such as Hydropsychidae, Tricorythidae and Elmidae. The riffle biotopes are likely to be most affected by this scenario, and some of the marginal vegetation. The lower flows are expected to aggravate the suspected water quality problems, so taxa sensitive to water quality are expected to be affected.	2

2.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results for setting EWR scenarios are summarised in Table 2.13.

Table 2.13 EWR 1: Summary of EcoClassification results

IHI			Driver Components	PES and REC Category	Trend	AEC↓1	AEC↓2
INSTREAM	C	RIPARIAN B	HYDROLOGY	C			
			WATER QUALITY	C	Stable	C	C
			GEOMORPHOLOGY	B/C	Negative	C	C
			Response Components	PES Category	Trend	AEC↓1	AEC↓2
			FISH	C (B)	Negative	D	D
			MACRO INVERTEBRATES	C (B)	Stable	C	D
			INSTREAM	C		C	D
			RIPARIAN VEGETATION	A/B	Stable	B/C	B/C
			ECOSTATUS	B/C (B)		C	C

IHI Hydro	Diatoms
E	C

Note: Applicable to all EcoClassification summary results:

- IHI hydrology is provided as it includes an ecological evaluation of the potential impact on habitat.
- Diatoms (as a biological response variable) are provided as it provides additional information on the water quality assessment in terms of current pollution levels and possible trends in physical chemical variables.
- Categories in red relates to a REC based on water quality improvements.

3 EWR 2: GROOTDRAAI (VAAL RIVER)

3.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 3.1.

Table 3.1 EWR 2: Summary of data availability

Component	Data availability	Conf
Hydrology	C1H019 is the nearest gauge. It has a 29 year flow record. Daily flow record was available.	4
Physico-chemical	C1H019Q01 Grootdraai Dam on Vaal River: Down stream weir 1979 – 2007 (*n* = 516).	4
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site and catchment was available. Ecological reports and specialist assessments for this study.	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Two site visits and fish sampling during September 2007 and December 2007. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006*)*: *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC data base.	3.5
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	3

3.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 3.2) was rated as **MODERATE** (present).

Table 3.2 EWR 2: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	*Labeobarbus kimberleyensis.*
Unique (endemic, isolated, etc.)	2	4	*Austroglanis sclateri*, *Labeo capensis.*
Intolerant (flow & flow related water quality)	2.5	4	*L. kimberleyensis*, *L. aeneus*, *L. capensis*, *A. sclateri*, Heptageniidae.
Species/taxon richness	3	4	10 fish species, 25 macroinvertebrate taxa.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2	4	Riffles, pools, marginal vegetation (growing instream), and flood bench.
Refugia	2	4	Pools.
Sensitivity to flow changes	1.5	3	
Sensitivity to flow related water quality changes	2	4	
Migration route/corridor (instream & riparian)	2	3	Yellowfish migration route within reach.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Importance of conservation & natural areas	1	3	Soweto Highveld Grassland (endangered status).
MEDIAN	2		
EIS EVALUATION	**MODERATE**		

3.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 3.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 3.3 EWR 2: Reference conditions

Component	Reference conditions	Conf
Hydrology	A 29 year gauge record was available from C1H019. Natural hydrology was determined at this site as part of the Vaal River System Analysis Update (VRSAU) study. Virgin MAR: 457.7 MCM.	4
Physico-chemical	Benchmark tables were used according to Kleynhans *et al.* (2005). Refer to Table 2.4.	3
Geomorphology	This reach would have had fewer cut banks, smaller bars and coarser bedload.	2
Riparian vegetation	Marginal zone Sedge dominated zone with minor herbaceous component. *S. mucronata* and *G. virgatum* could also form a minor woody component, but distribution is expected to be patchy, even in the reference condition. Lower zone Sedge dominated zone with minor herbaceous component. *S. mucronata* and *G. virgatum* could also form a minor woody component. Grasses (especially *M. junceous*) also expected to occur where lateral alluvia occur, especially along pools and lateral bars. Upper portion of lower zone is expected to be colonised by terrestrial grasses (adjacent to grassland biome). Upper zone Grass dominated (mainly terrestrial grasses).	3
Fish	Ten species present. Refer to Table 3.4.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967); Sites 3 and 5 (Chutter, 1967: Table 11). The reference SASS5 score is 183 and the ASPT is 6.5.	4

3.3.1 Fish

EWR 2 falls within the Lowland geomorphic zone and EcoRegion 11.03, NRU E, MRU C, and RAU C.1. Reference conditions as set for the NRHP site, C1Vaal-Braks (Kleynhans *et al.,* 2007), which is 42 km downstream of the site and falls within the same EcoRegion, NRU and MRU, was used as starting point for setting reference conditions for EWR 2. Based on the latest available information and professional judgement the following changes were made:

- The FROC of BANO and TSPA was reduced to 2. There is strong evidence (especially Scott *et al.,* 2006) that this species mainly occur in the tributaries of the Vaal River and very seldom in the main stem.
- BPAL was removed from the expected list. There is strong evidence (especially Scott *et al.,* 2006) that this species mainly occurs in the tributaries of the Vaal River.

Ten indigenous fish species are expected under reference conditions and are listed in Table 3.4.

Table 3.4 EWR 2: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 2 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	2	2
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	5	5
Barbus anoplus	Chubbyhead barb	BANO	2	1
Barbus paludinosus	Straightfin barb	BPAU	3	2
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	2	2
Clarias gariepinus	Sharptooth catfish	CGAR	3	3
Labeo capensis	Orange River labeo	LCAP	5	4
Labeo umbratus	Moggel	LUMB	3	2
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	3	2
Tilapia sparrmanii	Banded tilapia	TSPA	2	1

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

3.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Heptageniidae, Simuliidae, Potamonautidae, Coenagrionidae, Hydroptilidae, Hydracarina, Tipulidae, Ceratopogonidae, Sphaeriidae, Gyrinidae, Tricorythidae, Hydropsychidae >2 sp, Turbellaria, Ecnomidae, Elmidae/Dryopidae, Atyidae, Corixidae, Chironomidae, Oligochaeta, Caenidae, Leptophlebiidae, Gerridae, Notonectidae, Veliidae/M...veliidae, Dytiscidae/Noteridae, Porifera, Hirudinea, Baetidae >2 sp and Hydrophilidae.

3.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

3.4.1 Hydrology (D EC)

The EWR site is directly downstream from Grootdraai Dam and flow is dominated by releases from the dam, as well as natural spills. Compensation releases have to be made from the dam, based on the “normal” flow rule (i.e. the flow that occurs for 70% of the time upstream of the dam has to be released for downstream users). These releases are made for Standerton and downstream irrigation water use. This has resulted in decreased base flows especially during December – March (wet season). Moderate flood events have decreased and the seasonality of these events are most probably impacted as the first freshes are dependant on spills which depends on dam levels. Floods could therefore start later in the season than normal.

3.4.2 Geomorphology (D EC, 43%)

The site is located immediately below Grootdraai Dam with bedrock banks and the channel is incised. There are large paired bars composed of fines which are well vegetated which is unusual. This is due to the bottom releases (large suspended/fines load) from Grootdraai Dam and the

reduction of scouring moderate floods. No terraces are present. The site was a bedload system, but now upstream sediment supply is cut off due to Grootdraai Dam.

3.4.3 Physico chemical variables (B/C EC, 80%)

Two diatom samples were taken at this site (September and December 2007) and 2003 diatom data was also available (Taylor, 2004). Data records (1979 - 2007 (n = 516)) from water quality station C1H019Q01 were used for the physico chemical PES assessment.

The overall biological water quality EC is a C. The Leeuspruit and Blesbokspruit enter the Grootdraai Dam. The Leeuspruit has poor water quality with high levels of N and P (average 161 ug/l), which poses a threat to the long term trophic status of Grootdraai Dam. The nutrients are as a result of sewage plants in Bethal, Tukukani and New Denmark Colliery. The 2002 - 2003 monthly diatom monitoring data (Taylor, 2004) indicated that there was no drastic decline in water quality over the 12 month period and this was the only part of the Vaal that was classified as mesotrophic by Taylor (2004). It is assumed that the constant releases from Grootdraai Dam and the cleaner water from the Zaaihoek transfer were diluting water quality related impacts. The 2007 samples however indicate an increase in the presence of pollution tolerant diatoms and the water is classified as eutrophic. It is therefore evident that the biological water quality has deteriorated markedly from 2004 to present and that the buffer capacity of the Grootdraai Dam is impaired.

The impacts of the higher TDS and sulphate values in the Blesbokspruit are attributed to the coal mining in the Ermelo area. There are also high phosphate concentrations (average 303 ug/l) as well as fairly high nitrogen concentrations from sewage and agricultural runoff. The impacts of the Blesbokspruit and Leeuspruit are attenuated in the Grootdraai Dam due to mixing with good water quality runoff and water transferred from Zaaihoek Dam, although phosphate levels are sufficient to drive algal blooms in the dam. The Grootdraai Dam is of strategic importance as it supplies water to power stations as well as Sasol (Secunda). The outflows of the dams are for downstream farmers and for domestic water in Standerton. PES values for the physico-chemical variables are provided in Table 3.5 and in Volume 2 - Appendix C of this report.

Table 3.5 EWR 2: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	44.5
	Na_2SO_4	3.89
	$MgCl_2$	3.61
	$CaCl_2$	7.38
	NaCl	16.9
	$CaSO_4$	0.48
Nutrients (mg/L)	SRP	0.024
	TIN	0.135
Physical variables	pH (5^{th}+95^{th} percentiles)	7.14 – 8.38
Toxics	Fluoride (mg/L)	0.28
	Ammonia (mg/L)	0.083

3.4.4 Index of Habitat Integrity (IIHI: D EC, 53.8%, RIHI: C EC, 71%)

The IIHI is in a D category due to altered flow regimes from Grootdraai Dam. The presence of Grootdraai has also caused impoundment induced changes in water temperature and forms a barrier in the Vaal River system. The RIHI of C is due to decreased floods and altered flooding regimes from Grootdraai Dam.

3.4.5 Fish (C EC, 73%)

All the expected fish species is still present within this MRU. The FROC of BKIM and LCAP have been altered potentially as a result of flow modification/fluctuations and deteriorated substrate quality related to benthic algal growth at times. Water quality deterioration can also not be excluded as potential contribution as BKIM is moderately intolerant to water quality changes. The FROC of BANO, PPHI and TSPA have also been reduced, potentially related to the presence of the aggressive alien predator MSAL, although alterations in slow habitats due to flow modification from Grootdraai Dam, as well as potential loss of cover (vegetation as result of bank erosion and sedimentation of substrates) may also have contributed to the present condition.

3.4.6 Macroinvertebrates (C EC, 74.6%)

September 2007:	SASS5 score: 141	No of Taxa: 25	ASPT: 5.6
April 2008:	SASS5 score: 110	No of Taxa: 25	ASPT: 5.0

Macroinvertebrate taxa were typical of impoundment outlets, with plenty of zooplankton discharged from Grootdraai Dam, and dominated by filter feeders (e.g. Tricorythidae, *Plumatella*, *Simulium damnosum, S. adersi*). Taxa that were expected but missing or scarce were mainly taxa that prefer slow-flowing water in the vegetation (e.g. Naucoridae, Hydroptilidae, Gyrinidae and Ceratopogonidae), and the gravel-sand-mud (GSM) habitat (e.g. Gomphidae, Tipulidae, Sphaeriidae and Corbiculiidae). This suggests that the main driver of macroinvertebrate composition is the release of water from Grootdraai Dam. Absence of blackflies in September 2007 is significant, and presumably linked to the release of bottom water. Impoundment-induced changes in temperature are likely to have highly significant impact on seasonality, as reflected by a massive emergence of Tricorythidae in April 2008 that was not seen at other sites along the river at that time. Four species of Hydropsychidae and the presence of Heptageniidae mayflies indicate that water quality is not a major problem.

3.4.7 Riparian vegetation (B/C EC, 81%)

The site occurs within the Soweto Highveld Grassland vegetation type, which has an endangered conservation status with 52.7% of the type remaining and only 0.2% protected. The channel morphology appears modified or landscaped.

Marginal zone: Dominated by non-woody component (sedges) due to altered flow regime and increased fine alluvia.

Vegetation removal and mowing occurs in the upper and lower zone and has led to a decrease in non-woody cover.

3.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 3.6.

Table 3.6 EWR 2: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	D	4	Decreased base flows.	Grootdraai Dam.	F	4
			Decrease in frequency of floods.			
Physico-chem	B/C	1.5	Temperature fluctuations.	Grootdraai Dam.	F	1.5
			High levels of N and P.	Sewage plants in Bethal, Tukukani, New Denmark Colliery and agriculture.	NF	
			Elevated TDS and sulphates.	Coal mining.		
Geom	D	3.5	Reduced sediment transport capacity due to decreased flood frequency and near constant baseflow.	Grootdraai Dam.	F	3.3
			Reduced sediment supply.	Coarse sediment is trapped in Grootdraai Dam which is immediately upstream. Some replenishment of fines through bottom releases from the dam.	NF	
Rip veg	B/C	3.7	Increased non-woody (sedge) cover in marginal zone.	Grootdraai Dam.	F	3.5
			Reduced non-woody cover in lower and upper zones.	Vegetation removal, mowing.	NF	
Fish	C	4	Altered habitat diversity (fluctuation from natural composition) as a result of flow modification.	Flow modification by Grootdraai Dam, other sources of abstraction upstream of dam and water transfer schemes.	F	3.5
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming activities.	NF	
			Increased sedimentation resulting in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and dryland crops.		
			Decreased substrate quality related to increased benthic growth.	Increased nutrients from point and diffuse sources.		
			Decreased water quality affect species with requirement for high water quality.	Bottom release from Grootdraai dam.		
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL).	Presence of aggressive alien predatory species (MSAL) naturally spreading and for recreation/angling.		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Grootdraai Dam and other major downstream dams as well as various weirs. Also farm dams in tributaries reduce refuge areas.		
Inverts	C	3	Changed flow regime.	Grootdraai Dam.	F	3
			Temperature changes.			
			Release of bottom water.			

3.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 3.7.

Table 3.7 EWR 2: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	B/C	Negative	C	5 years	Water quality of the inflowing streams is deteriorating impacting the water quality of Grootdraai Dam and hence the water quality could be under pressure.	3
Geom	D	Stable	D		Site and reach has adjusted to the highly elevated base flows.	2.5
Rip veg	B/C	Stable	B/C		Marginal and lower zone vegetation have already responded to flow changes. Some aggressive exotics present but unlikely to increase as numbers are too few.	3
Fish	C	Stable	C		Fish in this section have adapted to the conditions in this reach as a result of the flow modification and fluctuations as a result of the Grootdraai Dam releases, which have been present for a long period (since 1981).	3
Inverts	C	Stable	C		The macroinvertebrates have already adapted to the changes in the system.	3

3.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 3.8. The Instream EC is a C (72%).

Table 3.8 EWR 2: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**73.1**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	100		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	80		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	3	40		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**10**	220	**71.1**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		550	**71.9**	**C**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	4	0.57	41.77	
Confidence rating for macroinvertebrate information	3	0.43	30.47	
	7	1	72.24	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 3.9). The EcoStatus EC is a B/C (80%).

Table 3.9 EWR 2: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	81.1	B/C	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	3.57143	0.49	35.48
Confidence rating for riparian vegetation zone information	3.7	0.51	41.27
	7.27143	1	76.75
ECOSTATUS	EC		C

3.7 REC: C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 2 is **MODERATE** and the REC is therefore to maintain the PES. However it must be noted that the rare and endangered *L. kimberleyensis* is present which warrants an improvement in the fish EC.

3.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

Two alternative scenarios were designed based on the implementation of different hydrological regimes and are discussed below.

3.8.1 AEC up: B

This ecological scenario is important due to the presence of *L. kimberleyensis*. The hypothetical scenario includes the following:

- Change in the operation of Grootdraai dam, which includes the release of flows (base flows) with more natural seasonal patterns and the release of moderate floods to remove fines.
- No bottom releases.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 3.10.

Table 3.10 EWR 2: B AEC

	PES	AEC	Comments	Conf
Physico-chem	B/C	B	Water quality improvements include greater dissolved oxygen, and temperatures that are closer to natural. Increased releases could however also have a detrimental impact as the buffering capacity of Grootdraai Dam could be reduced and the poorer water quality from the Blesbokspruit and Leeuspruit could impact this site.	4
Geom	D	Upper D	With the release of more moderate floods there will be a slight improvement in the sediment transport capacity, but this change will occur within the current EC.	2.5
Rip veg	B/C	B	The scenario will result in reduced sedge cover in the marginal and lower zones, with some open space. The upper zone will remain unchanged.	2
Fish	C	B	Under this scenario the FROC of some fish species will be improved. This more natural flow, together with flushing of fine sediment will result in overall improved substrate quality. This should lead to improved FROC of species such as BKIM and LCAP. The availability of more natural slow habitats may improve the FROC of species such as BANO and TSPA, although their FROC is currently mostly as a result of the presence of the predatory MSAL, and the only real improvement is likely to be associated with the removal/control of this species.	2.5
Inverts	C	B/C	The scenario is likely to have a significant impact on invertebrate composition, particularly for taxa in the marginal vegetation and sediments. Taxa that are expected to benefit the greatest from these changes are Corbiculidae, Sphaeriidae, Ancylidae and Heptageniidae.	3

3.8.2 AEC down: C/D

A hypothetical scenario includes the following:

- Less spilling (i.e. less floods) and decreased base flows.
- Increased bottom releases.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 3.11.

Table 3.11 EWR 2: C/D AEC

	PES	AEC	Comments	Conf
Physico-chem	B/C	B/C	Water quality deterioration due to increased temperature and lower dissolved oxygen due to bottom releases from the dam.	4
Geom	D	D/E	More fines are expected, as well as increased embeddedness. Vegetation encroachment will occur as well as more marginal sedges.	2.5
Rip veg	B/C	C	This will result in increased sedge and *Gomphostigma* cover in the marginal and lower zones and a changed species composition in the lower zone (more grasses encroaching on the zone).	2
Fish	C	D	Decreased base flows and deterioration of substrates may result in an alteration of FROC of species with a preference for fast habitats and substrate (BAEN, ASCL, BKIM, LCAP, and LUMB). Deteriorated water quality may further reduce the FROC of species such as BKIM.	2.5
Inverts	C	C/D	This scenario is likely to affect the macroinvertebrate fauna by reducing the suitability of the stones-in-current (SIC) and vegetation biotopes. Taxa that are expected to be most affected are Heptageniidae, Elmidae and Hydropsychidae.	3

3.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 3.12.

Table 3.12 EWR 2: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	Trend	AEC↑	AEC↓
INSTREAM	D	RIPARIAN	C	HYDROLOGY	D			
				WATER QUALITY	B/C	Negative	B	B/C
				GEOMORPHOLOGY	D	Stable	D	D/E
				Response Components	PES Category	Trend	AEC↑	AEC↓
				FISH	C	Stable	B	D
				MACRO INVERTEBRATES	C	Stable	B/C	C/D
				INSTREAM	C		B/C	C/D
				RIPARIAN VEGETATION	B/C	Stable	B	C
				ECOSTATUS	C		B	C/D

IHI Hydro	Diatoms
E	C

4 EWR 3: GLADDEDRIFT (VAAL RIVER)

4.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 4.1.

Table 4.1 EWR 3: Summary of data availability

Component	Data availability	Conf
Hydrology	C1H012 is the nearest gauge. It has a 23 year flow record. Low flows and zero flows are measured accurately by this gauge. Daily flow record was available.	4
Physico-chemical	Good data with 979 data points was available from 1984 to 2008 from C1H017Q01 Villiers 492 at flood section on Vaal River although measuring station is below the EWR site. The water quality data that has been used for EWR 3 is downstream of EWR 3 and the Waterval confluence and therefore not representative of the site.	1.5
Geomorphology	Historical aerial photographs from Land Surveyors Offices Google Earth imagery of the site and catchment Information from the field assessment	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used:0 Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Two site visits and fish sampling during September 2007 and December 2007. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC data base.	3.5
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	3

4.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 4.2) was rated as **MODERATE** (present).

Table 4.2 EWR3: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	*Labeobarbus kimberleyensis.*
Unique (endemic, isolated, etc.)	2	4	*Austroglanis sclateri*, *Labeo capensis.*
Intolerant (flow & flow related water quality)	2.5	3	*L. kimberleyensis*, *L. aeneus*, *L. capensis*, *A. sclateri.*
Species/taxon richness	3	4	20 Macroinvertebrate taxa, 10 fish species.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2	4	Islands, rapids, riffles, pools, bedrock dominated, large river in SA.
Refugia	1	3	Pools.
Sensitivity to flow changes	1	3	
Sensitivity to flow related water quality	2	3	

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
changes			
Migration route/corridor (instream & riparian)	3	4	Yellowfish migration route.
Importance of conservation & natural areas	1	4	
MEDIAN	2		
EIS EVALUATION	**MODERATE**		

4.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 4.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 4.3 EWR 3: Reference conditions

Component	Reference conditions	Conf
Hydrology	A 23 year gauge record was available from C1H012. Natural hydrology was scaled to EWR site which may have cause a reduction in accuracy. Virgin MAR: 858.1 MCM	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al. (2005)*. Refer to Table 2.4.	3
Geomorphology	The single thread sinuous channel with fewer cut banks, fewer and smaller islands in the reach. Bed material is coarser with a smaller fine component.	2
Riparian vegetation	Marginal zone Dominated by non-woody vegetation (sedges and *Persecaria* sp) with small woody component (*S. mucronata* and *G. virgatum*). Lower zone Dominated by non-woody vegetation (sedges and *Persecaria* sp) with small woody component (*S. mucronata* and *G. virgatum*). Upper zone Typical Highveld grassland with almost no woody vegetation, dominated by terrestrial grasses.	4
Fish	Ten species present. Refer to Table 3.5.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 5A and 6 (Chutter, 1967: Table 11). The reference SASS5 score is 172 and the ASPT is 5.9.	4

4.3.1 Fish

EWR 3 falls within the Lowland geomorphic zone and EcoRegion 11.03, NRU E, MRU C and WQSU 8. The reach considered stretched from the Klip River confluence to end of EcoRegion 11.03 (end of NRU E/MRU D). Reference conditions set for site NRHP site C1Vaal-Villi (Kleynhans *et al.,* 2007), 36 km downstream of the site, falls within this reach, and used as basis for setting reference conditions. Based on the latest available information and professional judgement the following changes were made:

- The FROC of BAEN and LCAP was increased to 5 as these species were present at all sampling points at the site for each survey, and is expected to be the most widespread and common species in this reach.
- The FROC of BANO and TSPA was reduced to 2. There is strong evidence (especially Scott *et al.,* 2006) that this species mainly occur in the tributaries and are very seldom in the Vaal River main stem.
- The FROC for LUMB was reduced to 2 as this species is often not sampled (although it may be present) as a result of its preference for SD habitats.

Table 4.4 EWR 3: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 3 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	3	2
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	5	5
Barbus anoplus	Chubbyhead barb	BANO	2	2
Barbus paludinosus	Straightfin barb	BPAU	3	2
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	2	2
Clarias gariepinus	Sharptooth catfish	CGAR	3	3
Labeo capensis	Orange River labeo	LCAP	5	5
Labeo umbratus	Moggel	LUMB	2	1
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	3	3
Tilapia sparrmanni	Banded tilapia	TSPA	2	1

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

4.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Hydropsychidae > 2 sp, Heptageniidae, Baetidae > 2 sp, Tricorythidae, Ecnomidae, Elmidae/Dryopidae, Atyidae, Leptophlebiidae, Hydracarina, Simuliidae, Coenagrionidae, Hydroptilidae, Tipulidae, Caenidae, Gerridae, Veliidae/M...veliidae, Dytiscidae/Noteridae, Gyrinidae, Ceratopogonidae, Porifera, Hydrophilidae, Turbellaria, Potamonautidae, Corixidae, Chironomidae, Sphaeriidae, Oligochaeta, Notonectidae and Hirudinea.

4.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

4.4.1 Hydrology (C EC)

Flows are influenced by the upstream Grootdraai Dam since 1980 and gradual increase in irrigation on the Klip River. Grootdraai Dam releases are only made for Standerton and farmers situated mostly upstream from this site. Water from the Klip River is used for irrigation and there are quite a large number of farm dams which support the irrigation. There has been a decrease in the volume of base flows during wet and dry season and moderate floods have decreased due to Grootdraai Dam.

4.4.2 Geomorphology (C EC, 62.8%)

The site consists of bedrock and riffles. The bed is predominantly (>70%) bedrock, but cobbles/boulders are present in the main riffle and fines/mobile sediment are found in the lee and hollows of the bedrock bed. The cobbles in the main riffle have a median around 40 cm, but this is not representative of the reach which generally has a finer sediment load. There are no morphological cues and the banks are cut and steep. The upper level of the main channel bank is composed of quaternary sedimentary deposits which is highly dispersive. There is decreased

transport capacity due to the altered flow regime, although the impact is less here than at EWR 2 due to the tributaries influence that ameliorate this impact. Sediment input is limited to a few tributaries, many of which are eroding and increasing the fines load causing an increase in islands at this site.

4.4.3 Physico chemical variables (C EC, 70%)

Three diatom samples were taken at this site (September, December 2007 and April 2008) and 2003 diatom data was also available (Taylor, 2004), although only the September 2007 sample was viable as the flows during the other sampling effort was very high, and diatom counts were too low to provide results. Data records (1984 - 2008 (n = 979)) from water quality station C1H017Q01 were used for the physico-chemical PES assessment. The water quality data that has been used for EWR 3 is downstream of EWR 3 and the Waterval confluence.

The overall biological water quality EC is a C. The SPI score of the September 2007 sample was 14.4 indicating good water quality although the diatom community indicates the onset of severe water quality impacts with the presence of dominant species (*Nitzschia frustulum, Navicula reichardtiana* and *N. palea*) which tolerate very high to critical levels of pollution (Taylor *et al.*, 2007b). The 2002 - 2003 monthly monitoring data (Taylor, 2004) indicated that there were sharp declines in biological water quality during the months February, March, May and August (deterioration to a C/D and D EC) and the SPI scores indicate an increase in nutrient load, ionic concentrations and organic pollution. This is most likely due to increased agricultural activities and increased abstraction during this period as well as mines upstream of the site as well as Waste Water Treatment Works (WWTW) in Standerton. Salinity, nutrients and organic pollution are increasing and are variables of concern.

It is important to note that EWR 3 is upstream of the impacts of the Waterval River. The Waterval catchment is impacted by effluents from Sasol 2 and 3, Evander Goldmine, Evander and Secunda. Phosphate values relatively low although the total phosphate (TP) values are high. Nitrogen concentrations are low and electrical conductivity and sulphates do not seem problematic. PES values for the physico-chemical variables are provided in Table 4.5 and in Volume 2 - Appendix C of this report.

Table 4.5 EWR 3: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	55.5
	Na_2SO_4	10.9
	$MgCl_2$	7.36
	$CaCl_2$	16.9
	NaCl	35.8
	$CaSO_4$	0.56
Nutrients (mg/L)	SRP	0.035
	TIN	0.158
Physical variables	pH (5^{th}+95^{th} percentiles)	7.1 – 8.59
Toxics	Fluoride (mg/L)	0.43
	Ammonia (mg/L)	0.14

4.4.4 Index of Habitat Integrity (IIHI: C EC, 65%; RIHI: C EC, 72.7%)

The IIHI is a C mostly due to changes in the flow regime due to the presence of Grootdraai Dam and the current operation of the dam. Deteriorating water quality is also impacting on the instream habitat which is due to Grootdraai Dam as well as upstream anthropogenic activities (i.e. agriculture, mining and WWTW). The bank structure has altered due to agriculture, the presence of willow trees and erosion and the upstream dams and weirs are barriers in this system. The RIHI condition is due to substrate exposure and erosion as a result of farming activities in the vicinity and the presence of exotic species.

4.4.5 Fish (C EC, 76.7%)

All the expected fish species is still present within this RU although the FROC of some species have been reduced from reference conditions. Increased siltation and flow modification have resulted in altered habitat conditions which include deteriorated substrate condition and the loss of fast shallow (FS) and SD habitats causing a reduced occurrence of ASCL, BKIM and LUMB. Bank erosion and sedimentation of substrates has caused a loss in cover for TSPA as well as the presence of the alien predator *Micropterus salmoides*.

4.4.6 Macroinvertebrates (C EC, 66.7%)

September 2007:	SASS5 score: 103	No of Taxa: 20	ASPT: 5.2
April 2008:	SASS5 score: 120	No of Taxa: 20	ASPT: 6.0

The macroinvertebrates present during low flow conditions in September 2007 were dominated by low-scoring taxa, such as Turbellaria and Chironomidae. The highest scoring taxon was Leptophlebiidae, and the ASPT was low (5.2). In April 2008 the flows were higher, and the ASPT increased to 6.0. The fauna was dominated by baetid mayflies (mainly *Baetis glaucus*) and the pest blackfly, *Simulium damnosum.* Taxa that were notably absent included those with a presence for SIC (Heptageniidae, Elmidae) and marginal vegetation (MV) (Atyidae, Hydracarina, Gerridae, Notonectidae and Dytiscidae).

4.4.7 Riparian vegetation (C EC, 73.6%)

The riparian zone occurs within Frankfort Highveld Grassland which has a conservation status of "Vulnerable" (although 65.8% of vegetation type remains). The riparian vegetation composition is close to reference, with some exotic vegetation and bank slumping occurring from the upstream bridge and cattle trampling. Vegetation is impacted by extensive livestock trampling, erosion due to the bridge and debris control. There is extensive harvesting of sedges for crafts.

4.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 4.6.

Table 4.6 EWR 3: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	C	4	Flow modification. Decrease in frequency of floods.	Grootdraai Dam, illegal irrigations, farm dams.	F	3

	PES	Conf	Causes	Sources	F/NF	Conf
Physico-chem	C	2.3	Increased TP, some salinity and nutrients.	Agricultural runoff and as a result increased nutrients from point and diffuse sources (e.g. agriculture, Standerton WWTW, industrial and residential runoff).	NF	3
Geom	C	3.5	Decreased transport capacity as there is almost no floods.	Grootdraai Dam.	F	3.2
			Decreased sediment supply.			
			Morphological change: increased islands.	Due to increased fines load and decreased floods.	NF	
Rip veg	C	3.6	Removal of vegetation.	Extensive trampling by livestock and erosion; small scale from cattle and large scale from bridge and debris control. Also extensive harvesting of sedges for crafts.	NF	5
Fish	C	4	Altered habitat diversity (fluctuation from natural composition) as a result of flow modification.	Grootdraai Dam, water transfer scheme upstream of Grootraai Dam, other sources of abstraction.	F	3
			Decreased overhanging vegetation as cover for fish due to bank erosion.	Agricultural and livestock farming activities.	NF	
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.)	Bank erosion and vegetation removal and dryland crops and grazing.		
			Decreased substrate quality related to increased benthic growth.	Increased nutrients from point and diffuse sources (e.g. agriculture, Standerton WWTW, industrial and residential runoff).		
			Decreased water quality affect species with requirement for high water quality.			
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL) and GAFF.	Presence of aggressive alien predatory species (MSAL) naturally spreading for recreation/angling.		
			Increased turbidity.	Erosion and presence of bottom feeding alien CCAR.		
			Loss of aquatic vegetation (AV) and MV as cover for fish.	Potential presence of herbivorous alien CIDE (grass carp).		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Grootdraai Dam upstream and Vaal Dam downstream, as well as other major dams and various weirs. Farm dams in tributaries reduce refuge areas.		
Inverts	C	3	Reduced baseflows.	Grootdraai Dam.	F	2
			Water quality (nutrients).	Agricultural runoff.	NF	

4.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 4.7.

Table 4.7 EWR 3: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	C	Stable	C		Most variables indicate a stable trend although an increase is detected in P levels.	3
Geom	C	Stable	C		Site and reach has adjusted to the adjusted flood flows.	2.5

	PES	Trend	Trend PES	Time	Reasons	Conf
Rip veg	C	Stable	C		The main causes for the current EC are grazing/trampling and harvesting of vegetation. Left as is, this is not likely to be a trajectory of change in the EC.	3.5
Fish	C	Stable	C		Fish in this section have adapted to the conditions in this reach as a result of the flow modification and sedimentation which have been present for a long period.	3
Inverts	C	Stable	C		The macroinvertebrates have already adapted to the changes in the system.	3

4.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 4.8. The Instream EC is a C (72%).

Table 4.8 EWR 3: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**76.7**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	75		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	100		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	2	60		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**9**	235	**66.7**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		565	**71.0**	**C**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	4	0.57	43.83	
Confidence rating for macroinvertebrate information	3	0.43	28.59	
	7	1.00	72.41	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 4.9). The EcoStatus EC is a C (73%).

Table 4.9 EWR 3: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	73.6	C	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	3.57	0.50	36.06
Confidence rating for riparian vegetation zone information	3.6	0.50	36.95
	7.17	1.00	73.01
ECOSTATUS	EC		C

4.7 REC: C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 3 is **MODERATE** and the REC is therefore to maintain the PES. However it must be noted that the rare and endangered *L. kimberleyensis* is present which warrants an improvement in the fish EC.

4.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

Two alternative scenarios were designed and are discussed below.

4.8.1 AEC up: B

A hypothetical scenario includes the following:

- Improved base flows (no zero flows), and increased frequency of moderate floods.
- Improved water quality due to improved flow regime.
- Removal of cattle grazing in the marginal zone.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 4.10.

Table 4.10 EWR 3: B AEC

	PES	AEC	Comments	Conf
Physico -chem	C	B/C	This scenario will improve temperatures closer to natural, and reduce the nutrients and salts. The turbidity will not be reduced.	4

	PES	AEC	Comments	Conf
Geom	C	Upper C	Increased frequency of moderate floods will scour the bed of the channel; flush out the fines and keep the bar/island growth in check. An improvement within the EC is expected.	2.5
Rip veg	C	B/C	Under this scenario a B/C was achievable as the marginal zone will improve due to increased sedge presence. A slight reduction in grazing and trampling pressure would achieve a B EC.	2
Fish	C	B	Improved moderate flood should improve the substrate quality (flushing of sediment and algae), which should have a positive impact on species such as ASCL, BKIM and LUMB. Closer to natural base flows, especially during the winter (low flow months) will furthermore improve habitat conditions for various species (especially semi-rheophilic species) such as BAEN, BKIM, and LCAP. Improved condition of aquatic and marginal vegetation and decreased grazing pressure, will also improve conditions for species such as TSPA and other small tilapia and barbs.	2.5
Inverts	C	B/C	Increased baseflows is likely to provide improved SIC, marginal vegetation in current (MVIC) and marginal vegetation out of current (MVOC). Taxa that are expected to be present are Heptageniidae, Elmidae, Atyidae, Hydracarina, Gerridae, Notonectidae and Dytiscidae.	2

4.8.2 AEC down: C/D

A hypothetical scenario includes the following:

- Increased duration of zero flow periods.
- Decreased frequency of floods.
- Very low base flows in the dry season when flowing.
- Associated water quality deterioration.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 4.11.

Table 4.11 EWR 3: C/D AEC

	PES	AEC	Comments	Conf
Physico -chem	C	D	This scenario will increase nutrient loading, salts, temperature and there will be possible impacts of toxics such as ammonia. The dissolved oxygen will be reduced as well as the turbidity.	4
Geom	C	D	Decreased frequency of moderate floods will allow for more fines accumulation, possibly more embeddedness and further expansion of the bars/islands composed of fines. Decreased connectivity will occur.	2.5
Rip veg	C	Lower C	Marginal zone is already dry at base flow, and the vegetation is likely to dry out further with further reduced base flows. Cover in the lower zone would be reduced with reduced base flows due to increased water stress (especially during dry season) and facilitate an influx of grasses.	2
Fish	C	D	This scenario will result in loss of fast habitats and especially decreased substrate quality (increased siltation and benthic algal growth), that will negatively affect species such as ASCL, BAEN, BKIM and LCAP. A further reduction in the already low abundance of vegetation as cover for fish will occur, and affect species with a preference for this cover type (BANO, BPAU, and PPHI).	2.5
Inverts	C	B/C	This scenario is likely to be detrimental to all taxa that need flow, e.g. Tricorythidae, Simuliidae and Hydropsychidae. Reduced flows are likely to cause deterioration in water quality, and this is likely to be detrimental to sensitive taxa, such as the number of Baetidae, Hydraenidae and Leptophlebiidae. The total SASS score is predicted to drop to 68 and ASPT to 5.0.	3

4.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results for setting EWR scenarios are summarised in Table 4.12.

Table 4.12 EWR 3: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	Trend	AEC↑	AEC↓	IHI Hydro	Diatoms
INSTREAM	C	RIPARIAN	C	HYDROLOGY	C				C	C
				WATER QUALITY	C	Stable	B/C	D		
				GEOMORPHOLOGY	C	Stable	C	D		
				Response Components	PES Category	Trend	AEC↑	AEC↓		
				FISH	C	Stable	B	D		
				MACRO INVERTEBRATES	C	Stable	B/C	D		
				INSTREAM	C		B	D		
				RIPARIAN VEGETATION	C	Stable	B	C		
				ECOSTATUS	C		B	C/D		

5 EWR 4: DE NEYS (VAAL RIVER)

5.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 4.1.

Table 5.1 EWR 4: Summary of data availability

Component	Data availability	Conf
Hydrology	C2H122 is the nearest gauge. It has a 26 year flow record. Low flows and zero flows are measured accurately by this gauge. The observed station is a very good station which reflects the actual releases from Vaal Dam since 1980. Daily data was available.	4
Physico-chemical	Data from C2H122Q01 was available as well as Rand water data: Engelbrecht's drift for 2003 – 2005 (n = 225).	4
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site and catchment was available. Ecological reports and specialist assessments for this study.	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Two site visits and fish sampling during September 2007 and December 2007. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database.	4
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): Hydro biological Studies of the Vaal River. Chutter (1963): Hydro biological studies on the Vaal River in the Vereeniging Area.	3

5.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 5.2) was rated as **HIGH** (present), due to mainly:

- The presence of the rare and endangered *Labeobarbus kimberleyensis*.
- The Vaal River being a relatively large river in South Africa which is scarce.
- The diversity of riparian and instream habitats which include runs, rocky outcrops and rapids as well as pools.
- Important refugia such as pools.
- Being the only area between the Vaal Dam and barrage where yellowfish can breed.

Table 5.2 EWR 4: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	*Labeobarbus kimberleyensis.*
Unique (endemic, isolated, etc.)	2	4	*Austroglanis sclateri*, *Labeo capensis* and *Leucosidea sericea* (Ouhout).
Intolerant (flow & flow related water quality)	2.5	4	*L. kimberleyensis*, *L. aeneus*, *L. capensis*, *A. sclateri.*
Species/taxon richness	3	3	20 Macroinvertebrate taxa, 10 fish species.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	3.5	3	Pools, runs rocky outcrops rapids, and size of river (rare in SA).
Refugia	3	4	Only area between Dam and barrage where yellowfish can breed.
Sensitivity to flow changes	1	4	Large river.
Sensitivity to flow related water quality changes	2	3	Because it is managed, water quality changes are reasonably stable.
Migration route/corridor (instream & riparian)	1.5	3	Yellowfish moving upstream and Labios.
Importance of conservation & natural areas	1	3	Importance of area for yellowfish conservation.
MEDIAN	2.25		
EIS EVALUATION	**HIGH**		

5.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 5.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 5.3 EWR 4: Reference conditions

Component	Reference conditions	Conf
Hydrology	A 26 year gauge record was available from C2H122. Natural hydrology was simulated at this point as part of the VRSAU study. Virgin MAR: 1977.26 MCM	4
Physico-chemical	Vaal Dam built in 1938 and Vaal Barrage in 1914. There would have been lower phosphate contamination due to less agricultural runoff into the Vaal Dam. Relatively low nitrogen concentrations and low salts (electrical conductivity and sulphates) would have been present. Low Faecal coliforms counts and limited algal blooms. No Lesotho Highlands water and water from other transfers would have been present.	3
Geomorphology	The reach would have finer bed material, more extensive riparian areas and probably fewer, smaller islands.	2
Riparian vegetation	Marginal zone Dominated by non-woody vegetation (sedges and *Persecaria* sp) with small woody component (*S. mucronata* and *G. virgatum*). Lower zone Dominated by non-woody vegetation (sedges and *Persecaria* sp) with small woody component (*S. mucronata* and *G. virgatum*). Upper zone Typical Highveld grassland with almost no woody vegetation, dominated by terrestrial grasses.	3
Fish	Ten species present. Refer to Table 5.5.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 5A and 6 (Chutter, 1967: Table 11), and Site 1 (Chutter, 1963). The reference SASS5 score is 182 and the ASPT is 6.1.	4

5.3.1 Fish

EWR 4 falls within the Lower foothills geomorphic zone and EcoRegion 11.03, NRU G, MRU D and WQSU 18. The reach considered for the application of the FRAI stretched from the Vaal Dam outflow to the Lethabo weir (equates to WQSU 18 and approximately the Lower foothill geomorphic zone of MRU D). Reference conditions, as set for NHRP site C2Vaal-Deney (Kleynhans *et al.,* 2007), was used as basis and based on the latest available information and professional judgement the following changes were made (Table 5.4):

- The FROC of BANO was reduced to 2. There is strong evidence (especially Scott *et al.,* 2006) that this species mainly occur in tributaries and very seldom in the Vaal River main stem with decreasing probability of occurring downstream within the main stem.

Table 5.4 EWR 4: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 4 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	3	2
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	4	3
Barbus anoplus	Chubbyhead barb	BANO	2	1
Barbus paludinosus	Straightfin barb	BPAU	3	1
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	3	3
Clarias gariepinus	Sharptooth catfish	CGAR	3	3
Labeo capensis	Orange River labeo	LCAP	4	3
Labeo umbratus	Moggel	LUMB	3	2
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	3	3
Tilapia sparrmanii	Banded tilapia	TSPA	3	2

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

5.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Atyidae, Porifera, Turbellaria, Oligochaeta, Hirudinea, Potamonautidae, Hydracarina, Baetidae > 2 sp, Caenidae, Heptageniidae, Leptophlebiidae, Polymitarcyidae, Tricorythidae, Coenagrionidae, Corixidae, Gerridae, Notonectidae, Veliidae/M...veliidae, Ecnomidae, Hydropsychidae > 2 sp, Hydroptilidae, Dytiscidae/Noteridae, Elmidae/Dryopidae, Gyrinidae, Hydrophilidae, Ceratopogonidae, Simuliidae, Tipulidae, and Sphaeriidae.

5.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

5.4.1 Hydrology (D/E EC)

Present day flows reflect required releases from the Vaal Dam to maintain a target TDS concentration of 600 mg/l downstream of Vaal Barrage. Releases are also made for Sasol's Sasolburg Complex and Eskom. Under severe drought conditions releases are also made in support of downstream users (e.g. Midvaal and Sedibeng Water) and Bloemhof Dam. In recent

analysis, large discrepancies were identified in actual releases made from the dam for dilution purposes. Flows have increased significantly (more than natural) in the dry season with continuous releases. During the wet period (December – January), flows are significantly less compared to natural with a resulting seasonal reversal. The frequency in floods has also decreased due to dam releases.

5.4.2 Geomorphology (D EC, 50.7%)

The multi-thread straight channel is within a bedrock anastomosing section below the Vaal Dam. The channel is dominated by bedrock with cobbles and consists of morphological units that include rapids, riffles, bedrock runs, shallow pools, vegetated islands and secondary channels. Sediment supply is reduced as well as coarsening of the bed material, which is essentially absent due to critically reduced moderate and large floods. Moderate and large floods have been critically reduced. The banks are disturbed by farming and housing.

5.4.3 Physico chemical variables (C EC, 66.4%)

Three diatom samples were taken at this site (August 2007, January and April 2008) and 2003 diatom data was also available (Taylor, 2004). Data records from water quality station C2H122Q01 and Rand Water data from CV2: Engelbrecht's Drift (2003 – 2005; n = 225) were used for the physico-chemical PES assessment.

The overall biological water quality EC is a C. The SPI score of the August 2007 sample was 6.5 indicating poor water quality. Of the 16 species present, 11 species (e.g. *Mayamaea atomus var. permitis*, *Navicula veneta, Nitzschia palea and Amphora pendiculus*) are tolerant to critical levels of pollution and their presence indicate very high pollution which may be due to a source point pollution at the site or mixed releases from the Vaal Dam. The 2002 - 2003 monthly monitoring data (Taylor, 2004) indicated moderate water quality (C category). No drastic decline in water quality was observed during the 12-month monitoring period which is most probably due to the required releases from the Vaal Dam to maintain a target TDS concentration of 600 mg/l downstream of Vaal Barrage. Both 2008 samples are similar to the 2002 – 2003 data although slightly deteriorated. Salinity and organic pollution has increased from 2002 and is problematic at this site along with nutrient input. It is evident that pollution levels in the Vaal Dam are increasing and may be more polluted than is generally thought.

The data indicates that there is phosphate contamination due to agricultural runoff into the Vaal Dam. Nitrogen concentrations, salts and faecal coliforms are low at this site. The water temperature is increased due to the dam releases while oxygen levels are high. Turbidity is highly variable due to runoff and natural soils but generally low due to settling in the dam. Chl-a is seasonally high due to algal blooms in the Vaal Dam. The PES values for the physico-chemical variables are provided in Table 5.5 and in Volume 2 - Appendix C of this report.

Table 5.5 EWR 4: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	34.2
	Na_2SO_4	4.84
	$MgCl_2$	2.72
	$CaCl_2$	8.08
	NaCl	16.2
	$CaSO_4$	0.73
Nutrients (mg/L)	SRP	18 (14 - 200)
	TIN	0.034
Physical variables	pH (5^{th}+95^{th} percentiles)	0.299
	Temperature	22 (17 - 26)
	Turbidity (NTU)	1.4 (67 - 165)
Toxics	Fluoride (mg/L)	0.32
	Ammonia (mg/L)	0.102

5.4.4 Index of Habitat Integrity (IIHI: D EC, 48%; RIHI: D EC, 55%)

The IIHI is a D mostly due to the presence of the Vaal Dam. Changes in the flow regime, along with water quality changes (including water temperature and the Vaal Dam water quality), are impacting on this site. The dam is also a barrier in the system. Changes in the flow regime is also impacting on the condition of the riparian integrity along with substrate exposure, erosion and alien vegetation due to recreational activities and housing next to the river.

5.4.5 Fish (C EC, 66.7%)

All the expected fish species is still present within this RU although the FROC of some species have been reduced from reference conditions. The FROC of ASCL have been reduced from reference conditions, probably related to deteriorated substrates condition (increased siltation) as well as decreased flows (loss of FS habitats) and fluctuations. The FROC of BKIM, BAEN and LCAP has been altered potentially as a result of flow modification (decreased flow and therefore fast habitat) deteriorated substrate quality related to benthic algal growth and siltation as well as potential water quality deterioration. FROC of LUMB has also been reduced, potentially related to loss of SD habitats (siltation and decreased flows). The FROC of BANO and TSPA have also been reduced potentially related to the presence of the aggressive alien predator MSAL, although alterations in slow habitats as a result of flow modification as well as potential loss of cover (vegetation as result of bank erosion and sedimentation of substrates) may also have contributed to the scenario.

5.4.6 Macroinvertebrates (C/D EC, 61.7%)

August 2007:	SASS5 score: 131	No of Taxa: 20	ASPT: 6.6
April 2008:	SASS5 score: 120	No of Taxa: 18	ASPT: 6.7

Taxa expected but not present are mainly taxa that prefer standing water (Gerridae; Notonectidae; Veliidae; Dytiscidae; Oligochaeta). These are mainly low-scoring SASS taxa, which explain why the present ASPT is significantly higher than expected. The scarcity of taxa that prefer standing water is related to high base flows. The SASS scores are high in relation to the quality of habitats, and this supports the Macroinvertebrate Response Assessment Index (MIRAI) results. The reduced seasonal variation in water temperature is likely to have changed significantly from reference conditions because of the buffering effect on temperature by Vaal Dam.

5.4.7 Riparian vegetation (C EC, 62.7%)

The current and historic vegetation type is Andesite Mountain Bushveld of which 85% of this vegetation type is remaining and it has a conservation status of “Least threatened”.

Marginal Zone: Is dominated by non-woody vegetation with small woody (S. mucronata and *G. virgatum*) component. Cover is reduced due to increased base flows.

Lower Zone: Is as the marginal zone and merged (both zones inundated more frequently than expected). There is an increased occurrence of exotic woody species due to reduced moderate flows.

Upper Zone: Is dominated by grassland with rocky tree/shrub mix. It is largely modified due to anthropogenic activities. Reduced cover and abundance of species due to exotic species and recreational housing in the area.

5.4.8 PES: Causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 5.6.

Table 5.6 EWR 4: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	D/E	4	Decreased base flows and frequency of floods.	Vaal Dam.	F	4
Physico-chem	C	3	Fluctuations in temperature.	Vaal Dam.	F	3
			Phosphate contamination.	Agricultural runoff entering Vaal Dam.	NF	
Geom	D	3.5	Transport capacity impacted by decreased frequency of moderate floods.	Vaal Dam.	F	3.5
			Sediment supply – sediment is trapped in the dam although small tributaries are replenishing some of the bed sediment.			
			Connectivity – loss of floods has almost severed connectivity between active channel and upper islands/riparian zones.			
Rip veg	C	3.2	Reduced vegetation cover in marginal zone.	Vaal Dam.	F	3.3
			Increased occurrence of exotic woody species in lower zone.			
			Reduce cover, abundance and species composition throughout all zones.	Exotic species and recreational houses.	NF	
Fish	C	4	Altered habitat diversity (fluctuation from natural composition).	Flow modification due to Vaal Dam, the barrage and other sources of abstraction.	F	3
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming and recreational activities.	NF	
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and vegetation removal (grazing) contribute to increased sedimentation.		
			Decreased substrate quality related to increased benthic growth.	Increased nutrients from point and diffuse sources (agriculture).		
			Decreased water quality affect species with requirement for high water quality.	Bottom released from Vaal Dam, agricultural activities.		

	PES	Conf	Causes	Sources	F/NF	Conf
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL) and GAFF.	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation / angling.		
			Increased turbidity.	Erosion and presence of bottom feeding alien CCAR.		
			Decreased bottom substrate quality.	Impact of bottom feeding alien CCAR and siltation.		
			Loss of AV and MV as cover for fish.	Potential presence of herbivorous alien CIDE (grass carp).		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Vaal Dam upstream and Lethabo weir and Vaal Barrage downstream, as well as other major dams and various weirs. Farm dams in tributaries reduce refuge areas.		
Inverts	C/D	3	Elevated and constant baseflow releases from Vaal Dam.	Vaal Dam.	F	4
			Water temperature fluctuations are buffered, and seasonality probably changed significantly		F	

5.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity are stable or still changing. The results are summarised in Table 5.7.

Table 5.7 EWR 4: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	C	Stable	C		Data indicates that variables are stable.	3
Geom	D	Stable	D		Site and reach have adjusted to the operating rules of the dam.	3
Rip veg	C	Negative	D	10 years	Trend stable in terms of flow related responses, but highly invasive aliens are likely to increase if left unchecked e.g. *Acacia mearnsii* and *Eucalyptus* species.	3
Fish	C	Stable	C		Fish in this section have adapted to the conditions in this reach as a result of the flow modification and sedimentation which have been present for a long period (Vaal Dam present since 1938).	3
Inverts	C/D	Stable	C/D		The macroinvertebrates have already adapted to the changes in the system.	3

5.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 5.8. The Instream EC is a C (72.8%).

Table 5.8 EWR 4: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**66.7**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	100		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	85		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	2	90		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**9**	275	**61.7**	**C/D**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		605	**63.9**	**C**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	4	0.57	38.11	
Confidence rating for macroinvertebrate information	3	0.43	26.44	
	7	1.00	64.56	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 5.9). The EcoStatus EC is a C (63.7%).

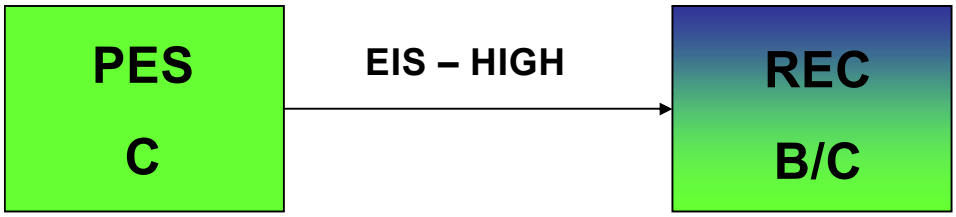
Table 5.9 EWR 4: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**62.7**	**C**	
ECOSTATUS	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for instream biological information	3.57	0.53	34.05
Confidence rating for riparian vegetation zone information	3.2	0.47	29.63
	6.77	1.00	63.68
ECOSTATUS	**EC**		**C**

5.7 REC: B/C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 4 is **HIGH** and the REC is an improvement of the PES to a B/C. A B EC could not be attained due to the limited operational possibilities from the Vaal Dam.



A hypothetical scenario includes the following:

- Improvement of seasonal variability (decreasing base flows during the dry season and increasing wet season flows above the base flows.
- Removal of alien vegetation and reduction of non woody vegetation removal.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 5.10.

Table 5.10 EWR 4: B/C REC

	PES	REC	Comments	Conf
Physico -chem	C	C	Water quality conditions will be similar to the PES conditions. The recommendation is to maintain the PES.	3
Geom	D	D	There are no realistic flow alterations which can be instituted to improve the current EC.	4
Rip veg	D	D	This will result in improved indigenous woody cover and abundance throughout, as well as improved grass cover as there will be less shading. Population parameters for indigenous woodies (structure and recruitment) will also improve, as well as species composition. Over time, indigenous woody species that are currently absent will return if mowing and harvesting is reduced or stops.	3.1
Fish	C	B	Closer to natural seasonal variability in flow will increase the overall habitat conditions. In summer more marginal vegetation inundation, (increased spawning habitat) for TSPA, CGAR, BANO, and BPAU will occur. Improved riffle/rapid habitats will improve spawning habitat for semi-rheophilics (BKIM, BAEN, LCAP, and ASCL). Closer to natural low flow periods will provide better refuge areas for species with preference for slow habitats (LUMB, BANO, TSPA, and PPHI).	2.5
Inverts	C/D	D	This scenario would provide flow habitat for taxa that prefer slow and standing water, and increase the overall diversity of taxa and in doing so, increases overall SASS scores, but reduce the ASPT. More importantly, this will reduce the incidence of pest outbreaks of blackflies. Furthermore, reduced flows is expected to cause a slight deterioration in water quality, so some taxa sensitive to water quality may be negatively affected.	3

5.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

5.8.1 AEC down: D

A hypothetical scenario includes the following:

- Increased constant base flows if salinity problems are exacerbated leading to a loss of variability.
- Decreased frequency of floods.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically report and summarised in Table 5.11.

Table 5.11 EWR 4: D AEC

	PES	AEC	Comments	Conf
Physico-chem	C	C/D	Increased nutrients upstream due to agricultural runoff, less water into the system due to Vaal pipeline augmentation to Secunda, waste water treatment works deteriorating (greater phosphate and other nutrients). Increasing salt concentrations trend due to greater coal mining influence.	3.6
Geom	D	D	With a higher baseflow, there will be some increase in the extent of cut banks and reduction of the extent of islands (due to inundation and erosion). However this will not cause a change in the current EC.	2.5
Rip veg	D	D	This scenario will result in loss of marginal zone species cover and abundance. Increased aliens will further reduce indigenous woody and non-woody cover and affect population parameters. Species composition will also change as indigenous species become proportionately less.	2.9
Fish	C	D	Increased constant base flows will lead to a further loss in natural seasonal variability and more constant fast habitats and less slow habitats. This will affect especially marginal vegetation as cover and influence species such as BANO, BPAU, TSPA and PPHI. The loss of slow deep habitats can be expected to reduce the FROC of species with preference for SD habitats (LUM, and CGAR). Loss of variability in flow may also reduce optimal spawning habitats for species such as BAEN during the required periods, if riffle/rapid habitats are transformed into runs/glides.	2.5
Inverts	C/D	C/D	Increased baseflows is likely to reduce the availability of the lower marginal reeds and islands, and this is likely to be detrimental to freshwater shrimps, Leptoceridae and possibly Aeshnidae.	2

5.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 5.12.

Table 5.12 EWR 4: Summary of EcoClassification results

IHI				Driver Components	PES Category	Trend	REC	AEC↓	IHI Hydro	Diatoms
INSTREAM	D	RIPARIAN	D	HYDROLOGY	D/E				E	C
				WATER QUALITY	C	Stable	C	C/D		
				GEOMORPHOLOGY	D	Stable	D	D		
				Response Components	PES Category	Trend	REC	REC		
				FISH	C	Stable	B	D		
				MACRO INVERTEBRATES	C/D	Stable	C	C/D		
				INSTREAM	C		B/C	D		
				RIPARIAN VEGETATION	C	Negative	B/C	D		
				ECOSTATUS	C		B/C	D		

6 EWR 5: SCANDINAVIA (VAAL RIVER)

6.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 6.1.

Table 6.1 EWR 5: Summary of data availability

Component	Data availability	Conf
Hydrology	C2H018 is the nearest gauge. It has a 70 year flow record. Low flows and zero flows are not measured accurately by this gauge.	3
Physico-chemical	Data records was available from water quality station C2H018Q01 (1979 – 2008; n = 1227) and Rand Water data from V17: Barrage outlet (2003 – 2008; n = 226).	4
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from two field assessments.	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Two site visits and fish sampling during August 2007 and December 2007. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database.	4
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and August 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1963): *Hydro biological studies on the Vaal River in the Vereeniging Area*.	3

6.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 6.2) was rated as **HIGH** (present), as the endangered *Labeobarbus kimberleyensis* is present as well as the Rand Highveld Grassveld vegetation type that is endangered. Most importantly, this site falls within the Vredefort Dome World Heritage Site and the river is an important feature within this World Heritage Site.

Table 6.2 EWR 5: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	*Labeobarbus kimberleyensis*, Rand Highveld Grassveld (vegetation type with endangered conservation status).
Unique (endemic, isolated, etc.)	2	3	*Austroglanis sclateri*, *Labeo capensis* and Leucosidea sericea (Ouhout).
Intolerant (flow & flow related water quality)	2.5	4	*L. kimberleyensis*, *L. aeneus*, *L. capensis*, *A. sclateri.*
Species/taxon richness	3	3	11 fish species, 19 macroinvertebrate taxa.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	3.5	4	Pools, runs, rocky outcrops, rapids, islands, riffles, large river in SA.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Refugia	3	3	Deep pools.
Sensitivity to flow changes	1	3	Large river.
Sensitivity to flow related water quality changes	1	3	Large river.
Migration route/corridor (instream & riparian)	3	4	Relatively long uninterrupted stretch for migration for semi-rheophilics.
Importance of conservation & natural areas	4	4	World heritage site: Vredefort dome.
MEDIAN	3		
EIS EVALUATION	**HIGH**		

6.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 6.3. Additional information on fish and invertebrate reference conditions are also provided.

Table 6.3 EWR 5: Reference conditions

Component	Reference conditions	Conf
Hydrology	A 70 year gauge record was available from C2H018. Natural hydrology was scaled to EWR site which may have caused a reduction in accuracy. Virgin MAR: 2288 MCM.	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al*. (2005). Refer to Table 2.4. There would have been lower phosphate contamination due to less agricultural runoff into the Vaal Dam. Relatively low nitrogen concentrations and low salts (electrical conductivity and sulphates) would have been present. Low Faecal coliforms counts and limited algal blooms. Limited runoff from Vaal Triangle and Johannesburg areas.	4
Geomorphology	Denser woody vegetation in the riparian zones would have occurred with clearer (undisturbed) terraces. The bed would have been more mobile due to frequent flooding.	2
Riparian vegetation	Marginal zone Dominated by non-woody vegetation (sedges and reeds with small woody component (*S. mucronata* and *G. virgatum*) (reeds and sedges not mixed). Lower zone Sedge/grass dominated, with small woody component (*S. mucronata* mainly). Upper zone Typical Highveld grassland (mostly terrestrial grasses) with Savanna woody mix, especially where banks are steeper and rocky.	4
Fish	Eleven species expected. Refer to Table 6.4.	3
Macroinvertebrates	There are no historical data. Reference conditions are based on professional judgment and data from Chutter (1963), from Site 15. The reference SASS5 score is 175 and the ASPT is 6.7.	2

6.3.1 Fish

EWR 5 falls within the Lowland geomorphic zone and EcoRegion 11.08, NRU H, MRU E and WQSU 28. The reach considered stretched from the Vaal Barrage to the Mooi-Vaal River confluence. Reference conditions, as set for the NHRP site C2Vaal-Parys (Kleynhans *et al.,* 2007) 46 km upstream of the EWR site, was used as basis for setting reference conditions. Based on the latest available information and professional judgement the following alterations were made (Table 6.4):

- FROC of BANO was reduced. There is strong evidence (especially Scott *et al.,* 2006) that this species mainly occur in the tributaries and very seldom in the Vaal River main stem with decreasing probability of occurring downstream within the main stem.

Table 6.4 EWR 5: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 5 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	3	1
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	5	5
Barbus anoplus	Chubbyhead barb	BANO	2	1
Barbus paludinosus	Straightfin barb	BPAU	3	2
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	3	2
Barbus trimaculatus	Threespot barb	BTRI	3	1
Clarias gariepinus	Sharptooth catfish	CGAR	3	3
Labeo capensis	Orange River labeo	LCAP	5	5
Labeo umbratus	Moggel	LUMB	3	2
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	3	3
Tilapia sparrmanii	Banded tilapia	TSPA	3	3

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

6.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Perlidae, Ancylidae, Heptageniidae, Prosopistomatidae, Simuliidae, Turbellaria, Tipulidae, Corixidae, Gyrinidae, Coelenterata, Hydropsychidae > 2 sp, Potamonautidae, Polymitarcyidae, Elmidae/Dryopidae, Coenagrionidae, Gomphidae, Naucoridae, Chironomidae, Oligochaeta, Caenidae, Leptophlebiidae, Lestidae, Aeshnidae , Veliidae/M...veliidae, Hirudinea, and Baetidae > 2 sp.

6.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

6.4.1 Hydrology (D EC)

Hydrology is affected by Vaal Dam releases and urban and industrial related impacts, i.e. mining and urban return flows as well as urban runoff enhancements. The most recent information in terms of mine discharges were obtained from surveys done for the area and was included in the simulation of present day flows. The present day and the observed record correlate well, except for the low flows, where the present day flows are higher than the observed There is an increase in base flow volume in the wet and the dry season with wet season volumes significantly lower than natural.

6.4.2 Geomorphology (C EC, 66.5%)

The site is a bedrock/boulder riffle area, but the reach is characterised by generally long pools. There are limited impacts at the site. Although flow regulation effects from Vaal Dam and the Vaal Barrage are still prominent, these are ameliorated by tributaries. Islands are still common in the

reach, suggesting that sediment supply is not critically reduced. The site has pronounced alluvial terraces on the north bank.

6.4.3 Physico chemical variables (D EC, 43.6%)

Three diatom samples were taken at this site (August 2007, January and April 2008) and 2003 diatom data was also available (Taylor, 2004). Data records from water quality station C2H018Q01 (1979 – 2008; n = 1227) and Rand Water data from V17: Barrage outlet (2003 – 2008; n = 226) were used for the physico-chemical PES assessment.

The data indicates high salinity levels due to mine water decants from Witwatersrand and high nutrient levels due to waste water treatment works discharges and informal settlement runoff. This has led to seasonal algal growth (rooted macrophytes, filamentous, exotic and floating). Diffuse runoff from un-sewered areas leads to seasonally high microbiological contamination. Chlorophyll-a values are seasonally high. High ammonia values are evident as well as occasional high metal values due to mining and industrial discharges into and directly downstream of the Vaal River Barrage. Water temperature is elevated due to warming in the Vaal Barrage while there are diurnal fluctuations in DO due to algal growth and releases from the Vaal Barrage. SPI scores ranged between 6.9 – 9.9 for samples taken during 2007 – 2008 (moderate – bad water quality) and the overall biological water quality EC is a C/D. All samples indicated deteriorated water quality due to highly urbanised industrialised and intensely mined areas of Southern Gauteng. The 2003 data shows that water quality conditions deteriorate alarmingly to unacceptable levels for survival of biota, and general recreational activities (E/F EC) at Goosbay canyon and Schoemans drift. Metal contamination is evident and the diatom communities of all three samples have a dominance of species that are tolerant of high to critical levels of pollution indicate industrially impacted waters.

Turbidity is variable due to releases from the Vaal Barrage but the Barrage also allows for settlement. There are seasonal water quality changes due to high flushes from the Vaal Dam which negate the return flows from the WWTWs. It is suspected that the town of Parys is also a major point source pollutant in this reach due to the uncompliant WWTW. PES values for the physico-chemical variables are provided in Table 6.5 and in Volume 2 - Appendix C of this report.

Table 6.5 EWR 5: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	55.1
	Na_2SO_4	208
	$MgCl_2$	10.9
	$CaCl_2$	90.2
	NaCl	76.2
	$CaSO_4$	0.73
Nutrients (mg/L)	SRP	0.35
	TIN	0.72
Physical variables	pH (5^{th}+95^{th} percentiles)	7.2 – 8.96
	Temperature (ºC)	22 (15 – 27)
	Turbidity (NTU)	13 (0.5 – 210)
Toxics	Fluoride (mg/L)	0.72
	Ammonia (mg/L)	0.138

6.4.4 Index of Habitat Integrity (IIHI: D EC, 49%; RIHI: D EC, 50.4%)

IIHI is impacted by changes in the flow regime due to Vaal Dam and the Barrage. Deteriorated water quality and associated benthic growth are also impacting on the instream habitat due to urban and agricultural activities in the area. Sedimentation due to the altered flow regime and the presence of carp is problematic and Vaal Dam is a major barrier in the system along with gauges and other barriers in the system. The riparian instream habitat condition is mainly due to the alteration of the flooding regime due to the Vaal Dam and the Barrage as well as substrate exposure, erosion and algal growth due to agricultural and recreational activities in the area. Spreading of invasive macrophytes due to water quality problems are also an issue within this reach.

6.4.5 Fish (C EC, 69%)

All the expected fish species is still present within this RU. The FROC of ASCL and BKIM have been reduced from reference conditions, probably related to deteriorated substrate condition (increased siltation and algal growth) as well as decreased flows (loss of fast habitats) and fluctuations and deteriorated water quality. The FROC of LUMB has been reduced, potentially related to loss of SD habitats (siltation and decreased flows). The FROC of BANO, BTRI and BPAU have also been reduced, potentially related to the presence of the aggressive alien predator MSAL and other alien fish species contributes to the deterioration in habitat quality (CCAR and CIDE). Alterations in slow habitats as a result of flow modification as well as loss of cover (vegetation as result of bank erosion and sedimentation of substrates) may also have contributed to their decline as well as the presence of hyacinth. Predation on indigenous fish larvae by *Gambusia affinis* (GAFF) may also have an impact on the occurrence of smaller fish species.

6.4.6 Macroinvertebrates (C EC, 65.4%)

The most notable taxa that were absent from this site were those that are sensitive to water quality changes. These included Perlidae, Ancylidae, Heptageniidae and Prosopistomatidae. The SASS scores are extremely low in relation to the quality of biotopes available. Overall the data indicate that the macroinvertebrate composition is driven mainly by deterioration in water quality, and elevated winter base flows. The abundance of water hyacinth is likely to have a major influence on oxygen levels, and this could partly explain why sensitive macroinvertebrates are absent from or scarce at this site. Physidae were recorded at the site in August 2007. The species was not recorded but it was presumably *Physa acuta*, which is an exotic species that could impact on local snail species. Elevated base flows during winter allow pest blackfly populations to overwinter, and this leads to major problems with outbreaks of blackflies, particularly in spring.

6.4.7 Riparian vegetation (D EC, 48%)

The current vegetation type is Rand Highveld Grassland, which is endangered with only 0.9% of the vegetation type protected and 58.5% remaining. There is reduced cover, abundance and species composition throughout all zones due to the presence of exotic species. Increased low flows facilitate more exotic woody species in lower zone and increased terrestrialization (*Acacia karoo*).

6.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 6.6.

Table 6.6 EWR 5: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydrology	D	3	Increased base flows and reduced frequency of moderate floods.	Vaal Dam and Barrage.	F	3
				Paved urban runoff enhancements, urban return flow, urban consumptive use, mine dewatering, mining consumptive use and to a lesser extent wetlands.	NF	
Physico-chemical	D	3.9	High salinity. High nutrients which has led to seasonal algal growth – rooted macrophytes, filamentous, exotic and floating. Chlorophyll-a values seasonally high.	Mine water decants from Witwatersrand. WWTW treatment works discharges and informal settlement runoff. Mining and industrial discharges into and directly downstream of the Vaal River Barrage.	NF	3
			High microbiological contamination.	Diffuse runoff from unsewered areas leads to seasonally dense algal blooms and diurnal oxygen fluctuations.		
				Input from Klip River and Rietspruit that are a combination of microbial input from incompliant WWTW such as Sebokeng works and Vereeniging works as well as diffuse runoff from unserviced areas.		
			High ammonia values.	Seasonal water quality changes due to high flushes from Vaal dam which negate the return flows from the waste water treatment works.	F	
			Occasional high metal values.			
Geomorphology	C	3.5	Deceased transport capacity. Moderate floods are very reduced and prolonged elevated base flows.	Upstream dams (Vaal Dam and farm dams).	F	3.3
			Connectivity – loss of floods has reduced connectivity between active channel and upper islands/riparian zones.	Vaal Dam.		
			Sediment supply is altered due to dams and catchment erosion.	Erosion from the agricultural areas has increased sediment supply, and this might offset the effects of the Vaal Barrage and Vaal Dam.	NF	
Rip veg	D	3.2	Reduced vegetation cover in marginal zone.	Increased low flows – Vaal Dam and Barrage.	F	3.3
			Facilitates more exotic woody species in lower zone and increased terrestrialization (*Acacia karoo*).			
			Reduced cover, abundance and species composition throughout all zones.	Exotic species.	NF	
Fish	C	4	Altered habitat diversity (fluctuation from natural composition) as a result of flow modification.	Flow modification by Vaal Barrage, other sources of abstraction.	F	F
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming and recreational activities.	NF	
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and vegetation removal (grazing) contribute to increased sedimentation.		
			Decreased substrate quality related to increased benthic growth.	Increased nutrients from point and diffuse sources.		
			Decreased water quality affect species with requirement for high water quality.	Diffuse effluent from industrial activities and agriculture. Excessive exotic macrophytes contribute to oxygen fluctuation.		

	PES	Conf	Causes	Sources	F/NF	Conf
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL) and GAFF.	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation/angling.		
			Increased turbidity reduces predatory success (BKIM, CGAR).	Erosion and presence of bottom feeding alien CCAR.		
			Decreased bottom substrate quality.	Impact of bottom feeding alien CCAR and siltation.		
			Loss of AV and MV as cover for fish.	Presence of herbivorous alien CIDE (grass carp).		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Vaal Barrage upstream and Goosebay weir, as well as other major dams and various weirs. Also farm dams in tributaries reduce refuge areas.		
Inverts	C	3	Water quality.	Agriculture, and urban sewage and industrial waste (high metals).	NF	3
			Low oxygen.	Water hyacinth.		
			Elevated base flows in winter.	Releases from the Barrage, comprising mainly return flows from sewer works and mines.	F	

6.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 6.7.

Table 6.7 EWR 5: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	D	Stable	D		The data indicates that pH and nitrogen values are stable. Salt and sulphate concentrations stable with a slight decreasing trend (due to the controlled releases for salts). Although phosphate values are variable data also indicates a stable trend.	3
Geom	C	Stable or weakly negative (within EC)	C		Site and reach have adjusted to the operating rules of the Vaal Dam.	3
Rip veg	D	Negative	D/E	10 years	Trend is stable in terms of flow related responses, but highly invasive aliens are likely to increase if left unchecked e.g. *Acacia mearnsii* and *Eucalyptus* species.	2.8
Fish	C	Stable	C		Fish in this section have adapted to the conditions in this reach as a result of the flow modification, excessive benthic algal growth and exotic macrophytes and fish species which have been present for a long period (Vaal Dam present since 1938).	3
Inverts	C	Stable	C		The macroinvertebrates have already adapted to the changes in the system.	3

6.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 6.8. The Instream EC is a C (67.6%).

Table 6.8 EWR 5: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**69.2**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	100		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	99		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	2	70		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**9**	269	**65.4**	**C**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		599	**67.0**	**C**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	4	0.57	39.54	
Confidence rating for macroinvertebrate information	3	0.43	28.03	
	7	1.00	67.57	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 6.9). The EcoStatus EC is a C/D (58%).

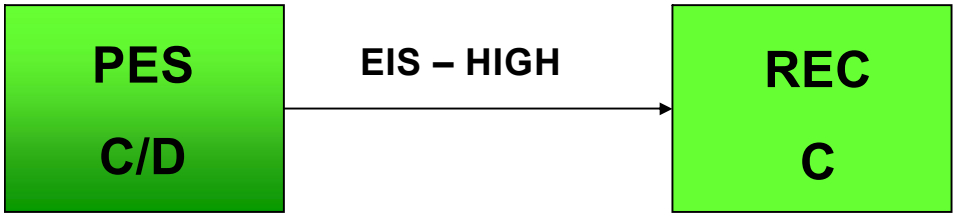
Table 6.9 EWR 5: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**48.1**	**D**	
ECOSTATUS	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for instream biological information	3.57143	0.53	35.64
Confidence rating for riparian vegetation zone information	3.2	0.47	22.73
	6.77143	1.00	58.37
ECOSTATUS	**EC**		**C/D**

6.7 REC: C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 5 is **HIGH** and the REC is therefore an improvement of the PES. A B/C EC could however not be attained due to the limited operational possibilities from the Vaal Dam.



A hypothetical scenario includes the following:

- Decreased base flows for 3 days (during winter) (to improve macroinvertebrates EC).
- Increased moderate floods in the wet season.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 6.10.

Table 6.10 EWR 5: C REC

	PES	REC	Comments	Conf
Physico-chem	D	D/E	This scenario will not improve water quality. The only way to improve the water quality would be to have a water quality management plan in the Upper Vaal. This would include the management of the waste water treatment works effluents, mine water effluents and industrial effluents. This would mean that the flow regime would have to be altered although this would possibly result in higher levels of ammonia, and greater turbidity. Improved dissolved oxygen and reduced potential water temperature changes will occur.	3
Geom	C	C	This scenario will inundate the lower banks/lower terraces, scour the channel; deepen pools, scour the gravels and cobbles, reduce armouring and embeddedness and flush out the water hyacinth.	2
Rip veg	D	C	This will only affect the marginal and lower zones where it will improve woody population metrics and reduce exotics. A Reduction of alien invasion on the lower and upper zones will be enabled by an alien removal programme.	2.8
Fish	C	B	This scenario will result in improved habitat condition for species, especially those with preference for slow habitats (BANO, BTRI, and LUMB). Availability of more overhanging vegetation will furthermore improve conditions for BANO and BTRI. Improved habitat condition through flushing of sediment and algae from riffle/rapid will improve conditions for ASCL, with a resultant improved FROC. This will also have a positive impact on spawning habitats for species such as BAEN, BKIM and LCAP. Improved water quality may furthermore improve conditions for species such as BKIM, ASCL, LCAP, and BAEN.	3
Inverts	C	C	This scenario would provide habitat for taxa that prefer slow and standing water, and increase the overall diversity of taxa, as well as reduce the incidence of outbreaks of pest blackflies. Increased high flows are expected to improve water quality, and some of the sensitive species are expected to reappear. These changes are expected to have a significant influence, but not enough to change the current EC.	2

6.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

6.8.1 AEC down: D

A hypothetical scenario includes the following:

- Increased base flows.
- Possibility of further decrease of floods due to the development in tributaries.
- Increased return flows.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 6.11.

Table 6.11 EWR 5: D AEC

	PES	AEC	Comments	Conf
Physico-chem	D	E	Water quality will deteriorate due to higher residence time in the Barrage and less flushing from Vaal Dam. Water quality variables that deteriorate would be nutrients, salts and microbiology. Increased base flows will result in greater turbidity. There will however be an improvement in DO and a reduction in temperature changes. There will be an overall deterioration within the current EC.	3
Geom	C	C/D	This scenario would further accelerate terrestrialisation, prevent scour of the channel and gravels and cobbles; increase armouring and embeddedness and prevent flushing of the water hyacinth.	2
Rip veg	D	D	This will affect the marginal and lower zones only as indigenous woody species cover and abundance as well as recruitment will be reduced due to inundation stress and habitat loss respectively. Non-woody cover will also be reduced due to increased and prolonged inundation, especially during the dry season. There will be deterioration within the EC.	3
Fish	C	D	Increased fines and embeddedness due to lack of floods will lead to critical deterioration in the already limited riffle/rapid (FS) habitats in the reach. This will decrease the FROC of species such as ASCL, BAEN, BKIM, and LCAP. Loss of marginal vegetation will be reflected by decreased FROC of species such as BANO, BTRI, BPAU, TSPA and PPHI.	3
Inverts	C	C/D	Increased base flows will provide improved habitat for overwintering blackfly larvae, and this will lead to increased outbreaks of pest blackflies in spring. Reduced flushing flows is likely to aggravate the hyacinth problem, which is likely to reduce oxygen levels, and cause further disappearance of taxa that are sensitive to water quality changes.	2

6.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results for setting EWR scenarios are summarised in Table 6.12.

Table 6.12 EWR 5: Summary of EcoClassification results

IHI				Driver Components	PES Category	Trend	REC	AEC↓
INSTREAM	D	RIPARIAN	D	HYDROLOGY	D		C/D	D
				WATER QUALITY	E	Negative	D/E	E
				GEOMORPHOLOGY	C	Negative	C	C/D
				Response Components	**PES Category**	**Trend**	**REC**	**AEC↓**
				FISH	C	Stable	B	D
				MACRO INVERTEBRATES	C	Stable	C	C/D
				INSTREAM	C		B/C	D
				RIPARIAN VEGETATION	D	Negative	C	-D
				ECOSTATUS	C/D		C	D

IHI Hydro	Diatoms
C	C/D

7 EWR 6: KLIP (KLIP RIVER)

7.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 7.1.

Table 7.1 EWR 6: Summary of data availability

Component	Data availability	Conf
Hydrology	C1H002 is the nearest gauge, which has a 102 year flow record, although this gauge is very far from the site, and data only useful after 1960. Low and zero flows are measured accurately by the gauge.	1
Physico-chemical	Data from C1H002Q01, Klip River at Sterkfontein/Delangesdrift was available for 1974 – 2004 (n = 1239) as well as Rand water data, C-KD Klip River at Delangesdrif for 2003 – 2008 (n = 56).	3.6
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from the site assessment. DEAT (2008): *South African Wetlands Conservation Programme: Seekoeivlei.* Tooth *et al.* (2002): *A guide to the geology and geomorphology of the Klip River valley.*	4
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Two site visits and fish sampling during September 2007 and December 2007. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database. Kotze and Niehaus (2001 – 2002): Biomonitoring of Klip River (Vaal Dam catchment).	3.5
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	3

7.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 7.2) was rated as **MODERATE** (present).

Table 7.2 EWR 6: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING (0 - 4)	CONF	
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	2	4	Oligoneuridae.
Unique (endemic, isolated, etc.)	1	4	*Leucosidea sericea* (Ouhout).
Intolerant (flow & flow related water quality)	3	3	Two water quality sensitive macroinvertebrate taxa, *L. aeneus*, *L. capensis,* and *Barbus paludinosus.*
Species/taxon richness	4	1	30 macroinvertebrate taxa, 5 fish species.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	3	3	Runs, pools, riffles, overhanging vegetation and rapids.
Refugia	3	3	Pools are critical as refuge.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Sensitivity to flow changes	2	3	
Sensitivity to flow related water quality changes	2	3	
Migration route/corridor (instream & riparian)	2	3	Birds.
Importance of conservation & natural areas	1	4	River system.
MEDIAN	2		
EIS EVALUATION	**MODERATE**		

7.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 7.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 7.3 EWR 6: Reference conditions

Component	Reference conditions	Conf
Hydrology	Although a 102 year gauge record was available from C1H002 only data after 1960 could be used. Natural hydrology was scaled to EWR site which may have cause a reduction in accuracy. Virgin MAR: 95.31 MCM	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al*. (2005). Refer to Table 2.4.	3
Geomorphology	Site is essentially in Reference State and there are very few morphological impacts.	4
Riparian vegetation	Marginal zone The marginal zone is expected to be dominated by non-woodies (sedges and reeds with a small woody component (*S. mucronata* and *G. virgatum*). Reeds and sedges are not mixed however, but are patchy and mutually exclusive. Lower zone Sedge and grass dominated, mainly *Cyperus* and *Miscanthus* spp. Upper zone Expected to be a 3-way mix comprising of grasslands on terraces (*Miscanthus* spp.) and gentle slopes, a woody component in the riparian zone (*Leucosidea* spp. mainly) and a grass/woody mix on the steep rocky slope (terrestrial grasses and *D. lyceoides*).	3
Fish	Five species present. Refer to Table 7.4.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 26 (this site) and 8 (Chutter, 1967: Table 11). The reference SASS5 score is 205 and the ASPT is 6.8.	4

7.3.1 Fish

EWR 6 falls within the Lower foothills geomorphic zone and EcoRegion 11.06, Secondary NRU Klip B.2, MRU Klip C and WQSU 13. The reach applicable for the PES assessment consists of the entire secondary NRU B.2/MRU C. Reference conditions (Kleynhans *et al.,* 2007) is available for two sites in the Klip River, namely NHRP sites C1Klip-Unspe and C1Klip-Unspe2. C1Klip-unspe2 is approximately 30 km upstream within the same EcoRegion (6.01), and it also falls within the same reach as EWR 6. The fish species observed however compared better to those expected at site C1Klip-Unspe, although this site is a long distance downstream and in a different Level II EcoRegion (11.03). The information for both these sites were therefore used in the compilation of reference conditions and provided in Table 7.4.

Table 7.4 EWR 6: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 6 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	2	0.5
Barbus anoplus	Chubbyhead barb	BANO	3	3
Barbus paludinosus	Straightfin barb	BPAL	2	0.5
Labeo capensis	Orange River labeo	LCAP	3	2
Labeo umbratus	Moggel	LUMB	2	2

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

7.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Oligoneuridae, Tricorythidae, Polymitarcyidae, Hydroptilidae, Perlidae, Hydropsychidae > 2 sp, Heptageniidae, Baetidae > 2 sp, Psephenidae, Ecnomidae, Elmidae/Dryopidae, Leptophlebiidae, Hydracarina, Simuliidae, Coenagrionidae, Gomphidae, Tipulidae, Pleidae, Dytiscidae/Noteridae, Gyrinidae, Ceratopogonidae, Porifera, Ancylidae, Turbellaria, Potamonautidae, Corixidae, Chironomidae, Sphaeriidae, Notonectidae, and Hirudinea.

7.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

7.4.1 Hydrology (C EC)

According to the modelled present day data, the Klip River is considered to be reasonably natural, There is a large number of farm dams (combined storage of approximately 10 MCM) situated in the catchment upstream of the site. According to the VRSAU (DWAF, 1999b) of the Upper Vaal WMA there is also unlawful irrigation water usage within this catchment. The modelled present day data (which shows more flows than natural due to irrigation return flows) do not agree with observations that zero flows often occurs. The irrigation water use was scaled based on areas as no information is no information is available of the spread of land use in the area for which the present day hydrology was modelled. The comparison between the natural and present day flows suggests that there are relatively few differences despite the fact that the impact of the farm dams and unlawful irrigation is reflected in the present day simulation. This is obviously not correct as zero flows are often experienced during the dry season. There seems to be no changes in moderate and high floods from natural conditions. Present day MAR: 84.95 MCM.

7.4.2 Geomorphology (B EC, 83.6%)

The site is representative of the reach and consists of a bedrock/boulder riffle area, cobble beds with some fines; in a long reach consisting of dolerites. The right bank (RB) is bedrock, so no paired terraces occur. Upstream there is a large meandering floodplain located in the sandstone areas. There seems to be little impact on the site, and the bedrock nature of the river also makes the site relatively insensitive to flow changes. The site is a bedload system, and although there are

dams far upstream, the fines component at the site suggests that the impact of the upstream dam is lessened due to subsequent tributary inputs of sediment.

7.4.3 Physico chemical variables (B/C; 80%)

Three diatom samples were taken at this site (September and December 2007, April 2008) and no additional data was available. Data records from water quality station C1H002Q01; Klip River at Sterkfontein/Delangesdrift (1974 – 2004; n = 1239) and Rand Water data from C-KD Klip River at Delangesdrif (2003 – 2008; n = 56) were used for the physico-chemical PES assessment.

SPI scores ranged between 12 – 12.8 for samples taken during 2007 – 2008 (moderate water quality) and the overall biological water quality EC is a B/C. The diatom samples and physico-chemical data indicates elevated nutrient and turbidity levels due to agricultural runoff. Due to the high seasonal sediment flows the turbidity is variable. Cattle trampling in the riparian and instream zone is present which may impact slightly on the water quality at the site. Overall the data set indicates low nitrogen and phosphate levels as well as low salt values and metal values are below detection limits.

Increased organic pollution levels at the site are of concern and may be due to the presence of dead cows in the vicinity, observed during December 2007 and April 2008. There is evidence that the upstream wetland plays an important role in the filtration of water and improvement of water quality. This is evident from the presence of wetland diatom species e.g. *Pinnularia gibba*, *Diadesmis contenta* and *Tryblionella debilis* (September 2007 sample). PES values for the physico-chemical variables are provided in Table 7.5 and in Volume 2 - Appendix C of this report.

Table 7.5 EWR 6: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	35.1
	Na_2SO_4	5.64
	$MgCl_2$	4.29
	$CaCl_2$	9.09
	NaCl	20.5
	$CaSO_4$	0.5
Nutrients (mg/L)	SRP	0.024
	TIN	0.11
Physical variables	Electrical conductivity (mS/m)	52.05
	pH (5^{th}+95^{th} percentiles)	6.91 – 8.54
	Temperature (ºC)	18-26
	Turbidity (NTU)	35 (1.3 - 4450)
Toxics	Fluoride (mg/L)	0.49
	Ammonia (mg/L)	0.12

7.4.4 Index of Habitat Integrity (IIHI: C EC, 67%; RIHI: C EC, 77%)

The major impact on the instream habitat is agriculture and roads which has caused bank modification, increased nutrient loading, benthic growth and sedimentation. Decreased low flows occur due to abstraction, various small weirs in the Klip River and associated tributaries as well as agriculture. The riparian zone is also impacted by agricultural activities and roads and habitat is impacted by substrate exposure in the non-marginal zone, erosion and presence of alien vegetation.

7.4.5 Fish (B EC, 82%)

It is perceived that all the expected fish species is still present within this RU although the FROC of some species have been reduced from reference conditions. Although BAEN and BPAL were not sampled during the current study, they have been sampled at site C1Klip-Unspe1 during 2001 (Kotze and Niehaus, 2001). It is estimated that the decreased FROC of BAEN may be attributed to the decreased flow (which resulted in less habitat for breeding, feeding and refuge) and presence of migration barriers (weirs and farm dams). The FROC of BPAL (if it naturally occurred in this reach) may have been reduced by decreased water quality (the only moderately intolerant species expected), together with a loss of habitat.

7.4.6 Macroinvertebrates (B EC, 87%)

September 2007:	SASS5 score: 173	No of Taxa: 28	ASPT: 6.2
April 2008:	SASS5 score: 169	No of Taxa: 30	ASPT: 5.6

The site is in an excellent ecological state, despite the very low flows and limited biotopes present during the September 2007 site visit. Key indicators recorded at this site were taxa that are highly sensitive to deterioration in water quality, such as Polymitarcyidae, Oligoneuridae, Heptageniidae, Leptophlebiidae, Perlidae and Psephenidae. The only consistently missing taxon was Hydroptilidae.

7.4.7 Riparian vegetation (B/C EC, 78.7%)

The site falls within the Amersfoort Highveld Clay Grassland vegetation type, which has a conservation status of “Vulnerable” with 75.5% remaining.

Marginal zone: Dominated by non-woody vegetation (mainly sedges and grasses). The zone is moderately impacted by the removal of sedge species. Exotic species (non-woody weeds) have a 10% presence and has a small impact on this zone.

Lower zone: Dominated by non-woody vegetation (mainly sedges and grasses). Cover and species composition of the non-woody component has been reduced due to the high proportion of exotics (presence of 20 – 40% exotic non-woody weeds) and especially the shading impact of *S. babylonica*). There has also been vegetation loss due to soil erosion around *S. babylonica* trees.

Upper zone: Is essentially a grass/tree/shrub mix and is seriously impacted by the presence of exotics (40 – 60% non-woody weeds mainly) and vegetation removal due to farming, roads and artificial canals. There is higher proportion of *Leucosidea* spp. due to canalisation.

7.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 7.6.

Table 7.6 EWR 6: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	C	2	Decreased base flows and even zero flows. Possible reduction in moderate floods.	Dams and weirs.	F	1

	PES	Conf	Causes	Sources	F/NF	Conf
Physico-chem	B/C	3.6	Variable turbidity.	High seasonal sediment flows.	F	3
			Elevated nutrients and salinity levels.	Agricultural runoff.	NF	
			Benthic growth.	Cattle and agriculture.		
Geom	B	3.5	Slight reduction in system connectivity.	Small farm dams.	NF	3
			Increased sediment supply due to erosion in smaller tributaries, buffered somewhat by upstream wetland.	Cattle grazing.		
			Slight reduction in transport capacity due to reduction in base flows and moderate floods.	Presence of dams in the upper catchment.	F	
Rip veg	B/C	3.1	Reduced non-woody cover.	Exotic species, especially *S. babylonica*.	NF	3.5
			Reduced or absent woody recruitment.	Reduced moderate floods.	F	
			Reduced or absent woody recruitment.	Disturbance at the site, agricultural activities, roads within the riparian zone and sedge removal.	NF	
Fish	B	3	Loss of habitat (decreased FS and FD) diversity as a result of flow modification (especially during natural low flow periods).	Dams in main stream and tributaries.	F	3
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming activities.	NF	
			Increased sedimentation resulting in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).			
			Decreased substrate quality related to increased benthic growth.	Increased nutrients from point and diffuse sources.		
			Decreased water quality affect species with requirement for high water quality.	Effluents from mines and agricultural areas (pesticides).		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Weirs in Klip River and also farm dams in tributaries reduce refuge areas.		
Inverts	B	4	Decreased low flows.	Abstraction and various small weirs.	F	3
			Nutrients and associated benthic growth.	Cattle.	NF	
			Sedimentation.	Roads, farming activities.		

7.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 7.7.

Table 7.7 EWR 6: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	B/C	Negative	C	10 years	Stable trend in phosphate and other nutrients. Salt concentrations (sulphates) slight increasing trend.	3
Geom	B	Stable	B		Site is stable under current conditions and is located in the dolerites, which is relatively insensitive to flow changes. Upstream the alluvial floodplain areas would be highly susceptible to changes in moderate floods.	3
Rip veg	B/C	Stable	B/C		Non aggressive aliens are present and unlikely to increase to such and extent as to cause deterioration in EC.	3

	PES	Trend	Trend PES	Time	Reasons	Conf
Fish	B	Stable	B		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the conditions. It must however be noted that the PES falls within the very low B EC boundary and any small alteration may result in a shift to a B/C.	3
Inverts	B	Stable	B		The macroinvertebrates have already adapted to the changes in the system.	3

7.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 7.8. The Instream EC is a B (84.66%).

Table 7.8 EWR 6: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2	70		
2.What is the natural diversity of fish species with a preference for different cover types	2.5	80		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3	100		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	9.5	320	**82.2**	**B**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	70		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	5	100		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	5	75		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**14**	245	**86.5**	**B**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		565	**85.3**	**B**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	3	0.43	35.23	
Confidence rating for macroinvertebrate information	4	0.57	49.43	
	7	1.00	84.66	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**B**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 7.9). The EcoStatus EC is a B/C (81.9%).

Table 7.9 EWR 6: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	78.7	B/C	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	3.6	0.54	45.32
Confidence rating for riparian vegetation zone information	3.1	0.46	36.57
	6.7	1.00	81.89
ECOSTATUS	EC		B/C

7.7 REC: B/C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 6 is **MODERATE** and the REC is to maintain the PES.

7.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

An improved scenario was not deemed viable as a B EcoStatus can be achieved by removing exotic vegetation as an improvement in flow will not improve the vegetation EC. An alternative deteriorated scenario was designed and is discussed below.

7.8.1 AEC down: C

A hypothetical scenario is designed and also includes the following:

- Increased zero flows and low flows.
- Decreased moderate floods.
- Deterioration in water quality.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 7.10.

Table 7.10 EWR 6: C AEC

	PES	AEC	Comments	Conf
Physico -chem	B/C	C	Temperature will decrease in winter as well as dissolved oxygen especially during zero flow periods. Agriculture runoff will not be diluted and will cause an increase in nutrients, benthic algal growth and toxics.	4

	PES	AEC	Comments	Conf
Geom	B	C	Under this scenario sediment supply will decrease and the presence of dams and weirs will have a bigger impact. Transport capacity will also be affected.	3
Rip veg	B/C	C	Reduced base flows will facilitate the migration of the marginal zone sedges towards the stream. This will result in an increase in non-woody cover and abundance because it's unlikely that already established sedges will die. Lower zone sedges will benefit from reduced flooding disturbance and are also likely to increase in density and cover. Reduced moderate floods will likely reduce woody recruitment on the upper zone. This in turn will skew the population structure.	3.5
Fish	B	C	This scenario will result in a loss in fast habitats which will impact on the semi-rheophilic species or species with a preference for this habitat. A reduced FROC of BAEN and LCAP is therefore expected. Water quality deterioration may also further reduce the FROC of BPAL, being moderately intolerant to water quality alterations. The loss in substrate quality due to increased sedimentation as a result of decreased flushing will also directly affect all of the above species.	3
Inverts	B	C	This scenario is certain to eliminate flow sensitive taxa from the area. Key taxa that are expected to disappear are Polymitarcyidae, Oligoneuridae, Perlidae and Psephenidae. Taxa that are sensitive to water quality changes are also expected to be affected (e.g. Heptageniidae and taxa already listed above).	3

7.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 7.11.

Table 7.11 EWR 6: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	Trend	AEC ↓
INSTREAM	C	RIPARIAN	C	HYDROLOGY	C		
				WATER QUALITY	B/C	Negative	C
				GEOMORPHOLOGY	B	Stable	C
				Response Components	**PES Category**	**Trend**	**AEC↓**
				FISH	B	Stable	C
				MACRO INVERTEBRATES	B	Stable	C
				INSTREAM	B		C
				RIPARIAN VEGETATION	B/C	Stable	C
				ECOSTATUS	B/C		C

IHI Hydro	Diatoms
B/C	B/C

8 EWR 7: UPPER WILGE (WILGE RIVER)

8.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 8.1.

Table 8.1 EWR 7: Availability of data

Component	Data availability	Conf
Hydrology	C8H002 is the nearest gauge, although situated far from the site and has a 10-year intermittent flow record from the 1950s and 1970s.	2
Physico-chemical	Very limited water quality data but have a good Rand Water database downstream at Harrismith (above the potential influence of the Sterkfontein Dam interbasin transfer). Limited data from Chutter (1967) and Eskom EIA (1999).	1.5
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from a field assessment and intensive previous EIA/EMP studies associated with the Braamhoek pumped storage dams.	4
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Single site visit and fish sampling during April 2008. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database. Kotze and Niehaus (2000): *Biomonitoring of Wilge River for Rand Water*.	3.5
Macroinvertebrates	One SASS5 survey undertaken during April 2008. Report information used: Ecological reports and specialist assessments for this study.	3

8.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 8.2) was rated as **HIGH** (present), as there are rare and endangered species i.e. the flufftail crowned crane, bald ibis, and 11 red data vegetation species, There is a good diversity of habitats that include wetlands, flood plains, oxbow lakes and peat lands.

Table 8.2 EWR 7: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	Flufftail, 11 red data vegetation species, crowned crane, bald ibis.
Unique (endemic, isolated, etc.)	3	1	36 bird species of conservation importance, plant species.
Intolerant (flow & flow related water quality)	1	4	*Barbus paludinosus*.
Species/taxon richness	3	4	19 macroinvertebrate taxa, birds and vegetation.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	3	4	Wetland, floodplain, oxbow lakes, and peat lands.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Refugia	2	4	Minnows and birds.
Sensitivity to flow changes	1	4	U-shaped channel – No loss of habitat with loss of depth.
Sensitivity to flow related water quality changes	2	2	
Migration route/corridor (instream & riparian)	2	3	Birds - uninterrupted wetland vegetation.
Importance of conservation & natural areas	3	4	Eastern Freestate Sandy Grassveld, large wetland in good condition.
MEDIAN	2.5		
EIS EVALUATION	**HIGH**		

8.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 8.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 8.3 EWR 7: Reference conditions

Component	Reference conditions	Conf
Hydrology	Natural hydrology was scaled to the site. There is limited land use upstream from the site and the hydrology is largely natural. Virgin MAR: 23.47 MCM.	4
Physico-chemical	Good water quality with low nutrients and salts. Seasonally high turbidity due to natural erosion.	2
Geomorphology	Meandering floodplain system with ox-bow lakes (seasonal and permanent), wide floodplain, seasonal channels, point bars and cut banks. There are very few morphological impacts.	4
Riparian vegetation	Marginal zone Expected to be a narrow band comprising open sand, sedges and herbaceous riparian species. Lower zone Similar to the marginal zone, expected to be mainly herbaceous such as *Rumex, Ludwigia* and *Persecaria* spp. Upper zone Consists of extensive grassland floodplain, dominated by non-woody wetland species with sedges and forbs, but mainly grasses.	4
Fish	Three species present. Refer to Table 8.5.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 9 (this site) and 9A (Chutter, 1967: Table 11). The reference SASS5 score is 157 and the ASPT is 5.8.	4

8.3.1 Fish

EWR 7 falls within the Lowland geomorphic zone and EcoRegion 11.03, NRU Wilge B, MRU Wilge A and WQSU 13. Reference conditions are applicable for the entire secondary MRU Wilge A. No reference conditions (Kleynhans *et al.,* 2007) is available for this reach of the Wilge River, and reference conditions were therefore based on previous experience and information available for other sites in the area (Table 8.4).

Table 8.4 EWR 7: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 7 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	4	4
Barbus anoplus	Chubbyhead barb	BANO	2	1
Barbus paludinosus	Straightfin barb	BPAU	2	1

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

8.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Leptophlebiidae, Turbellaria, Hydraenidae, Hydrophilidae, Hydracarina**,** Oligochaeta, Potamonautidae, Baetidae > 2 sp, Caenidae, Coenagrionidae, Lestidae, Aeshnidae, Gomphidae, Corixidae, Veliidae/M...veliidae, Hydropsychidae >2 sp, Hydroptilidae, Dytiscidae/Noteridae, Elmidae/Dryopidae, Chironomidae, Simuliidae, Tipulidae and Sphaeriidae.

8.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

8.4.1 Hydrology (A EC)

There are no major upstream land uses, apart from a few farm dams. The hydrology is close to natural. Present day MAR: 23.47 MCM.

8.4.2 Geomorphology (A EC, 97%)

This is a meandering floodplain area – representative of the whole reach. The system is a suspended load (fine silts and clays) dominated system and the site is near reference condition.

8.4.3 Physico chemical variables (B EC, 85%)

Three diatom samples were taken during the site visit. One sample was taken upstream of the cross section at a roadbridge the other at the cross section one in an oxbow lake adjacent to EWR 7. Data records from water quality station WMW (Wilge on Bethlehem Warden road) 2000 – 2002 were used for the physico-chemical PES assessment. The diatom samples indicate that there is minimal impact on this site, with the water being generally circumneutral, and oxygen rich. There are elevated turbidity levels due to highly erodable soils and nutrient levels may be slightly elevated due to agriculture in the area. PES values for the physico-chemical variables are provided in Table 8.5 and in Volume 2 - Appendix C of this report.

Table 8.5 EWR 7: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	No data available.	
Nutrients (mg/L)	SRP	0.025
	TIN	0.445
Physical variables	Electrical conductivity (mS/m)	54
	pH (5^{th}+95^{th} percentiles)	7.3 – 8.9
	Temperature (ºC)	7.3
	Dissolved Oxygen (Mg/L)	11
	Turbidity (NTU)	8.3
Toxics	Fluoride (mg/L)	0.17
	Ammonia (mg/L)	0.025

8.4.4 Index of Habitat Integrity (IIHI: B EC, 85.9%; RIHI: B EC, 82.4%)

Instream Habitat integrity is impacted by farming and roads in the area which have caused bank and bed modification leading to increased sedimentation. Abstraction is also an issue at this site. Riparian Integrity is affected by bank modification caused by alien vegetation, roads and grass removal from the wetlands.

8.4.5 Fish (B EC, 86.7%)

It is perceived that all the expected fish species is still present within this RU. BAEN was the only indigenous species sampled at the site, but in very low abundance. The other two expected species (BANO and BPAL) was absent, but have been sampled in the area previously. It is thought that their absence from the site and general low abundance in this reach is not habitat related (as habitat was optimal) but rather as a result of the presence of the predatory alien MSAL. The PES is D considering the impact of alien species. The habitat is however still optimal, and if alien species are not considered, a PES of B is calculated for this reach.

8.4.6 Macroinvertebrates (B EC, 85.3%)

April 2008: SASS5 score: 108 No of Taxa: 19 ASPT: 5.7
The available instream aquatic biotopes were poor and limited to a small riffle upstream of a road bridge. As such, the site was not suitable for the application of SASS5. The riffle was made up mainly by wood debris that had accumulated upstream of the bridge, plus small stones and gravels in current that provided reasonable habitat for flow-dependent species. The site provides the best available sampling instream biotopes, although it is unrepresentative of the type of stream, which is a meandering lowland system that is naturally devoid of fast-flowing water. Oxbow lakes were abundant in the area, and although the diversity of invertebrates in each of these lakes was low, each lake supported a different biota, so the invertebrate diversity of the combined lakes was high.

The diversity of aquatic invertebrates was good, although the standard method of assessment (SASS5) could not be used because of the limited riffle habitats available, so the confidence in the assessment is low. The presence of the mayfly *Adenophlebia auriculata* indicates excellent quality water. Taxa expected but not found were Turbellaria, Hydracarina, Hydraenidae and Hydrophilidae.

8.4.7 Riparian vegetation (A/B EC, 90%)

The site falls within the Eastern Free State Sandy Grassland vegetation type which has a conservation status of "Endangered", with 55.3% remaining and only 1.8% protected. Reduced cover and changed species composition is present due to minor exotic species component.

8.4.8 PES causes and sources

The PES for the components at EWR 7 as well as the reasons for the PES are summarised in table 8.6.

Table 8.6 EWR 7: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	A	4	Very minor altered flow regime	Few upstream dams and agriculture.	NF	3
Physico-chem	B	3.5	Elevated turbidity.	Erodable soils.	NF	3
			Slightly elevated nutrient levels.	Agriculture.		
Geom	A	4.5	System connectivity.	A few small farm dams are very slightly reducing connectivity.	NF	3
			Sediment supply.	Small change in sediment supply from the catchment due to a few small farm dams as well as fire and grazing in the upper catchment areas.		
Rip veg	A/B	4	Some reduced cover and changed species composition.	Minor exotic species component. Presence of roads in the wetland. Mowing of wetland grasses.	NF	4
Fish	B (D)	3	Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL).	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation/angling.	NF	4
Inverts	B	2	Predation by exotic fish.	MSAL.	NF	3
			Periodic elevated levels of ammonia.	Cattle Farming.		

8.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 8.7.

Table 8.7 EWR 7: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	B	Negative	B/C	10 years	Possible increase in turbidity and nutrients.	2
Geom	A	Rapid negative	B/C	5 - 10 years	New dams (Eskom pumped storage scheme) is coming online and will cause reductions in baseflows, as well as likely changes to moderate floods.	2

	PES	Trend	Trend PES	Time	Reasons	Conf
Rip veg	A/B	Stable	A/B		Exotics are unlikely to increase under current conditions.	3
Fish	B (D)	Negative	D/E	Long term	It is estimated that the predatory alien MSAL may over the long term eradicate the indigenous barbs from the system, which would lead to a further decrease in ecological integrity	3
Inverts	B	Stable	B		The macroinvertebrates have already adapted to the changes in the system.	3

8.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 8.8. The Instream EC is a B (86%).

Table 8.8 EWR 7: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	1.5	60		
2.What is the natural diversity of fish species with a preference for different cover types	2	80		
3.What is the natural diversity of fish species with a preference for different flow depth classes	2.5	100		
4. What is the natural diversity of fish species with various tolerances to modified water quality	1.5	60		
FISH ECOLOGICAL CATEGORY	7.5	300	**86.7**	**B**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	70		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	5	100		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	5	75		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**14**	245	**85.3**	**B**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		545	**85.6**	**B**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	3	0.60	52.02	
Confidence rating for macroinvertebrate information	2	0.40	34.12	
	5	1.00	86.14	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**B**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 8.9). The EcoStatus EC is an A/B (88.3%).

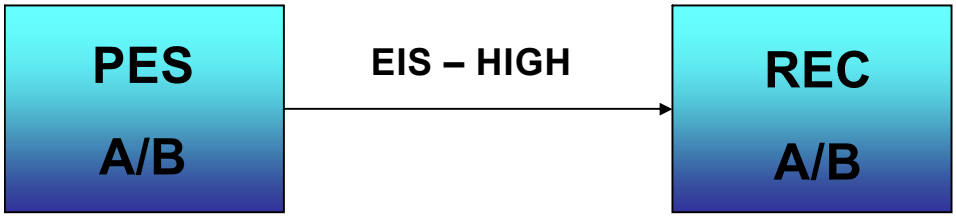
Table 8.9 EWR 7: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	90.0	A/B	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	2.6	0.43	36.72
Confidence rating for riparian vegetation zone information	3.5	0.57	51.64
	6.1	1.00	88.35
ECOSTATUS	EC		A/B

8.7 REC: A/B

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 7 is **HIGH**. As the PES is also relatively high, the attainable and realistic objective is to maintain the PES even though a high EIS would normally warrant improvement.



8.8 AEC: C

Due to the size of the river, sensitivity to flow related impacts is high at this site. Fish and macroinvertebrate species and taxa are limited and therefore any changes would result in a rapid deterioration in these biotic components. Therefore an AEC of a C was considered instead of a B/C EcoStatus. The hypothetical scenario includes the following:

- Decreased base flows, some periods of zero flows and decreased moderate floods.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 8.10.

Table 8.10 EWR 7: C AEC

	PES	AEC	Comments	Conf
Physico -chem	B	-B	This will result in increased erosion and turbidity as well as nutrients and microbes due to the development of a small village to manage the hydro-electric scheme (Braamhoek).	3
Geom	A	B/C	The floodplain at EWR 7 is highly sensitive to reduced overbank flooding, and these impacts will result in a rapid decline to a B/C EC.	3
Rip veg	A/B	B/C	Marginal zone non-woody cover will reduce as zone migrates. Lower zone non-woody cover will reduce as zone dries out and species composition will change as wetland grasses colonise lower zone. Upper zone (wetland) will dry out and species composition will change. Oxbows and lower portions of the wetland will undergo species changes.	2.7

	PES	AEC	Comments	Conf
Fish	B	C	Note: For the purpose of the AEC scenario calculations, the B PES, calculated based on the present status of habitats available for indigenous fish species and the exclusion of alien species, were used. Decreased base flows will result in a loss of fast shallow and fast deep habitats, which will probably reduce the FROC of BAEN, a species with a high requirement for this habitat type.	2.5
Inverts	B	C/D	Instream habitats in this area are highly sensitive to flow reductions, as there is very limited habitat available under present conditions. Any small reduction in flow is likely to reduce what is available significantly. Extended periods of very low or no flow is likely to affect taxa that depend on flowing water (Leptophlebiidae and Hydropsychidae) and taxa that prefer marginal vegetation (Lestidae and Aeshnidae).	2

8.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 8.11.

Table 8.11 EWR 7: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	Trend	AEC↓	IHI Hydro	Diatoms
INSTREAM	B	RIPARIAN	B	HYDROLOGY	A			A/B	B
				WATER QUALITY	B	Negative B/C	-B		
				GEOMORPHOLOGY	A	Negative B/C	B/C		
				Response Components	PES Category	Trend	AEC↓		
				FISH	B (D)	Negative D/E	C		
				MACRO INVERTEBRATES	B	Stable	C/D		
				INSTREAM	B		C		
				RIPARIAN VEGETATION	A/B	Stable	B/C		
				ECOSTATUS	A/B		C		

9 EWR 8: BAVARIA (WILGE RIVER)

9.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 9.1.

Table 9.1 EWR 8: Summary of data availability

Component	Data availability	Conf
Hydrology	C8H028 is the nearest gauge. It has a 19 year flow record.	1
Physico-chemical	Data from C8H014Q01 (1984 – 1992; n = 93) was available as well as Rand water data, Harrismith, C-WH for 2003 – 2008 (n = 56).	2.3
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from one field assessment.	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Single site visit during April 2008. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database. Kotze and Niehaus (2000): *Biomonitoring of Wilge River for Rand Water.*	4
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*	3

9.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 9.2) was rated as **MODERATE** (present).

Table 9.2 EWR 8: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING (0 - 4)	CONF	
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	0	3	
Unique (endemic, isolated, etc.)	2	3	*Austroglanis sclateri*, *Labeo capensis*, *Leucosidea sericea.*
Intolerant (flow & flow related water quality)	2.5	3	*L. aeneus*, *L. capensis*, *A. sclateri*, *B. paludinosus.*
Species/taxon richness	2	3	23 macroinvertebrate taxa, 8 fish species.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2.5	4	Pools, runs, bedrock and boulder rapids.
Refugia	2	3	Pools.
Sensitivity to flow changes	1.5	3	Wide river.
Sensitivity to flow related water quality changes	2	3	
Migration route/corridor (instream &	2	3	Yellowfish.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
riparian)			
Importance of conservation & natural areas	1	2	Eastern Freestate Clay Grassland vegetation type of conservation importance.
MEDIAN	2		
EIS EVALUATION	**MODERATE**		

9.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 9.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 9.3 EWR 8: Reference conditions

Component	Reference conditions	Conf
Hydrology	A 19 year gauge record was available from C8H028. The gauge does not however measure low flows and zero flows accurately. Virgin MAR: 474.35 MCM.	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al.* (2005). Refer to Table 2.4.	3
Geomorphology	Site is currently not very different from natural, but under reference conditions there would be denser woody vegetation in the riparian zones (maintained by more frequent moderate floods), a slightly larger proportion of fines on the bed (these having been scoured due to the elevated baseflows) and less erosion of the banks, and no extensively cut banks in both banks.	2
Riparian vegetation	Marginal zone The marginal zone is expected to be dominated by non-woodies (sedges and reeds (minor component) with small woody component (*S. mucronata* and *G. virgatum*). Lower zone Sedge and grass dominated, mainly *Cyperus* and *Miscanthus* spp. Upper zone Expected to be a mix of terrestrial grasslands on terraces and gentle slopes, and grass/woody mix on the steep rocky slope (terrestrial grasses and *Diospyros lyceoides, Rhus dentata*).	3
Fish	Eight species present. Refer to Table 9.4.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Site 12 (this site) (Chutter, 1967: Table 11). The reference SASS5 score is 185 and the ASPT is 6.0.	4

9.3.1 Fish

EWR 8 falls within the Lowland geomorphic zone and EcoRegion 11.03, NRU Wilge B, MRU Wilge B and WQSU 13 and reference conditions are applicable for this MRU. Reference conditions set for the NRHP site C8Wilg-BELWH (Kleynhans *et al.,* 2007) was used for the compilation of reference conditions (Table 9.4).

Table 9.4 EWR 8: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 8 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	3	3
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	3	3
Barbus anoplus	Chubbyhead barb	BANO	3	2
Barbus pallidus	Goldie barb	BPAL	2	1
Barbus paludinosus	Straightfin barb	BPAU	2	1

Expected Reference and Habitat derived FROC of fish at EWR 8 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Clarias gariepinus	Sharptooth catfish	CGAR	3	3
Labeo capensis	Orange River labeo	LCAP	3	3
Labeo umbratus	Moggel	LUMB	3	3

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

9.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Turbellaria, Oligochaeta, Potamonautidae, Atyidae, Hydracarina, Perlidae, Baetidae > 2 sp, Heptageniidae, Leptophlebiidae, Gerridae, Hydroptilidae, Elmidae/Dryopidae, Porifera, Hirudinea, Caenidae, Tricorythidae, Coenagrionidae, Belostomatidae, Corixidae, Hydrometridae, Naucoridae, Notonectidae, Hydropsychidae, Dytiscidae/Noteridae, Gyrinidae, Hydrophilidae, Chironomidae, Simuliidae, Ancylidae, Bulininae, Corbiculidae, and Sphaeriidae.

9.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

9.4.1 Hydrology (D EC)

There are mostly farm dams and irrigation as well as small urban demand upstream from the site. Flow at the EWR site is influenced by releases from Sterkfontein Dam in support of Vaal Dam. Base flow volumes have decreased from natural and near zero flows were experienced at this site. This is mainly due to instream dams and irrigation of which some might be illegal. Present day MAR: 437.34 MCM.

9.4.2 Geomorphology (C EC, 67%)

The moderate floods have been reduced and high (although infrequent) flush releases are made from Sterkfontein Dam. The banks are cut extensively on both sides upstream of the site (but at the site, which is near a gorge, the banks are largely bedrock and not sensitive to flow changes). This condition is probably in response to the infrequent releases from Sterkfontein Dam. Large volumes of exotic woody debris at the site suggest that bank erosion is accelerating and eroding the trees from the bank.

9.4.3 Physico chemical variables (C EC, 70%)

Two diatom samples were taken at this site (August 2007 and April 2008) and 2003 diatom data was also available (Taylor, 2004). Data records from water quality station C8H014Q01 (1984 – 1992; n = 93) and Rand Water data from C-WH: Harrismith (2003 – 2008; n = 56) were used for the physico-chemical PES assessment.

Both diatom samples indicate alkaline waters with low oxygen saturation and sodium based salinity (presence of *A. coffaeformis*) problems. The 2003 diatom data shows that water quality fluctuated between a C and D EC during the year. The biological water quality is overall of poor quality and

the current biological water quality is a C/D. The site is impacted by WWTWs (Harrismith, Industriqwa, Warden and Tshiane) and receives diffuse runoff from agricultural, urban (Harrismith) and industrial activities (Industriqwa). Weirs occur in the system for the purposes of abstraction for purification purposes, fish dams and tankers. Sterkfontein Dam releases potentially have an impact on turbidity levels, habitat loss, decreased temperature and oxygen levels. Physico-chemical data indicates that nitrogen and phosphate concentrations are relatively low. There are indications that EC and sulphate levels reach seasonal winter highes and metal contamination is below detection limits. PES values for the physico-chemical variables are provided in Table 2.6 and in Volume 2 - Appendix C of this report.

Table 9.5 EWR 8: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	12.3
	Na_2SO_4	5.82
	$MgCl_2$	0.97
	$CaCl_2$	3.85
	NaCl	17.7
	$CaSO_4$	0.49
Nutrients (mg/L)	SRP	0.022
	TIN	0.278
Physical variables	Electrical conductivity (mS/m)	54.25 (4.8 - 64)
	pH (5^{th}+95^{th} percentiles)	6.5 – 8.5
	Temperature (ºC)	22 (18 - 26)
	Turbidity (NTU)	41.5 (1.2 - 88)
Toxics	Fluoride (mg/L)	0.19
	Ammonia (mg/L)	0.124

9.4.4 Index of Habitat Integrity (IIHI: C/D EC, 58.1%; RIHI: C EC, 66%)

Instream habitat is affected by abstractions for agricultural purposes causing zero flows at times as well as interbasin transfers from Sterkfontein Dam. Deteriorated water quality occurs due to water use from Harrismith and agriculture and bed and bank modification has occurred due erosion caused by agriculture, roads and alien willow spp. The main impacts on instream riparian habitat is increased high flows/floods and zero flow periods caused by interbasin transfers from Sterkfontein Dam and agriculture. Erosion and bank instability due to the presence of exotic willows are also impacting on this habitat.

9.4.5 Fish (C EC, 76.1%)

All of the expected fish species are still present within this RU although the FROC of some species have been reduced from reference conditions. The most prominent reduction in FROC is evident in the small barb species (BANO, BPAL and BPAU), most probably related to the impact of the predatory alien MSAL. Some deterioration in habitats due to decreased flows and sedimentation has also impacted the overall ecological integrity slightly.

9.4.6 Macroinvertebrates (C/D EC, 61%)

September 2007:	SASS5 score: 118	No of Taxa: 22	ASPT: 5.4
April 2008:	SASS5 score: 115	No of Taxa: 23	ASPT: 5.0

Biotopes were highly suitable for assessing the PES, particularly the stones-in-current (SIC) and stones-out-of-current (SOOC). However, flows were very low in September 2007, and there was

limited habitat available. Biotopes that were notably scarce were sand and aquatic vegetation. The diversity of macroinvertebrates was relatively high, but most taxa were low scoring, so the ASPT was lower than expected. Taxa that were notably absent were high-scoring taxa that are sensitive to changes in water quality (Perlidae, Heptageniidae, Leptophlebiidae and Baetidae >2spp). Three species of Hydropsychidae were present.

9.4.7 Riparian vegetation (C EC, 65.3%)

The site occurs in the Eastern Free State Clay Grassland vegetation type which has a conservation status of Endangered (44.5% remaining and only 0.1% under protection).

Marginal zone: Is dominated by non-woody vegetation (*C. marginatus* mainly), but exotic woody debris is abundant and reduces zone habitat.

Upper zone: Is a mix of terrestrial grasses (soils) and grass/shrub mix where it is rocky and steeper. Extensive grazing occurs in this zone leading to vegetation loss.

9.4.8 PES causes and sources

The PES for the components at EWR 8 as well as the reasons for the PES are summarised in Table 9.6.

Table 9.6 EWR 8: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	D	1	Increased high flows/floods.	Interbasin transfers from Sterkfontein Dam.	F	3
			Decreased base flows, periods of zero flows and decreased floods.	Abstraction, agriculture, Harrismith.	NF	
Physico-chem	C	2.3	Elevated turbidity, habitat loss, cold water and low oxygen levels.	Sterkfontein Dam releases.	F	3
			Elevated N and P at times. Seasonal increase in salts.	WWTW, diffuse runoff from urban and industrial activities (Harrismith and Warden).	NF	
				Abstraction for water purification, tankers, fish dams and agriculture.		
Geom	C	3.5	Decreased transport capacity.	Moderate floods are smaller, but there are occasional high releases from Stekfontein Dam.	F	2.9
			Increased sediment supply.	Erosion of upstream tributaries and channel banks has increased the sediment load.	F/NF	
			Slight reduction in connectivity and change in sediment structure.	High releases (specifically occasional high releases from Stekfontein Dam) have caused cut banks and probably coarsened/armoured channel beds, thus reducing connectivity.		
Rip veg	C	3.4	Vegetation removal.	Extensive grazing on upper zone.	NF	3.6
			Exotic species invasion.	< 10% low impact, but exotic woody debris is unnatural.		
			Water quantity changes.	Non-woody cover increased by reduced low flows and increased fine sediments.	F	

	PES	Conf	Causes	Sources	F/NF	Conf
Fish	C	4	Slightly altered habitat diversity (fluctuation from natural composition) as a result of flow modification.	Abstraction.	F	3
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming and recreational activities.	NF	
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and vegetation removal (grazing) contribute to increased sedimentation.		
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL).	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation / angling.		
			Decreased bottom substrate quality.	Impact of bottom feeding alien CCAR and siltation.		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Dams and various weirs. Also farm dams in tributaries reduce refuge areas.		
Inverts	C/D	3	Water quality.	WWTW, diffuse runoff from urban and industrial activities (Harrismith and Warden).	NF	3
			Decreased low flows.	Abstraction for irrigation.	F	

9.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 9.7.

Table 9.7 EWR 8: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	C	Stable	C		Data indicates a stable trend in nitrogen and negative trend for phosphate. Salt concentrations, EC and pH trends are also stable.	3
Geom	C	Positive	Higher C	5 years	The improved management of Sterkfontein Dam releases and has resulted in the the cut banks on site becoming increasingly vegetated.	3
Rip veg	C	Stable	C		No aggressive aliens present.	4
Fish	C	Stable	C		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the conditions.	3
Inverts	C/D	Stable	C/D		The macroinvertebrates have already adapted to the changes in the system.	3

9.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 9.8. The Instream EC is a C (67.5%).

Table 9.8 EWR 8: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	3.5	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2.5	70		
FISH ECOLOGICAL CATEGORY	11.5	330	**76.1**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	2	100		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	1	30		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	4	40		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**7**	170	**61.0**	**C/D**
INSTREAM ECOLOGICAL CATEGORY (No confidence)	2	100		
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	3	0.43	32.61	
Confidence rating for macroinvertebrate information	4	0.57	34.86	
	7	1.00	67.47	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 9.9). The EcoStatus EC is a C (65.5%).

Table 9.9 EWR 8: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**63.5**	**C**	
ECOSTATUS	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for instream biological information	3.57	0.51	34.57
Confidence rating for riparian vegetation zone information	3.4	0.49	30.97
	6.97	1.00	65.53
ECOSTATUS	**EC**		**C**

9.7 RECOMMENDED ECOLOGICAL CATEGORY (REC)

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 8 is **MODERATE** and therefore the REC is to maintain the PES.

9.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

Two alternative scenarios were designed and are discussed below.

9.8.1 AEC up: B/C

A hypothetical scenario is designed and also includes the following:

- Dry season base flow increase and no zero flows.
- Ongoing improved management of the Sterkfontein Dam releases.
- Reduced grazing, burning and removal of debris.
- Removal of MSAL (although highly impractical, without this removal, the fish EC will not improve).

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 9.10.

Table 9.10 EWR 8: B/C AEC

	PES	AEC	Comments	Conf
Physico -chem	C	B/C	The quality of the WWTW discharges will be improved leading to an improvement of the overall water quality.	4
Geom	C	+C	These more frequent, smaller releases have a smaller impact upon the banks and promote better vegetation development. These would have a positive impact particularly upon the cut banks of the reach.	3
Rip veg	C	B/C	An improvement in EC is only possible if grazing and burning is reduced and debri is removed. Woody cover will improve in the upper zone while non woody species composition will decrease in lower and marginal zone as flows flush sediment and cover is improved with the removal of exotic debris.	4
Fish	C	B	This scenario will not improve the current fish EC since the primary impact on fish is estimated to be the predatory alien MSAL. It is expected that the removal of MSAL from the system will be required to improve the present status, based on fish. It can be expected that if these species are removed or controlled, the FROC of their prey species may be improved (BANO and BPAU).	2.5
Inverts	C/D	C	This scenario will improve habitat availability. Taxa that are expected to re-appear include Leptophlebiidae and a higher diversity of baetids.	3

9.8.2 AEC down: D

A hypothetical scenario includes the following:

- Further decrease of base flows (e.g. an additional dam).
- Decrease in small moderate floods.
- Associated water quality deterioration.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 9.11.

Table 9.11 EWR 8: D AEC

	PES	AEC	Comments	Conf
Physico -chem	C	C/D	Decreased flow will exacerbate water quality related problems from WWTW effluent. It is expected that toxicity will increase as well as salinity and nutrient levels. Temperature and oxygen levels will also be impacted.	3
Geom	C	C/D	This scenario will reduce the scouring of the bed, reduce cobble activation, riparian flooding and is likely to cause bed aggradations.	2.5
Rip veg	C	D	The marginal and lower zone will be impacted by this scenario. It is expected that non - woody cover will increased in these zones.	3.2
Fish	C	D	It can be expected that the FROC of semi-rheophilic species will be influenced negatively. Their feeding and breeding habitats (especially fast shallow, fast deep) will deteriorate and substrate quality can be expected to deteriorate as a result of decreased flushing of silt (related to loss of moderate floods). It can therefore be expected that the FROC of species such as BAEN, ASCL and LCAP will be reduced. Deterioration in water quality may lead to a further decrease in FROC of BPAL, being moderately intolerant to water quality changes.	2.5
Inverts	C/D	D	Increased periods of low flow are likely to cause reduced diversity of caddis and baetid species, and reduced abundance of Elmidae and Hydracarina.	2

9.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 9.12.

Table 9.12 EWR 8: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	Trend	AEC ↑	AEC↓
INSTREAM	C/D	RIPARIAN	C	HYDROLOGY	D			
				WATER QUALITY	C	Stable	B/C	C/D
				GEOMORPHOLOGY	C	Positive	+C	C/D
				Response Components	**PES Category**	**Trend**	**AEC ↑**	**AEC↓**
				FISH	C	Stable	B	D
				MACRO INVERTEBRATES	C/D	Stable	C	D
				INSTREAM	C		B/C	D
				RIPARIAN VEGETATION	C	Stable	B/C	D
				ECOSTATUS	C		B/C	D

IHI Hydro	Diatoms
C	C/D

10 EWR 9: SUIKERBOS US (SUIKERBOSRAND RIVER)

10.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 10.1.

Table 10.1 EWR 9: Summary of data availability

Component	Data availability	Conf
Hydrology	There are no observed flow data (despite a defined station at C2H131).As the present day hydrology does not include the upstream change, the confidence is low.	1
Physico-chemical	Data was available from C2H131Q01 Colliery point on Suikerbosrant River and Rand Water data from C-S1 (2003 - 2008) with n = 92.	2.5
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from two field assessments.	3
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Single site visit and fish sampling during April 2008. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database. Kotze and Niehaus (2000 – 2004): Biomonitoring program for Rand Water. Kotze (2002): *Ecological integrity of Klip & Suikerbosrand River*.	4
Aquatic macro invertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and August 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*. .	3

10.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 10.2) was rated as **HIGH** (present), as there are endangered species at this site, which includes *Labeobarbus kimberleyensis* and the Soweto Highveld grassland vegetation type (conservation status: endangered).

Table 10.2 EWR 9: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	*Labeobarbus kimberleyensis*, Soweto Highveld grassland vegetation type (with endangered conservation status).
Unique (endemic, isolated, etc.)	2	4	*L. capensis*, *Leucosidea sericea.*
Intolerant (flow & flow related water quality)	2.5	3	*L. kimberleyensis*, *L. aeneus*, *L. capensis.*
Species/taxon richness	3	4	20 macroinvertebrate taxa and nine fish species.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2	3	Pools, runs, riffles, bedrock and rapids.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Refugia	3	3	Refuge from water quality from Blesbokspruit.
Sensitivity to flow changes	3	2	Narrow riffle areas.
Sensitivity to flow related water quality changes	2	2	Small stream.
Migration route/corridor (instream & riparian)	2	3	Upstream dams and weirs.
Importance of conservation & natural areas	1	3	Gorge area.
MEDIAN	2.25		
EIS EVALUATION	**HIGH**		

10.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 10.3. Additional information on fish and invertebrate reference conditions are also provided.

Table 10.3 EWR 9: Reference conditions

Component	Reference conditions	Conf
Hydrology	Although the detailed WRSM2000 configuration compiled as part of the VRSAU study was used for the assessment of the natural hydrology, it was still necessary to scale the hydrology which may have cause a reduction in accuracy. Virgin MAR: 31.31 MCM.	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al.* (2005). Refer to Table 2.4.	3
Geomorphology	Denser woody vegetation in the riparian zones. Slightly wider active channel and fewer fines in the pools.	2.5
Riparian vegetation	Marginal zone Expect essentially sedge-dominated vegetation (*Cyperus* spp.) with a minor woody component, instream on cobble (*G. virgatum*) and on the marginal zone (*S. mucronata*). Lower zone Expect grassland dominated vegetation (*Miscanthus* spp.) with woody component (*S. mucronata*). Upper zone Terrestrial grassland.	3
Fish	Ten species present. Refer to Table 2.5.	4
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 7, 15, 16 and 17 (Chutter, 1967: Table 11). The reference SASS5 score is 182 and the ASPT is 6.1.	4

10.3.1 Fish

EWR 9 falls within the Lower foothills geomorphic zone and EcoRegion 11.01, NRU Suiker C, MRU Suiker A and WQSU 15 and reference conditions are applicable for the whole MRU. Reference conditions set for NRHP site C2Suik-Dehoe (Kleynhans *et al.,* 2007) was used for the compilation of reference condition (Table 10.4).

Table 10.4 EWR 9: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 9 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	4	1
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	4	3
Barbus anoplus	Chubbyhead barb	BANO	4	1
Barbus paludinosus	Straightfin barb	BPAU	3	1

Expected Reference and Habitat derived FROC of fish at EWR 9 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	3	0
Clarias gariepinus	Sharptooth catfish	CGAR	4	4
Labeo capensis	Orange River labeo	LCAP	4	3
Labeo umbratus	Moggel	LUMB	3	2
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	4	2
Tilapia sparrmanii	Banded tilapia	TSPA	4	4

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

10.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Hydropsychidae (>2 spp.), Heptageniidae, Hydraenidae, Coenagrionidae, Hydroptilidae, Corixidae, Sphaeriidae, Leptophlebiidae, Caenidae, Ceratopogonidae, Baetidae (>2 spp.), Tricorythidae, Simuliidae, Turbellaria, Potamonautidae, Ecnomidae, Elmidae/Dryopidae, Atyidae, Gomphidae, Chironomidae, Corbiculidae, Aeshnidae, Belostomatidae, Veliidae/M...veliidae, Dytiscidae/Noteridae, Gyrinidae, Oligochaeta, Porifera, Hirudinea and Ancylidae.

10.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

10.4.1 Hydrology (E EC)

Based on the VRSAU Study (DWAF, 1999b) information at the site was considered to be near pristine with limited upstream land use. The present day simulation, however, did not include the impact of a recently built dam owned by Balfour Municipality. The Balfour Dam was constructed on the main stem of the river in 1998 and limited information has been obtained from the DWA Dam Safety Office. Base flow volumes have decreased in wet and dry months due to farm dams upstream of the site. Moderate floods have been reduced but there seems to be no impact on high flows.

10.4.2 Geomorphology (B/C EC, 79%)

There are large areas of relatively pristine sections of this river, and the Suikerbosrand River is often considered as a “reference state” system for the Highveld rivers (which are otherwise generally very highly impacted rivers). The site is a bedrock rapid, and although the reach is generally characterised by long pools, there are a number of such rapids in the reach. The upper terrace is paired on the opposite bank and the lower bench is annually flooded. Erosion in the catchment has increased the fines load of the river, so possibly the pools are infilling and channels are reducing in width due to sedimentation.

10.4.3 Physico chemical variables (C/D EC, 62%)

Four diatom samples were taken at this site (August and December 2007 and January and April 2008). Data from C2H131Q01 (Colliery point on Suikerbosrant River) and Rand Water Data from C-S1 (2003 – 2008; n = 92) was used for the physico-chemical PES assessment.

The August 2007 diatom sample indicated that the biological water quality was good with moderate pollution levels, and that there slightly elevated levels of organically bound nitrogen in the water. The rest of the samples showed a gradual deterioration in biological water quality and the biological water quality is a C EC. Agricultural runoff (nutrients and sediments) are impacting this site. Instream dams (Harhoff and Belfast) for agricultural water supply and farm dams in tributaries are causing higher water temperatures. There are some sand mining activities in the area and may be causing elevated salt concentrations and turbidity levels. Faecal coliforms have seasonal highs while the physico-chemical data indicates that sulphates are low. PES values for the physico-chemical variables are provided in Table 10.5 and in Volume 2 - Appendix C of this report.

Table 10.5 EWR 9: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	197
	Na_2SO_4	258
	$MgCl_2$	22.9
	$CaCl_2$	51.3
	NaCl	44.9
	$CaSO_4$	0.734
Nutrients (mg/L)	SRP	0.05
	TIN	0.32
Physical variables	Electrical conductivity (mS/m)	48 (9.5 – 73)
	pH (5^{th}+95^{th} percentiles)	7.2 – 8.31
	Temperature (ºC)	22 (18-26)
	Turbidity (NTU)	38 (9.7 – 265)
Toxics	Fluoride (mg/L)	0.3
	Ammonia (mg/L)	0.8

10.4.4 Index of Habitat Integrity (IIHI: C EC, 74.5%; RIHI: B EC, 82.6%)

The main impact on instream habitat is the upstream dams (Balfour and Harhoff) and abstraction which have caused flow alteration, and changes in sediment transport. These dams are also barriers within the system. The riparian instream habitat has been altered due to changes in the flooding regime and bank structure.

10.4.5 Fish (D EC, 53%)

Most of the expected fish species are still present at this site. It is expected that ASCL have been lost as a result of the flow modification (Balfour Dam and abstraction), and the FROC of BKIM, BAEN, and LCAP have been reduced. Another prominent reduction in FROC is evident in the small species (BANO, BPAL and PPHI), most probably related to the impact of the predatory alien MSAL.

10.4.6 Macroinvertebrates (D EC, 50.6%)

August 2007:	SASS5 score: 69	No of Taxa: 12	ASPT: 5.8
April 2008:	SASS5 score: 119	No of Taxa: 20	ASPT: 6.0

Composition of macroinvertebrates is variable, depending on releases from Balfour Dam. In August 2007 the flow comprised a trickle only, and various taxa needing higher flows disappeared (Heptageniidae; 3 spp Hydropsychidae; and Hydraenidae). The total SASS score was significantly lower (69) than expected (182), but the ASPT was not significantly different to natural. This suggests that flow changes were more important in determining the PES than any deterioration in water quality. In April 2008, when flows were moderate, the composition of invertebrates recovered significantly (C EC). Overall, the taxa missing or scarce were mainly those that prefer slow or standing water in gravel, sand and mud substrates (Corixidae, Caenidae, Sphaeriidae, Leptophlebiidae, and Ceratopogonidae). The reason for this is not clear.

10.4.7 Riparian vegetation (B/C EC, 78.5%)

This site occurs within the Soweto Highveld Grassland vegetation type, which has an endangered conservation status with 52.7% of the type remaining and only 0.2% protected. Moderate to high rates of alien infestation is present in the lower zone.

10.4.8 PES causes and sources

The PES for the components at EWR 9 as well as the reasons for the PES are summarised in Table 10.6.

Table 10.6 EWR 9: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	E	1	Alteration in flow regime	Upstream Dams (Balfour and Harhoff), farm dams and abstraction.	F	4
Physico-chem	C/D	2.5	Faecal coliforms seasonal highs.	WWTW upstream.	NF	3
			Increased sediment and turbidity.	Agricultural runoff, upstream dams (Balfour and Harhoff).		
			Increased N and P.	Agricultural runoff.		
			Elevated temperatures.	Sand mining activities, upstream dams (Balfour and Harhoff).		
Geom	B/C	3	Reduced transport capacity.	Upstream farm dams and Balfour and Harhoff Dams.	F	2.9
			Increased sediment supply.	Erosion of the upstream tributaries in the farming areas.	NF	
			Slight reduction in connectivity.	Upstream farm dams and two moderately large dams.	F/NF	
			Slight reduction in channel width.	Sedimentation and reduced floods.		
Rip veg	B/C	3.3	Higher than expected woody and non-woody cover.	Reduced or loss of dry season base flows.	F	3.5
			Reduced indigenous riparian species cover and proportions in lower and upper zones.	Moderate to high alien infestation in lower and upper zones respectively.	NF	
Fish	D	3.5	Altered habitat diversity (fluctuation from natural composition) as a result of flow modification (especially low flow).	Balfour Dam and abstraction.	F	3
			Decreased overhanging vegetation as cover for fish.	Increased bank erosion related to agricultural and livestock farming.	NF	4
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and vegetation removal (grazing) contribute to increased sedimentation.		

	PES	Conf	Causes	Sources	F/NF	Conf
			Decreased species diversity and abundance (especially small species) as result of presence of aggressive alien predator (MSAL).	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation/angling.		
			Decreased bottom substrate quality.	Impact of bottom feeding alien CCAR and siltation.		
			Decreased fish species abundance.	Poaching.		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Dams and various weirs. Also farm dams in tributaries reduce refuge areas.		
Inverts	D	3	Increased periods of very low flow.	Upstream dam and abstractions.	F	4

10.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 10.7.

Table 10.7 EWR 9: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	C/D	Negative	D	5 years	Data indicates that P and N levels are increasing due to agricultural runoff.	3
Geom	B/C	Negative	Lower C	5 years	Site and reach will continue to adjust slowly to the increased sediment (from catchment erosion) and decreased floods (from dams).	3
Rip veg	B/C	Negative	C/D	10 years	Aliens are likely to increase (as the assumption is that there are no controls currently in place).	3
Fish	D	Stable	D		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the prevailing conditions.	3
Inverts	D	Stable	D		The macroinvertebrates have already adapted to the changes in the system.	3

10.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 10.8. The Instream EC is a D (50%).

Table 10.8 EWR 9: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**53.3**	**D**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	100		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	55		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	4	79		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**11**	234	**50.4**	**D**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		564	**51.5**	**D**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	3.5	0.64	33.92	
Confidence rating for macroinvertebrate information	2	0.36	18.33	
	5.5	1.00	52.25	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**D**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 10.9). The EcoStatus EC is a C (66%).

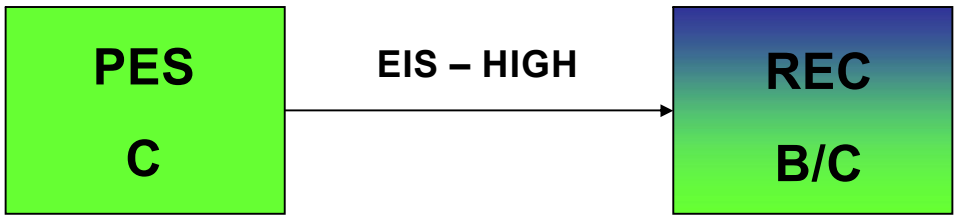
Table 10.9 EWR 9: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**78.5**	**B/C**	
ECOSTATUS	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for instream biological information	2.95	0.47	24.68
Confidence rating for riparian vegetation zone information	3.3	0.53	41.42
	6.25	1.00	66.10
ECOSTATUS	**EC**		**C**

10.7 RECOMMENDED ECOLOGICAL CATEGORY (REC): B/C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 9 is **HIGH** and the REC is therefore an improvement of the PES.



A hypothetical scenario includes the following:

- A hydrological regime with **increased** base flows (released from upstream dams).
- Erosion control measures in the tributaries to address erosion and increased sediment loads in the reach.
- Alien woody vegetation control.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 10.10.

Table 10.10 EWR 9: B/C REC

	PES	REC	Comments	Conf
Physico -chem	C/D	C	This will result in improved DO and temperature similar to natural conditions. There will be a greater dilution of nutrients. The salts and turbidity levels will remain the same as natural levels in this catchment are high.	3
Geom	B/C	B	Erosion control structures will address erosion and increased sediment loads in the reach. This would decrease sediment loads in the main river, inhibit channel narrowing and pool infilling.	2
Rip veg	B/C	B	This will reduce woody and non-woody cover and abundance in the marginal zone, which is currently higher than expected due to lack of inundation disturbance. Indigenous woody cover in the upper zone will improve as aliens are removed and species composition will become more natural as alien proportions decrease. A similar improvement will occur for the indigenous grasses as alien trees that shade them out are removed.	3
Fish	D	C	This scenario could result in suitable habitats for the maintenance of ASCL assemblages. If these conditions are regained, and ASCL cannot recruit this area due to the "chemical" migration barrier of DS section after Blesbokspruit inflow, they may have to be reintroduced. Improved flows will also result in improved FS habitats with potential improvement in FROC of BAEN and BKIM. Improved flows may also result in improved water quality which would be reflected by higher FROC of species such as BPAL and BKIM. The smaller barb species will however not improve, as their habitats are presently suitable, and it is estimated that the primary impact on this group is the predatory alien MSAL. Improved flooding would also improve substrate quality (flushing of silt and algae) which will benefit species such as ASCL, BAEN, BPAL, BANO, LCAP and LUMB.	3
Inverts	D	C	This scenario is likely to improve habitat availability for flow-dependent taxa. Improved baseflows are expected to result in an macroinvertebrate composition similar to that which was observed in April 2008. Key taxa expected at the site with improved baseflows include Hydropsychidae > 2 sp, Heptageniidae, Coenagrionidae, Corixidae and Leptophlebiidae and Baetidae >2sp.	3

10.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

An AEC D scenario was not developed as the macroinvertebrates and fish are already in a D EC. A D AEC would involve the maintenance of the current ECs of fish and macroinvertebrates and a deterioration of the riparian vegetation EC. Any flow related changes will however cause deterioration in the riparian vegetation EC and would result in the instream and biota ECs to drop to an E.

10.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results for setting EWR scenarios are summarised in Table 10.11.

Table 10.11 EWR 9: Summary of EcoClassification results

IHI				Driver Components	PES Category	Trend	REC
INSTREAM	C	RIPARIAN	B	HYDROLOGY	E		
				WATER QUALITY	C/D	Negative D	C
				GEOMORPHOLOGY	B/C	Negative C	B
				Response Components	**PES Category**	**Trend**	**REC**
				FISH	D	Stable	C
				MACRO INVERTEBRATES	D	Stable	C
				INSTREAM	D		C
				RIPARIAN VEGETATION	B/C	Negative C/D	B
				ECOSTATUS	C		B/C

IHI Hydro	Diatoms
B	C

11 EWR 10: SUIKERBOS DS (SUIKERBOSRAND RIVER)

11.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 11.1.

Table 11.1 EWR 10: Summary of data availability

Component	Data availability	Conf
Hydrology	Two gauges were used for the assessment. C2H070: 19 year flow record (1977 – 1996). Measures low flows and zero flows inaccurately. C2H004: 56 year flow record with 18 year gap (1952 – 2008). Measures low flows and zero flows accurately.	2
Physico-chemical	Data was available from C2H004Q01 Suikerbosrant River at Vereeniging Weir (RW S2) (1984 – 2000) with n = 649.	3
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from two field assessments.	3.5
Riparian vegetation	Google Earth imagery and aerial photos.. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Single site visit and fish sampling during April 2008. Rivers data base (2007): *Database on fish distribution in South African Rivers*. Scott *et al.* (2006): *Atlas of Southern African Freshwater Fishes*. SAIAB data base (2006). Kleynhans *et al.* (2007): FROC database. Kotze and Niehaus (2000 – 2004): Biomonitoring program for Rand Water. Kotze (2002): *Ecological integrity of Klip & Suikerbosrand River.*	4
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	4

11.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 11.2) was rated as **MODERATE** (present).

Table 11.2 EWR10: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	4	4	Vegetation type (Soweto Highveld Grassland) with endangered conservation status.
Unique (endemic, isolated, etc.)	2	3	*Labeo capensis*, *Austroglanis sclateri*, *Leucosidea sericea* (Ouhout).
Intolerant (flow & flow related water quality)	2.5	4	*Labeobarbus kimberleyensis*, *L. capensis*, *Labeobarbus aeneus* and *A. sclateri*.
Species/taxon richness	2	4	15 macroinvertebrate taxa (low), 9 fish species.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2	3	Long pools, runs, rapids, and riffles.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Refugia	2	3	Movement of fish from the barrage.
Sensitivity to flow changes	1.5	3	Wider than EWR 9.
Sensitivity to flow related water quality changes	2	3	
Migration route/corridor (instream & riparian)	2	3	Important link between Vaal and Upper Suikerbosrand reach.
Importance of conservation & natural areas	0	4	
MEDIAN	2		
EIS EVALUATION	**MODERATE**		

11.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 11.3. Additional information on fish and macroinvertebrates reference conditions is also provided.

Table 11.3 EWR 10: Reference conditions

Component	Reference conditions	Conf
Hydrology	Flow records were available from C2H070 and C2H004. Disaggregation of land use information decreases accuracy of naturalized flows. Virgin MAR: 86.98 MCM.	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al. (2005)*. Refer to Table 2.4.	3
Geomorphology	Site is currently not very different from natural, but under reference conditions the following is expected: Denser woody vegetation in the riparian zones (maintained by more frequent moderate floods). Probably a slightly larger proportion of fines on the bed (these having been scoured due to the elevated base flows). Less erosion of the banks.	2
Riparian vegetation	Marginal zone Expect narrow band of vegetation dominated by sedges (*C. marginata* mainly), with small reed component in places. Lower zone Expect a patchy mix of sedges (similar to marginal zone) and grasses, with small woody component (*S. mucronata* mainly). Upper zone Expect typical grassland dominated banks and terrestrial zone with some woody component in protected pockets (*Rhus* spp. mainly).	4
Fish	Ten species expected. Refer to Table 10.4.	4
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967) from Sites 7, 15, 16 and 17 (Chutter, 1967: Table 11). The reference SASS5 score is 182 and the ASPT is 6.1.	4

11.3.1 Fish

EWR 10 falls within the Lowland geomorphic zone and EcoRegion 11.01, NRU Suiker C, MRU Suiker B and WQSU 17. Reference conditions are applicable for the whole MRU Suiker B reach. Reference conditions set for the NRHP site C2Suik-Badfo (Kleynhans *et al.,* 2007) was used for the compilation of reference condition (Table 11.4).

Table 11.4 EWR 10: Reference conditions

Expected Reference and Habitat derived FROC of fish at EWR 10 (Values used in FRAI) Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock catfish	ASCL	4	1
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	4	4
Barbus anoplus	Chubbyhead barb	BANO	4	2
Barbus paludinosus	Straightfin barb	BPAU	3	0
Labeobarbus kimberleyensis	Largemouth yellowfish	BKIM	3	1
Clarias gariepinus	Sharptooth catfish	CGAR	4	3
Labeo capensis	Orange River labeo	LCAP	4	4
Labeo umbratus	Moggel	LUMB	3	1
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	4	4
Tilapia sparrmanii	Banded tilapia	TSPA	4	4

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

11.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Ancylidae, Hydropsychidae > 2 sp, Heptageniidae, Elmidae/Dryopidae, Leptophlebiidae, Turbellaria, Hydraenidae, Coenagrionidae, Hydroptilidae, Ceratopogonidae, Sphaeriidae, Baetidae > 2 sp, Tricorythidae, Simuliidae, Potamonautidae, Ecnomidae, Atyidae, Gomphidae, Corixidae, Chironomidae, Corbiculidae, Oligochaeta, Caenidae, Aeshnidae, Belostomatidae, Veliidae/M...veliidae, Dytiscidae/Noteridae, Gyrinidae, Porifera and Hirudinea

11.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

11.4.1 Hydrology (D EC)

Several land uses are present upstream from the EWR site, including mining consumptive use and dewatering, paved urban runoff enhancements (i.e. runoff from impervious portions of urbanised areas) and urban consumptive use and return flows. The most recent information on actual water use and mine discharges were obtained and used for the simulation of the present day flows. Observed flows from both stations indicate far lower flows than simulated present day flows although the observed record is relatively short. Base flows have increased in volume from natural. These changes are continuous throughout the year and are due to the upstream land uses. Present day MAR: 149.27 MCM.

11.4.2 Geomorphology (C EC, 74.4%)

The site is representative of the reach. Although the floods are relatively natural, the upstream confluence with the Blesbokspruit River has resulted in increased base flows due to mine dewatering. The banks are largely natural, although some erosion is present in places and has

increased in the catchment due to increased fines load of the river. Water quality is impacting the marginal vegetation, which is in turn is destabilizing the banks as the vegetation dies off.

11.4.3 Physico chemical variables (D/E EC, 40%)

Four diatom samples were taken at this site (August and December 2007 and January and April 2008). All four samples indicate that pollution levels are extreme and that the poor water quality of the Blesbokspruit River impacts heavily on this site. Nutrient loading, organic pollution and salinity are a major concern and mine water decant and industrial effluent impact at critical levels. Toxics, oxygen and temperature are also variables of concern at this site. Due to the continual elevated flows the impacts are diluted constantly. The biological water quality was assessed as a C/D EC due to the dilution effect. It must however be noted that this is not a true reflection of prevailing conditions and that a slight reduction in flows will cause the biological water quality to deteriorate rapidly to a D or E category. This site is the most severely impacted site of all the EWR sites assessed, and urgent management action is needed to prevent major biological water quality impacts on biota in the near future.

The current water quality status of the lower Suikerbosrand River is driven by the water quality of the Blesbokspruit River discussed under section 12.4.3. Low and moderated flows in the Suikerbosrand River are being changed by increased Blesbokspruit River base flows. PES values for the physico-chemical variables are provided in Table 11.5 and in Volume 2 - Appendix C of this report.

Table 11.5 EWR 10: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	326
	Na_2SO_4	361
	$MgCl_2$	30.5
	$CaCl_2$	162
	NaCl	233
	$CaSO_4$	0.73
Nutrients (mg/L)	SRP	0.15
	TIN	0.268
Physical variables	Electrical conductivity (mS/m)	140 (16 - 235)
	pH (5^{th}+95^{th} percentiles)	7 – 8.53
	Temperature (ºC)	22 (17 - 27)
	Turbidity (NTU)	15 (1.2 – 27)
Toxics	Fluoride (mg/L)	0.551
	Ammonia (mg/L)	0.14

11.4.4 Index of Habitat Integrity (IIHI: C EC, 64%; RIHI: C EC, 77%)

The major impact on instream habitat integrity is anthropogenic activities (e.g. mines and Sappi) and urban stormwater runoff that has caused increased runoff, water quality problems and scouring. Riparian integrity is mainly impacted by increased floods due to anthropogenic activities and farming as cattle trampling is evident and impacting on bank structure.

11.4.5 Fish (C/D EC, 61%)

Most of the expected fish species are still present within this. It is expected that BPAL has been lost from this reach as a result of the deteriorated water quality and increased flows (loss of slow habitats). This loss of slow habitats also influenced other species with a preference for this habitat

such as BANO, LUMB and possibly also CGAR. ASCL and BKIM assemblages have been altered due to substrate deterioration (sediment and algae) as well as water quality. Another prominent reduction in FROC is evident in the small species (BANO, BPAL and PPHI) as a result of the presence of the predatory alien MSAL. Other alien species GAFF and CCAR are also expected to have an impact on the indigenous species, especially regarding breeding (egg and larvae disturbance and predation). Migration barriers in the form of weirs also affect the fish assemblages of this reach to some extent.

11.4.6 Macroinvertebrates (C/D EC, 59.3%)

September 2007:	SASS5 score: 64	No of Taxa: 13	ASPT: 4.9
April 2008:	SASS5 score: 85	No of Taxa: 15	ASPT: 5.7

The SASS Scores (64 and 86) were significantly lower than expected (182), and results were very low in relation to the quality of biotopes available. Likewise, the ASPT results (4.9 and 5.7) were significantly lower than expected (6.1). The results suggest that habitat availability is having a significant impact on the composition. Three species of caddisflies and three species of blackflies indicate significant improvement compared to EWR 9, further upstream. However, all species present were tolerant of water quality deterioration. Taxa that were missing or scarce were those that prefer moderately fast-flowing water (e.g. Elmidae; Hydraenidae; Turbellaria), and taxa that are sensitive to water quality deterioration and found in cobble biotopes (e.g. Baetidae; Hydropsychidae; Elmidae). Heptageniidae were present on one occasion, and shrimps were present on both occasions.

11.4.7 Riparian vegetation (C EC, 62.4%)

This site occurs within the Soweto Highveld Grassland vegetation type, which has an endangered conservation status with 52.7% of the type remaining and only 0.2% protected. Increased dry season base flows have resulted in the loss of marginal vegetation. There are high levels of exotic species present in the lower and upper zones.

11.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 11.7.

Table 11.6 EWR 10: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	D	4	Elevated base flows and increased floods.	Mines, SAPPI, urban runoff.	NF	3
			Increased low and moderated flows.	Suikerbosrand River being changed by increased Blesbokspruit River base flows.	F	
Physico-chem	D/E	3	High salts (electrical conductivity and sulphates).	Mine water decants (point sources) of saline water – some of which are being pretreated and released above Merrievale wetland.	F	3
				Diffuse runoff from mining activities and urban runoff.	NF	
			Faecal contamination (potential water borne disease) and high nutrients (mainly phosphates).	Point source discharges from WWTW, runoff from formal and informal settlements.		

	PES	Conf	Causes	Sources	F/NF	Conf
			Increased nutrient loading and algal growth.	WWTW, agriculture.		
Geom	C	3	Increased transport capacity.	Moderate floods are larger due to baseflow increase from mine dewatering as well as development from the upper catchment.	F	2.9
			Increased sediment supply.	Erosion of the headwaters of upstream tributaries in farming areas has increased the sediment load.	NF	
			Slight reduction in connectivity.	Upstream small farm dams and two moderately large dams.	NF	
			Change in sediment structure.	Sedimentation, reduced floods and increased base flow together may offset each other slightly.	F/NF	
Rip veg	C	3.3	Loss of marginal zone vegetation.	Increased dry season base flows.	F	3.2
			Reduction in lower and upper zone species cover and composition.	High levels of aliens.	NF	
Fish	C/D	3.5	Altered habitat composition (slow habitats transformed to fast habitats).	Increased flows / altered hydrological regime.	F	4
			Decreased overhanging vegetation as cover for fish.	Grazing, agriculture and water level fluctuations.	NF	
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and vegetation removal (grazing) contribute to increased sedimentation.		
			Decreased species diversity and abundance (especially small species).	Presence of aggressive alien predatory species (MSAL) and GAFF naturally spreading and introduced for recreation / angling.		
			Decreased bottom substrate quality.	Impact of bottom feeding alien CCAR and siltation.		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Dams and various weirs. Also farm dams in tributaries reduce refuge areas.		
Inverts	C/D	3.5	Water quality problems, particularly elevated salinity and bacteria.	Industries (Mines, Sappi) and urban storm water.	NF	4
			Benthic algae.	Elevated nutrients and clear water.		
			High base flows.	Decanting mines, sewage treatment works and seepage from urban development.	F	

11.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity are stable or still changing. The results are summarised in Table 11.7.

Table 11.7 EWR 10: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico -chem	D/E	Slight negative	D/E	5 years	Salts (EC) and sulphate data indicate a downward trend over the past 5 years while nutrients and faecal coliforms indicate increasing levels.	3
Geom	C	Slow negative	C	5 years	Anticipated continuing slow adjustment of the channel to the current flows.	3

	PES	Trend	Trend PES	Time	Reasons	Conf
Rip veg	C	Negative	D	10 years	Aliens will continue to increase.	3
Fish	C/D	Stable	C/D		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the prevailing conditions.	3
Inverts	C/D	Stable	C/D		The macroinvertebrates have already adapted to the changes in the system.	3

11.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 11.8. The Instream EC is a C/D (60.1%).

Table 11.8 EWR 10: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**61.0**	**C/D**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	3	90		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	3	80		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	4	100		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**10**	270	**59.3**	**C/D**
INSTREAM ECOLOGICAL CATEGORY (No confidence)	3	90		
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	3.5	0.50	30.50	
Confidence rating for macroinvertebrate information	3.5	0.50	29.65	
	7	1.00	60.15	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**C/D**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 11.9). The EcoStatus EC is a C/D (61.2%).

Table 11.9 EWR 10: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	62.4	C	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	3.5	0.51	30.96
Confidence rating for riparian vegetation zone information	3.3	0.49	30.28
	6.8	1.00	61.24
ECOSTATUS	EC		C/D

11.7 REC: C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 10 is **MODERATE** and the REC is therefore to maintain the PES.

11.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

Two alternative scenarios were designed and are discussed below.

11.8.1 AEC up: C

The hypothetical scenario is based on improved water quality management in the Blesbokspruit catchment. The biotic condition of the biota will improve under this scenario although no improvement will be evident in the riparian vegetation component. The riparian vegetation EC is associated with increased flows rather than water quality.

NOTE: The recommendations at EWR 9 are to improve the low flows in the dry season. This could increase flows to the level that is problematic at EWR 10. This will have to be treated as a scenario in a systems context and evaluated.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 11.10.

Table 11.10 EWR 11: C AEC

	PES	AEC	Comments	Conf
Physico -chem	D/E	D	Salinity levels will decrease along with nutrients and faecal coliforms. Improved quality of industrial discharges will improve toxic levels as well.	3
Geom	C	C	This scenario will have no impact on the geomorphology.	3
Rip veg	C	C	The scenario will not improve riparian vegetation.	3
Fish	C/D	C	Improved water quality should benefit the species with requirement for high quality water. It may therefore result in conditions suitable for BPAL, as well as the improved FROC of species such as ASCL and BKIM. Habitat quality will improve with a decrease in benthic algae.	3
Inverts	C/D	C	Improved water quality is likely to reduce the growth of benthic algae, and this is expected to improve habitat availability in riffles. The changes are expected to increase the diversity of Baetidae, Hydropsychidae and Simuliidae. Other taxa that are expected to appear with improved water quality are Leptophlebiidae, Elmidae, Hydraenidae and Heptageniidae. The SASS scores and ASPT are expected to improve accordingly.	3

11.8.2 AEC down: D

The hypothetical scenario is based on:

- Increased base flows.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 11.11.

Table 11.11 EWR 11: D AEC

	PES	AEC	Comments	Conf
Physico -chem	D/E	D/E	This would not result in a deterioration of water quality but rather a dilution effect which would improve the water quality.	2
Geom	C	-C	This scenario will increase bank and bed scour in the channel, and result in a lower condition of the geomorphology, although still within the C EC.	2.5
Rip veg	C	D	This scenario will cause prolonged duration of inundation in marginal and lower zones and also reduce sediment. This will cause further inundation of the marginal and lower zones with associated loss of vegetation cover and abundance, especially in the marginal zone.	2.5
Fish	C/D	D	Increased base flows will further reduce the availability of slow habitats and alter the FROC of species with a preference/requirement for these habitats (BANO, TSPA, PPHI, LCAP, BAEN and even CGAR).	3
Inverts	C/D	D	Increased base flows will select against taxa that prefer standing and slow-flowing water, such as Caenidae, Notonectidae, Pleidae, Veliidae and Dytiscidae. The overall diversity of macroinvertebrates is therefore expected to be reduced.	2

11.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 11.12.

Table 11.12 EWR 10: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	Trend	AEC ↑	AEC↓	IHI Hydro	Diatoms
INSTREAM	C	RIPARIAN	C	HYDROLOGY	D				B	C/D
				WATER QUALITY	D/E	Negative	D	D/E		
				GEOMORPHOLOGY	C	Negative C	C	-C		
				Response Components	PES Category	Trend	REC	AEC↓		
				FISH	C/D	Stable	C	D		
				MACRO INVERTEBRATES	C/D	Stable	C	D		
				INSTREAM	C/D		C	D		
				RIPARIAN VEGETATION	C	Negative D	C	D		
				ECOSTATUS	C/D		C	D		

12 EWR 11: BLESBOKSPRUIT (BLESBOKSPRUIT RIVER)

12.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 12.1.

Table 12.1 EWR 11: Summary of data availability

Component	Data availability	Conf
Hydrology	A four year flow record was available from C2H133. The gauge does not measure low and zero flows accurately. No additional data could be obtained from Rand Water.	2
Physico-chemical	Data was available from C2H133Q01 and Rand Water: C-B10 at Heidelberg on Blesbokspruit River (2003 - 2008), n = 227.	2.6
Geomorphology	Historical aerial photographs from Land Surveyors Offices. Google Earth imagery of the site, reach and catchment. Information from field assessment.	3.5
Riparian vegetation	Google Earth imagery and aerial photos. Hydraulic cross-section (profile) at the site together with surveyed key vegetation points for setting flows. Data collected from field assessment in April 2008. Report information used: Ecological reports and specialist assessments for this study. Available floristic data – biomes, bioregions and vegetation type etc.	4.5
Fish	Single site visits and fish sampling during April 2008. Rivers Database (2007): *Database on fish distribution in South African Rivers*. Scott *et al.*, 2006: *Atlas of Southern African Freshwater Fishes*. South African Institute of Aquatic Biodiversity (SAIAB) Data base (2006). Kleynhans *et al.,* 2007: FROC database. Kotze and Niehaus (2000 – 2004): *Biomonitoring program for Rand Water*.	4
Macroinvertebrates	Two SASS5 surveys were undertaken to determine the PES during April 2008 and August 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	4

12.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 12.2) was rated as **LOW** (present), as this site is characterised by water quality problems and elevated flows.

Table 12.2 EWR11: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	1	4	Tsakane Clay Grassland Vegetation Unit with endangered conservation status.
Unique (endemic, isolated, etc.)	0	3	
Intolerant (flow & flow related water quality)	1	3	*L. aeneus*.
Species/taxon richness	2	3	7 fish species, 16 macroinvertebrate taxa.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2	3	Runs, riffles and pools.
Refugia	1	4	Not significant at any scale due to the water quality problems and increased flows.
Sensitivity to flow changes	1	3	Medium sized river.

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
Sensitivity to flow related water quality changes	2	3	Small to medium sized river.
Migration route/corridor (instream & riparian)	1.5	2.5	
Importance of conservation & natural areas	0	3	
MEDIAN	1		
EIS EVALUATION	**LOW**		

12.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 12.3. Additional information on physico-chemical variables, fish and invertebrate reference conditions are also provided.

Table 12.3 EWR 11: Reference conditions

Component	Reference conditions	Conf
Hydrology	A four year flow record was available from C2H133. There are several landuses upstream of the site and disaggregation of land use decreases accuracy of naturalized flows. Virgin MAR: 29.14 MCM.	3
Physico-chemical	Benchmark tables were used according to Kleynhans *et al. (2005)*. Refer to Table 2.4.	3
Geomorphology	Less steep, more well vegetated banks. Finer material on the beds of the river. Narrower active channel, possibly less deep than currently.	2.5
Riparian vegetation	Marginal zone Expect narrow band of vegetation dominated by sedges (*C. marginata* mainly), with small reed component in places. Lower zone Expect a patchy mix of sedges (similar to marginal zone) and grasses, with small woody component (*S. mucronata* mainly). Upper zone Expect typical grassland dominated banks and terrestrial zone with some woody component in protected pockets (*Rhus* spp. mainly).	4
Fish	Ten species expected. Refer to Table 12.4.	3
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 15 and 16 (Chutter, 1967: Table 11). The reference SASS5 score is 164 and the ASPT is .5.9.	3

12.3.1 Fish

EWR 11 falls within the Lower foothills geomorphic zone and EcoRegion 11.03, NRU Bles A, MRU Bles A and WQSU 4 and reference conditions are applicable for this downstream section of MRU Bles A (downstream of Marievale/Nigel. Reference conditions as set for the NRHP site C2Bles-Marai (Kleynhans *et al.,* 2007) was used for EWR 11 reference condition s (Table 12.4).

Table 12.4 EWR 11: Reference fish species

Expected Reference and Habitat derived FROC of fish at EWR 11 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Austroglanis sclateri	Rock-catfish	ASCL	2	0
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	4	3
Barbus anoplus	Chubbyhead barb	BANO	4	2
Barbus paludinosus	Straightfin barb	BPAU	3	1

Expected Reference and Habitat derived FROC of fish at EWR 11 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Clarias gariepinus	Sharptooth catfish	CGAR	3	2
Labeo capensis	Orange River labeo	LCAP	4	3
Labeo umbratus	Moggel	LUMB	4	0
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	3	0
Tilapia sparrmanii	Banded tilapia	TSPA	4	4

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

12.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Hydropsychidae > 2 sp, Simuliidae, Heptageniidae, Ecnomidae, Elmidae/Dryopidae, Potamonautidae, Hydraenidae, Hydroptilidae, Corbiculidae, Gomphidae, Sphaeriidae, Leptophlebiidae, Aeshnidae, Dytiscidae/Noteridae, Belostomatidae, Caenidae, Ceratopogonidae, Hirudinea, Baetidae > 2 sp, Turbellaria, Oligochaeta, Coenagrionidae, Pleidae, Veliidae/M...veliidae, Gyrinidae, Chironomidae and Ancylidae.

12.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

12.4.1 Hydrology (D/E EC)

Several land uses are present upstream from the EWR site, including mining consumptive use and dewatering, paved urban runoff enhancements and urban consumptive use and return flows. There is also a wetland upstream of this EWR site. Due to upstream activities the base flows have increased significantly from natural. This change is continuous throughout the year. Present day MAR: 100.69 MCM.

12.4.2 Geomorphology (C EC, 65.9%)

Due to the large increases in base flows the active channel banks are cutting, and the competence[8] of the river has increased. Water quality is impacting the marginal vegetation, which is in turn would destabilize the banks as the vegetation dies off. Paired terraces occur on each bank and instream features have been scoured out due to increased flows and recent floods.

12.4.3 Physico chemical variables (D/E EC, 40%)

Four diatom samples were taken at this site (August and December 2007 and January and April 2008). Data from C2H133Q01 and Rand Water C-B10 at Heidelberg on Blesbokspruit (2003 - 2008) with n = 227 was used for the physico-chemical PES assessment.

All four diatom samples indicate that pollution levels are extreme and that the Blesbokspruit River is of poor water quality. Organic pollution, metal contamination and salinity are a major concern

[8] The maximum size or weight of material a river can transport. In times of flood, a river's competence will increase – it will be able to carry bigger particles (http://www.slideshare.net/jacksonthree/river-transportation-hjulstrom-curve).

and mine water decant and industrial effluent impact at critical levels. Oxygen and temperature are also variables of concern at this site. Due to the continual elevated flows the impacts are diluted constantly. The biological water quality was assessed as a C/D EC due to the dilution effect. It must however be noted that this is not a true reflection of prevailing conditions and that a slight reduction in flows will cause the biological water quality to deteriorate rapidly to a D or E category.

The current water quality status of the Blesbokspruit is driven by the following:

- Mine water decants (point sources) of saline water – some of which are being pre-treated and released above the wetland. This results in high salts as seen in electrical conductivity and sulphates measurements.
- Diffuse runoff from mining activities on the Witwatersrand that are over 100 years old such as waste dumps and slimes dams. When it rains in the summer the salts are washed off the mine waste dumps and enter the surface and groundwater. In the winter months there are highly mobile particles that are blown around which have an effect on human health (respiratory).
- Urban runoff originating from large numbers of formal and informal settlements which results in faecal contamination (potential water borne diseases) and high nutrients (mainly phosphates) from unsewered areas.
- Point source discharges from waste water treatment works. These treatment works infrastructure are currently under capacitated and the final effluent discharged rarely meets the discharge requirements.
- Point and source discharges from industries such as SAPPI.
- Higher base flows due to higher surface area of impervious surfaces, return effluents from WWTW, mine water decants.

PES values for the physico-chemical variables are provided in Table 12.5 and in Volume 2 - Appendix C of this report.

Table 12.5 EWR 11: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	483
	Na_2SO_4	427
	$MgCl_2$	15.3
	$CaCl_2$	186
	NaCl	311
	$CaSO_4$	0.73
Nutrients (mg/L)	SRP	0.1
	TIN	0.56
Physical variables	Electrical conductivity (mS/m)	210
	pH (5^{th}+95^{th} percentiles)	6.7 – 8.8
	Temperature (ºC)	22 (17 - 27)
	Turbidity (NTU)	13 (0.4 - 310)
Toxics	Fluoride (mg/L)	0.35
	Ammonia (mg/L)	0.67

12.4.4 Index of Habitat Integrity (IIHI: D/E EC, 41.3%; RIHI: C EC, 64.9%)

The major impact on instream habitat integrity is anthropogenic activities (e.g. mines and Sappi) and urban stormwater runoff that has caused increased runoff, water quality problems and scouring. Riparian integrity is mainly impacted by increased floods due to the anthropogenic

activities and water quality problems which are causing the die off of reeds in some places and increased growth in other places.

12.4.5 Fish (D EC, 44.8%)

Most of the expected fish species have been altered within this RU. It is expected that ASCL has been lost from this reach as a result of the deteriorated water quality and substrate habitats. LCAP and LUMB have also most probably been lost as a result of water quality deterioration and especially loss of substrate quality. The loss of slow habitats influenced species such as BANO, BPAL, BPAU and LUMB and possibly also CGAR with a preference for slow habitats. The presence of alien species GAFF and CCAR are also expected to have an impact on the indigenous species, especially regarding breeding (egg and larvae disturbance and predation). Migration barriers in the form of weirs also affect the fish assemblages of this reach to some extent.

12.4.6 Macroinvertebrates (D/E EC, 39.8%)

August 2007:	SASS5 score: 57	No of Taxa: 14	ASPT: 4.1
April 2008:	SASS5 score: 61	No of Taxa: 16	ASPT: 3.8

The composition of macroinvertebrates is highly modified from expected natural conditions, and extremely low in relation to the availability of biotopes. The only species of baetid mayfly recorded was *Baetis harrisoni,* which is well-known to be highly tolerant to water quality deterioration. Likewise, the only species of hydropsychid caddisfly was *Cheumatopsyche thomasetti,* while the only species of blackfly was *Simulium adersi*. Both these species are highly tolerant to water quality deterioration. The SASS Scores (57 and 61) were significantly lower than expected (164). Likewise, the ASPT (4.1 and 3.8) was significantly lower than expected (5.9). Notable taxa that were absent included those that are sensitive to water quality (e.g. Heptageniidae), as well as taxa that prefer slow-flowing water (e.g. Sphaeriidae, Leptophlebiidae and Caenidae). The absence of the latter taxa reflects the elevated base flows that occur at this site.

12.4.7 Riparian vegetation (D EC, 46.6%)

The site occurs within the Tsakane Clay Grassland vegetation unit, which has a conservation status of “Endangered”, mainly because only 24% of this vegetation type remains, with only 1.5% under protection.

Marginal zone: Has no sedges; these appear to be "drowned out", and only non-woody vegetation is present that is associated with sediment i.e. *Phragmites* and *Typha.* Woody vegetation is absent.

Lower zone: Similarly is dominated by reeds and *Typha*, with *Schoenoplectus* spp. Indigenous woody species are also absent. Loss of indigenous species due to overgrazing.

Upper zone: Characterised by grassland species, but indicative of overgrazing (*Stoebe* spp.) and woody species are minimal. Loss of indigenous species due to overgrazing.

12.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 12.6.

Table 12.6 EWR 11: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	D/E	5	Higher base flows and increased floods.	Higher surface area of impervious surface. Return effluents from WWTW. Mine water decants.	NF	3
Physico-chemical	D/E	3	High salinity levels.	Mine water decants and waste dump diffuse pollution. Some of which are being pretreated and released above Merriespruit wetland.	F	3
			Traces of metals such as arsenic and cyanide.	From mines, mine ground water discharges, and industrial discharges. Large surface area of wetlands, urban runoff as well as constant groundwater temperature releases.		
			Diurnal temperature changes.	High algal growth – rooted macrophytes, filamentous, exotic floating macrophytes (Water hyacinth) and single cell blooms. Can result in diurnal oxygen fluctuations that can cause fish kills.		
			Microbial contamination (potential water borne disease) and high nutrients.	Urban runoff from large number of formal and informal settlements as well as point source discharges from waste water treatment works.	NF	
			Elevated water temperatures.	Large surface area of wetlands, urban runoff as well as constant groundwater temperature releases. .		
Geom	C	3.5	Increased transport capacity due to increased base flows.	Primarily dewatering from the mines; but also sewage return flows and runoff from urban areas.	F	3
			Morphological change: Cutting of the active channel banks; increased channel competency.	Increased base flows.		
			Increased sediment supply.	Erosion of the upstream tributaries and locally from eroding banks.	NF	
			Slight reduction in connectivity.	Upstream small dams and weirs.		
Rip veg	D	3.4	Loss of marginal zone vegetation.	Increased flows.	F	4.5
			Loss of riparian habitat.	Erosion from bridge, localized effect.		
			Change in species composition.	Exotic species, but small influence.	NF	
			Loss of indigenous species.	Overgrazing in lower and upper zones.		
Fish	D	4	Altered habitat composition (slow habitats transformed to fast habitats).	Increased flows / altered hydrological regime.	F	3
			Altered bottom substrate habitats result in loss of fish species diversity.	Increased filamentous algal growth related to increased nutrients.	NF	
			Decreased overhanging vegetation as cover for fish.	Grazing, agriculture and water level fluctuations.		
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion, residential areas and vegetation removal (grazing) contribute to increased sedimentation.		
			Decreased species diversity and abundance (especially small species) as result of presence of GAFF that preys on larvae.	Presence of aggressive alien predatory species (MSAL) and GAFF naturally spreading and introduced for recreation / angling.		
			Decreased bottom substrate quality.	Impact of bottom feeding alien CCAR and siltation.		

	PES	Conf	Causes	Sources	F/NF	Conf
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Dams and various weirs. Also farm dams in tributaries reduce refuge areas..		
Macroinvertebrates	D/E	5	High baseflows.	Decanting mines, sewage treatment works and seepage from urban development.	F	4
			Water quality problems, particularly elevated salinity and bacteria.	Industries (Mines, Sappi) and urban stormwater.	NF	
			Benthic algae.	Elevated nutrients and clear water.		
			Sediment (sand).	Large amount of sand from general erosion in catchment and sand mining.		

12.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity are stable or still changing. The results are summarised in Table 12.7.

Table 12.7 EWR 11: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	D/E	Negative	D/E	5 years	Data indicates that salts (EC), sulphates and nitrogen have a negative trend. Pphosphates have a strong positive trend since 2006 and faecal coliforms have a slight upward trend.	2
Geom	C	Negative	C/D	5 years	Due to anticipated continuing development in the upstream catchment, as well as further adjustment of the channel to the current flows.	3
Rip veg	D	Negative	D/E	5 years	Continued response to quality (unsure of response) and unchecked alien vegetation.	2
Fish	D	Stable	D		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the prevailing conditions.	3
Inverts	D/E	Stable	D/E		The macroinvertebrates have already adapted to the changes in the system.	3

12.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 12.8. The Instream EC is a D/E (41.7%).

Table 12.8 EWR 11: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**44.8**	**D**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	10		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	2	50		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	4	100		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**10**	160	**39.8**	**D/E**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		490	**41.8**	**D/E**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	3	0.38	16.80	
Confidence rating for macroinvertebrate information	5	0.63	24.88	
	8	1.00	41.68	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**D/E**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 12.9). The EcoStatus EC is a D (43.4%).

Table 12.9 EWR 11: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**45.6**	**D**	
ECOSTATUS	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for instream biological information	4.25	0.56	23.15
Confidence rating for riparian vegetation zone information	3.4	0.44	20.27
	7.65	1.00	43.42
ECOSTATUS	**EC**		**D**

12.7 REC: D

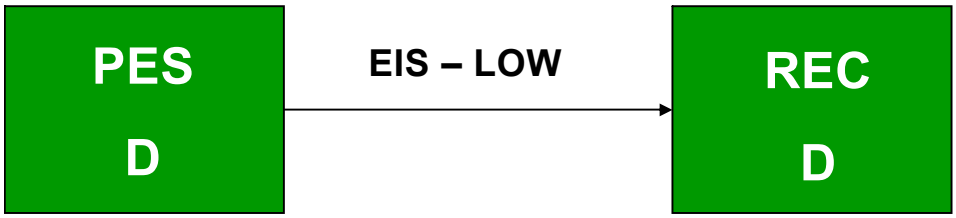
The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at EWR 11 is **LOW** and the REC is therefore to maintain the PES with macroinvertebrates improving to a D EC.

An improved EcoStatus based on a hypothetical flow regime is not feasible at this site. Decreased flows as a scenario is unattainable and will result in deteriorated water quality.

The improvement of the macroinvertebrate EC is only possible with improved water quality. Improved water quality is only possible with better water quality management, which is unlikely, but feasible at a cost. Due to the huge amount of salts in the system, this improvement will only be a long term option.

The implications for setting flows are the following:
Flow requirements to maintain the present state would be based on present flows. Only increased flows can be evaluated as a scenario to determine whether increased flows (with either improved or the same water quality) will maintain the EcoStatus.



Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are provided electronically and summarised in Table 12.10.

Table 12.10 EWR 11: D REC

	PES	REC	Comments	Conf
Physico -chem	D/E	D	Salinity levels will decrease along with nutrients and faecal coliforms. Improved quality of industrial discharges will improve toxic levels as well.	3
Geom	C	C	This scenario will not improve the geomorphology.	4
Rip veg	D	+D	Regain reed and *Typha* vigour, cover, and abundance (note that this is an interim improvement as these are not the vegetation types expected under reference conditions.	2
Fish	D	C	Improved water quality will directly benefit species intolerant to water quality deterioration such as BPAL, and also LCAP, BAEN, ASCL and BANO (moderately tolerant). Improved water quality (decreased nutrients) should result in decreased growth of filamentous algae, with resultant improved substrate quality (especially in riffles/rapids). This should provide suitable habitats for ASCL and LCAP to re-colonise this river section.	2.5
Inverts	D/E	D	Improved water quality is likely to reduce the growth of benthic algae, and this is expected to improve habitat availability in the riffle, as well as oxygen levels. The changes are expected to increase the diversity of Baetidae, Hydropsychidae and Simuliidae. Other taxa that are expected to appear with improved water quality are Leptophlebiidae, Elmidae, Hydraenidae and Aeshnidae. The total SASS scores and ASPT are expected to improve accordingly. The diversity of taxa that prefer slow flowing water is unlikely to change because no significant changes in the flow patterns are considered achievable.	3

12.8 SUMMARY OF ECOCLASSIFICATION RESULTS

The results for setting EWR scenarios are summarised in Table 12.11.

Table 12.11 EWR 11: Summary of EcoClassification results

IHI				Driver Components	PES Category	Trend	REC
INSTREAM	D/E	RIPARIAN	C	HYDROLOGY	D/E		
				WATER QUALITY	D/E	Negative D/E	D
				GEOMORPHOLOGY	C	Negative C/D	C
				Response Components	PES Category	Trend	REC
				FISH	D	Stable	C
				MACRO INVERTEBRATES	D/E	Stable	D
				INSTREAM	D/E		C/D
				RIPARIAN VEGETATION	D	Negative D/E	D
				ECOSTATUS	D		D

IHI Hydro	Diatoms
E	C/D

13 RE - EWR 1: KLEIN VAAL (KLEIN VAAL RIVER)

13.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 13.1.

Table 13.1 RE - EWR 1: Summary of data availability

Component	Data availability	Conf
Hydrology	No gauges in the area, and therefore no observed data.	1
Physico-chemical	Klein Vaal – Wonderfontein 100001153 (2004 – 2008; n = 24) and Rand Water C-VKV at Goodehoop (2003 – 2008; n = 56). The only literature available for this site is Chutter (1967).	1.5
Geomorphology	Google Earth imagery of the site, reach and catchment Site visit photos from other specialists One historical photograph of the site (circa 1960) No site assessment was conducted by the geomorphologist – this was an ***entirely desktop exercise.*** A **level III GAI** was applied to the site.	2
Riparian vegetation	Photographic assessment only.	2
Fish	Single site visits and fish sampling during September 2007. Scott *et al.*, 2006: *Atlas of Southern African Freshwater Fishes*. South African Institute of Aquatic Biodiversity (SAIAB) Data base (2006). Kleynhans *et al.,* 2007: FROC database. Kotze and Niehaus (2000 – 2004): *Biomonitoring program for Rand Water*.	2.5
Macroinvertebrates	One survey was undertaken during September 2007. Report information used: Ecological reports and specialist assessments for this study. Chutter (1967): *Hydro biological Studies of the Vaal River*.	2

13.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 13.2) was rated as **MODERATE** (present).

Table 13.2 RE-EWR1: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING (0 - 4)	CONF	
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	0	3	
Unique (endemic, isolated, etc.)	1	4	*Labeo capensis*, Leucosidea sericea (Ouhout).
Intolerant (flow & flow related water quality)	1.5	2	*Labeo capensis*, *L. aeneus.*
Species/taxon richness	2	3	7 fish species, 24 macroinvertebrate taxa.
RIPARIAN & INSTREAM HABITATS			
Diversity of types	1.5	3	Pools and riffles.
Refugia	1	3	
Sensitivity to flow changes	3	3	Small river, sensitive riffles.
Sensitivity to flow related water quality changes	2.5	3	
Migration route/corridor (instream & riparian)	0.5	3	
Importance of conservation & natural areas	0.5	2	
MEDIAN	1.25		
EIS EVALUATION	**MODERATE**		

13.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 13.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 13.3 RE - EWR 1: Reference conditions

Component	Reference conditions	Conf
Hydrology	Natural hydrology was scaled to EWR site which may have cause a reduction in accuracy. Small catchment area with a small amount of upstream land use.	4
Physico-chemical	Benchmark tables were used according to Kleynhans *et al.* (2005). Refer to Table 2.4.	3
Geomorphology	Less steep, more well vegetated banks (currently cut and trampled). Finer material on the beds of the river (bed appears armoured in present condition).	2
Riparian vegetation	Marginal zone Sedge dominated. Lower zone Sedge/grass mix. Upper zone Grass dominated (mainly terrestrial grasses), with woody component.	2
Fish	Seven species expected. Refer to Table 13.3.	2
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 21 and 21A (Chutter, 1967: Table 11). The reference SASS5 Score is 179 and the ASPT is 6.4.	4

13.3.1 Fish

RE - EWR R1 falls within the Lower foothills geomorphic zone and EcoRegion 11.02, MRU KVaal A and WQSU 1 of quaternary catchment C11C. Reference conditions are applicable for the reach from upstream of the water transfer outfall to the origin of the Klein Vaal River. Reference conditions set for site for NRHP C1Vaal-unspe (Kleynhans *et al.,* 2007) was used for the compilation of reference condition for the RE - EWR 1 (Table 13.4).

Table 13.4 RE - EWR 1: Reference fish species

Expected Reference and Habitat derived FROC of fish at RE - EWR 1 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Barbus anoplus	Chubbyhead barb	BANO	4	3
Labeobarbus aeneus	Smallmouth yellowfish	BAEN	3	3
Labeo capensis	Orange River labeo	LCAP	3	2
Tilapia sparrmanii	Banded tilapia	TSPA	3	2
Barbus pallidus	Goldie barb	BPAL	3	1
Labeo umbratus	Moggel	LUMB	1	1
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	4	3

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

13.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Atyidae, Hydroptilidae, Sphaeriidae, Oligochaeta, Perlidae, Tricorythidae, Hydropsychidae > 2 sp, Psephenidae, Simuliidae, Turbellaria, Potamonautidae, Heptageniidae, Leptoceridae, Hydraenidae, Coenagrionidae, Gomphidae, Corixidae, Chironomidae, Tipulidae, Caenidae,

Leptophlebiidae, Nepidae, Notonectidae, Pleidae, Dytiscidae/Noteridae, Gyrinidae, Ceratopogonidae, Hydracarina, Baetidae > 2 sp and Ancylidae.

13.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

13.4.1 Hydrology (A/B EC)

No suitable hydrological information was available for this site which is largely natural. The following information provided is for a point downstream of the transefer and may be usefull for EWR 1 as the transfer also inpacts EWR 1.

There is a relatively high amount of unlawful irrigation water use upstream of site. However, this is overshadowed with the Heyshope Dam transfers that are made in support of Grootdraai Dam. There has been an increase in base flow volume which is continuous throughout the year and the seasonal distribution has changed with flows being stable throughout the year.

13.4.2 Geomorphology (B/C EC, 78.8%)

The bed is armoured with steep cut banks. Banks are trampled and less vegetated than under reference condition.

13.4.3 Physico chemical variables (B/C EC, 80%)

One diatom sample was taken at this site during September 2007. Data from Klein Vaal – Wonderfontein 100001153 (2004 – 2008; n = 24) and Rand Water C-VKV at Goodehoop (2003 – 2008; n = 56) was used for the physico-chemical PES assessment.

The SPI index indicates very good water quality, and the diatom based ecological classification indicates high oxygen saturation and circumneutral water. The diatom water quality is in a B. The physico-chemical data indicates fairly good quality water although some impacts are detected. TDS could be from diffuse impacts originating from farming – mainly erosion and cattle watering and Ammonia levels are elevated due to cattle watering and faeces, and this is evident in the diatom samples with the presence of *Navicula antonii*, *Eolimna minima*, *Reimeria uniserata* and *Nitzschia sinuata var. tabellaria.* There are indications that the water temperature is elevated at times due to the presence of *Epithemia adnata and Acnanthidium exiguum.* The site has Increased PES values for the physico-chemical variables are provided in Table 13.5 and in Volume 2 - Appendix C of this report.

Table 13.5 RE - EWR 1: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	Not available.	
Nutrients (mg/L)	SRP	0.05
	TIN	0.25
Physical variables	Electrical conductivity (mS/m)	41
	pH (5^{th}+95^{th} percentiles)	7.1 – 8.18
	Temperature (ºC)	17 - 27
	Turbidity (NTU)	12 (4.8 - 105)

Water Quality Constituents		Value: PES
Toxics	Fluoride (mg/L)	0.125
	Ammonia (mg/L)	0.46

13.4.4 Index of Habitat Integrity ((IIHI: B EC, 84.9%; RIHI: B EC, 86.9%)

The main impact on instream habitat is farming activities and roads which have led to increased abstraction, and bed and bank modification. Farming activities and roads has caused bank structure modification which is impacting on the riparian habitat integrity of the site.

13.4.5 Fish (B EC, 87%)

All of the fish species expected under reference conditions is expected to still be present within this RU although the FROC of some species have been reduced from reference conditions. Some species have been affected as a result of deterioration of substrate due to siltation (LCAP, BPAL). Some species has also been affected as a result of decreased availability of overhanging vegetation (BANO, BPAL, PPHI, and TSPA). The potential presence of MSAL (alien predator) may be another potential contributor to decreased FROC of these small species. Increased flows downstream of site as result of the water transfer scheme may affect migration of some species to the upper reach to some extent.

13.4.6 Macroinvertebrates (A/B EC, 90.9%)

September 2007: SASS5 score: 152 No of Taxa: 24 ASPT: 6.3

The diversity of macroinvertebrates was high despite limited habitats available. The total SASS score was slightly lower (152) than expected (179), while the ASPT was not significantly different (6.3) to expected (6.4). Sensitive taxa recorded at the site included water pennies, three species of Hydropsychidae, Leptophlebiidae, Heptageniidae and water mites. Taxa that were noticeably scarce were shrimps, earthworms and pill clams. Mosquitoes were not expected but were common. The data suggest that water quality is excellent, but that habitats have deteriorated, presumably because of limited flows.

13.4.7 Riparian vegetation (D EC, 43.9%)

The site occurs in the Wakkerstroom Montane Grassland vegetation which has a conservation status of “Least threatened”, with 93.4% remaining.

Marginal zone: Is denuded and badly trampled. No vegetation is visible in September (trampled) or November (flooded). There is a high degree of erosion.

Upper Zone: Woody, mainly *Leucosidea sericea,* which is very dense and indicates overgrazing.

13.4.8 PES causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 13.6.

Table 13.6 RE - EWR 1: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	A/B	3	Decreased base flows.	Abstraction for irrigation.	F	3
Physico-chem	B/C	1.7	Elevated Ammonia.	Cattle watering and faeces.	NF	3
			Elevated nitrogen and phosphate at times.	Agriculture.		
			Increased salinity.			
Geom	B/C	2	Morphological change.	Catle grazing has destabilised the banks locally. Banks are denuded of vegetation and cut.	NF	2
			Reduced system connectivity.	Small dams in the tributaries.		
			Altered reach sediment balance.	Dams are trapping sediment, but the many eroded tributaries have increased the sediment load.		
			Altered channel perimeter resistance.	The cut banks and reduced vegetation.		
Rip veg	D	3.4	Change in species composition and loss of expected vegetation cover and abundance.	High grazing and trampling pressure.	NF	2
Fish	B	2	Some limited loss of fast habitats.	Farm dams and abstraction and livestock watering.	F	2.5
			Decreased overhanging vegetation as cover for fish.	Grazing, agriculture.	NF	
			Increased sedimentation result in deterioration of substrate as habitat (clogging interstitial spaces, loss of important spawning habitats, etc.).	Bank erosion and vegetation removal (grazing) contribute to increased sedimentation.		
			Potential decreased FROC of small species as result of presence of aggressive alien predator (MSAL).	Presence of aggressive alien predatory species (MSAL) naturally spreading and introduced for recreation/angling.		
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Farm dams limit migration into tributaries and downstream water transfer may limit some migration of species in the downstream section.		
Inverts	A/B	4	Reduced low flows and associated changes in habitat availability and elevated temperatures caused by shallow flows over bedrock substrate.	Abstraction and off-channel farm dams.	F	3

13.5 PES TREND

The PES for the components as well as the reasons for the PES are summarised in Table 13.7.

Table 13.7 RE - EWR 1: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	B/C	Negative	B/C	5 years	Salt concentrations (sulphates and electrical conductivity) are increasing.	1.5
Geom	B/C	Negative	C	5 years	Due to anticipated continuing erosion of the banks.	2

	PES	Trend	Trend PES	Time	Reasons	Conf
Rip veg	D	Stable	E	5 years	Grazing and trampling pressure.	2
Fish	B	Stable	B		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the prevailing conditions.	3
Inverts	A/B	Stable	A/B		The macroinvertebrates have already adapted to the changes in the system.	3

13.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 13.8. The Instream EC is an A/B (89.6%).

Table 13.8 RE - EWR 1: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**87.1**	**B**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	10		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	2	50		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	4	100		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**10**	160	**90.8**	**A/B**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		490	**89.3**	**A/B**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	2	0.33	29.03	
Confidence rating for macroinvertebrate information	4	0.67	60.53	
	6	1.00	89.57	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**A/B**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 13.9). The EcoStatus EC is a C (66.5%).

Table 13.9 RE - EWR 1: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	43.9	D	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	3.3	0.50	44.34
Confidence rating for riparian vegetation zone information	3.4	0.50	22.17
	6.7	1.00	66.51
ECOSTATUS	EC		C

13.7 REC: C

The REC is determined based on ecological criteria only and considers the EIS, the restoration potential and attainability there-of.

The EIS at RE - EWR 1 is **MODERATE** and the REC is to maintain the PES. The C EcoStatus is due to the riparian vegetation EC of a D as the instream EC is an A/B. The riparian vegetation PES (C EC) is due to non-flow related impacts (grazing and trampling) and highly likely a very localised impact. For the purposes of Reserve templates, an EcoStatus of an A/B will be run, thus ignoring the influence of the riparian vegetation score on the overall EcoStatus.

13.8 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

An AEC up will not be evaluated as the Instream EC is already an A/B.

13.8.1 AEC down: C/D

A hypothetical scenario includes the following:

- Decreased base flows.
- Increased periods of zero flows during dry season.

Each component is adjusted to indicate the metrics that will react to the scenarios. The changes in the rule based models are available electronically in Table 13.10.

Table 13.10 RE - EWR 1: C/D

	PES	AEC	Comments	Conf
Physico -chem	B/C	B/C	This scenario will not cause deterioration in water quality although temperature and DO will be impacted by zero flow conditions.	2

	PES	AEC	Comments	Conf
Geom	B/C	B/C	This scenario is unlikely to have a major impact upon the geomorphological EC, since the main reasons for the current condition are non-flow related (cattle trampling, erosion and dams in the catchment). .	2
Rip veg	D	D	This scenario will not change the riparian EC as impacts are non-flow related.	2
Fish	B	C	This scenario will result in a decreased FROC of species with a preference for flowing habitats (BAEN and LCAP).	2
Inverts	A/B	C	The scenario is likely to cause a number of flow dependent taxa to disappear. This includes water pennies, Tricorythidae, and species of Hydropsychidae and Baetidae. Shrimps may also be affected. The total SASS score is expected to drop to 97, and the ASPT to 4.9.	2

13.9 SUMMARY OF ECOCLASSIFICATION RESULTS

The results to be used for setting of EWR scenarios are summarised in Table 13.10.

Table 13.11 RE - EWR 1: Summary of EcoClassification results

IHI				Driver Components	PES and REC Category	AEC↓
INSTREAM	B	RIPARIAN	B	HYDROLOGY	A/B	
				WATER QUALITY	B/C	B/C
				GEOMORPHOLOGY	B/C	B/C
				Response Components	PES Category	REC
				FISH	B	C
				MACRO INVERTEBRATES	A/B	C
				INSTREAM	A/B	C
				RIPARIAN VEGETATION	D	D
				ECOSTATUS	C	C/D

IHI Hydro	Diatoms
A/B	B

14 RE - EWR 2: MOOI RIVER (MOOI RIVER)

14.1 DATA AVAILABILITY

Detailed information regarding available data is provided in the specialist appendices (Volume 2). Summarised data is given in Table 14.1.

Table 14.1 RE - EWR 2: Summary of data availability

Component	Data availability	Conf
Hydrology	Data was available from C2R003. It has a 60 year flow record but does not measure low and zero flows accurately.	2
Physico-chemical	Data was available from C2H006 Klerkskraal at Klerkskraal Dam on Mooi River for 1981 – 2008; n = 50.	2.1
Fish	Single site visits and fish sampling during September 2007. Scott *et al.*, 2006: *Atlas of Southern African Freshwater Fishes*. South African Institute of Aquatic Biodiversity (SAIAB) Data base (2006). Kleynhans *et al.,* 2007: FROC database. Kotze and Niehaus (2000 – 2004): Biomonitoring program for Rand Water.	2.5
Macroinvertebrates	One survey undertaken during September 2007. Report information used: Chutter (1967): *Hydro biological Studies of the Vaal River*.	1

14.2 ECOLOGICAL IMPORTANCE AND SENSITIVITY

The EIS (Table 14.2) was rated as **LOW** (present). The possibility of the occurrence of AJOH needs to be confirmed as this will be a new distribution for this species. The EIS was assessed as if AJOH does occur here.

Table 14.2 RE - EWR2: EIS results

DETERMINANTS/METRICS	PRESENT		COMMENTS
	RATING	CONF	
	(0 - 4)		
BIOTA (RIPARIAN & INSTREAM)			
Rare & endangered	0	4	
Unique (endemic, isolated, etc.)	4	4	*Aplocheilichthys johnstoni* (species to be confirmed).
Intolerant (flow & flow related water quality)	1	3	*Barbus paludinosus* and *Aplocheilichthys johnstoni*.
Species/taxon richness	2	3	8 fish species
RIPARIAN & INSTREAM HABITATS			
Diversity of types	2	4	Bedrock riffle, reed banks and peat.
Refugia	1	3	Refuge from quality from Wonderfonteinspruit, and the entire downstream physical disturbance.
Sensitivity to flow changes	1	2	Riffle areas.
Sensitivity to flow related water quality changes	2	3	Wetland acting as buffer.
Migration route/corridor (instream & riparian)	0	3	Dams and quality preventing migrations.
Importance of conservation & natural areas	0	4	
MEDIAN	1		
EIS EVALUATION	**LOW**		

14.3 REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 14.3. Additional information on fish and macroinvertebrate reference conditions are also provided.

Table 14.3 RE - EWR 2: Reference conditions

Component	Reference conditions	Conf
Hydrology	The natural hydrology was simulated at this site as part of the VRSAU Study and no scaling was required. However large uncertainty existed regarding the effects of the dolomitic spring near Ventersdorp.	2
Physico-chemical	Benchmark tables were used according to Kleynhans *et al*. (2005). Refer to Table 2.4.	
Fish	Eight species expected. Refer to Table 14.3.	2.5
Macroinvertebrates	Reference conditions are based on professional judgment and Chutter (1967), from Sites 7, 15, 16 and 17 (Chutter, 1967: Table 11). The reference SASS5 Score is 145 and the ASPT is 6.0.	1

14.3.1 Fish

RE - EWR 2 falls within the Lower foothills geomorphic zone and EcoRegion 11.01, NRU Mooi B, MRU Mooi B and WQSU 1 of quaternary catchment C23G. Reference conditions set for the NHRP site C2MOOI-KLERK (Kleynhans *et al.,* 2007) was used for the compilation of reference condition and is applicable for MRU Mooi B (Table 14.4).

Table 14.4 RE - EWR 2: Reference fish species

Expected Reference and Habitat derived FROC of fish at RE - EWR 2 (Values used in FRAI). Observed species (HIGHLIGHTED)				
Scientific Names	**Common Name**	**Spp abbreviation**	**Reference FROC**	**Derived FROC**
Barbus anoplus	Chubbyhead barb	BANO	4	3
Barbus Pallidus	Goldie barb	BPAL	3	2
Barbus paludinosus	Straightfin barb	BPAU	3	1
Barbus trimaculatus	Threespot barb	BTRI	3	1
Clarias gariepinus	Sharptooth catfish	CGAR	4	4
Pseudocrenilabrus philander	Southern mouthbrooder	PPHI	4	3
Tilapia sparrmannii	Banded tilapia	TSPA	4	3
Aplocheilichthys johnstoni	Johnston's topminnow	AJOH	2	1

FROC ratings:
0 = absent
1 = present at very few sites (<10%)
2 = present at few sites (>10 - 25%)
3 = present at about >25 - 50 % of sites
4 = present at most sites (>50 - 75%)
5 = present at almost all sites (>75%)

14.3.2 Macroinvertebrates

Macroinvertebrate taxa expected under reference conditions include:
Ancylidae, Hydropsychidae > 2 sp, Heptageniidae, Leptophlebiidae, Hydraenidae, Atyidae, Coenagrionidae, Hydroptilidae, Caenidae, Corixidae, Oligochaeta, Gyrinidae, Baetidae > 2 sp, Turbellaria, Potamonautidae, Hydracarina, Aeshnidae, Belostomatidae, Notonectidae, Pleidae, Veliidae/M...veliidae, Ceratopogonidae, Chironomidae and Simuliidae.

14.4 PRESENT ECOLOGICAL STATE

The component assessment models for the PES are part of the electronic information (DWA 2010a) provided with the final report (DWA, 2010b).

14.4.1 Hydrology (E EC)

Present day flows simulated at this site are influenced by spills from the upstream Klerkskraal Dam, constructed in 1969. Releases for irrigation water use are made from Klerkskraal Dam into a canal system. Klerkskraal Dam is also used to support the downstream Boskop Dam. Owing to the relatively high river losses that occur, a portion of the natural spills from Klerkskraal Dam are also diverted into the canal system. Since the latter is done on an ad hoc basis, it was not incorporated in the WRPM operating rules. The present day simulation, therefore, did not take this into account. The EWR site receives only spills from the reservoir (apart from a small leak) and therefore there has been a decrease in base flow volume that occurs continually throughout the year. This has also impacted on the frequency of floods.

14.4.2 Physico chemical (C/D EC, 60%)

Two diatom samples were taken at this site (August 2007 and January 2008). Data from C2H006 Klerkskraal at Klerkskraal Dam on Mooi River (1981 – 2008; n = 50) was used for the physico-chemical PES assessment.

Biological water quality of the August sample was bad (SPI score: 5.3) and the diatom based ecological classification indicated very low oxygen saturation and alkaline water. The diatom water quality was a D/E EC. Elevated inorganic nitrogen levels and salinity was evident and the diatom indices indicate a completely altered state and that polysaprobic conditions prevail. As the flow was very low during the August 2007 sampling, the low water quality score can be attributed to the fact that the site was stagnant and humic conditions prevailed. The dam does not release in low flows but overtops (water released in an irrigational canal). .

The biological water quality of the January 2008 sample was good (SPI score: 16.4) with high oxygen saturation and circumneutral water indicating that water quality of the Klerkskraal Dam is good. The overall biological water quality is a C. Releases from the Klerkskraal dam play an important role in the dilution of agricultural based pollution. Salinity, nutrient loading, temperature, and BOD can become problematic in this reach if regular releases are not made from the dam.

The Klerkskraal Dam is fed from Dolomitic water from the Bovensteoog which is approximately 1 km upstream of the dam and therefore the water quality is at least a B/C EC in the dam. During low flow situations in the river from Klerkskraal Dam to Boskop Dam the water quality would be influenced by return flow from large scale irrigation systems (maize) which would result in increased salinity as well as elevated nutrient levels. The high epiphytic algal growth on the rocks was evident in the late winter survey (August 2007).

There is instream peat and sand mining downstream of the EWR site which would result in higher turbidity and possible higher ammonia levels due to rotting organics. The river has been channelized and in some areas the reedbeds have been removed. The loss of the reeds and the channelization has reduced the potential of the wetlands to clean up or filter some of the instream water quality.

The Wonderfonteinspruit and associated impacts of the Randfontein and Libanon, West Driefontein gold mines flow into the Mooi River above the Boskop Dam. The mining impacts have high salinity (sulphates and electrical conductivity) as well as reportedly high radioactivity levels. It is projected that the EC of the Mooi River above the Boskop Dam will be a D/E. PES values for the physico-chemical variables are provided in Table 14.5 and in Volume 2 - Appendix C of this report.

Table 14.5 RE - EWR 2: Physico-chemical PES values

Water Quality Constituents		Value: PES
Inorganic salts (mg/L)	$MgSO_4$	242
	Na_2SO_4	5.45
	$MgCl_2$	56.0
	$CaCl_2$	52.8
	NaCl	9.69
	$CaSO_4$	0.69
Nutrients (mg/L)	SRP	0.05
	TIN	0.14
Physical variables	Electrical conductivity (mS/m)	49.79
	pH (5^{th}+95^{th} percentiles)	7.8 – 8.6
Toxics	Fluoride (mg/L)	0.2
	Ammonia (mg/L)	0.4

14.4.3 Wetland Habitat integrity (E)

Naturally this reach would have been a wetland with a badly defined channel. Therefore the Wetland Index of Habitat Integrity (WETLAND-IHI) was used to assess the driver state of the site as a surrogate for a more detailed EcoClassification approach. The overall score for the habitat integrity of the Mooi River floodplain from immediately below the Klerkskraal Dam to the Boskop Dam is an E EC (Table 14.6). This means that the reach is considered as "*seriously modified"* and that *"the loss of natural habitat, biota and basic ecosystem functions is extensive"* (Kleynhans *et al*, 2007). The individual components assessed are described below.

Vegetation Alteration

The alteration to the vegetation has been significant. Extensive peat mining across large areas of the former valley bottom wetland areas together with drainage for farming has resulted in highly modified vegetation of the wetland area.

Hydrology

There has been an enormous change in the hydrology of the wetland. This is due to both the catchment level of impacts, whereby the upstream Klerkskraal Dam only spills occasionally, and there is very little flow being maintained down the formerly strongly perennial channel.

Additionally, on the wetland surface itself there have been critical changes to the wetting regime of the floodplain. This is due both to the effects of peat mining and the removal of the wetland vegetation and substrate, as well as the construction of canalised sections of the river which now prevent flooding on to the former floodplain.

Geomorphology

The morphological integrity of the Mooi River section is highly altered from the Reference State, again due primarily to the effects of the peat mining which has occurred here.

Water Quality

The water quality in this reach ranges from a C to an E condition, the latter low values being the result of the impact of the Wonderfonteinspruit. The Wonderfonteinspruit has high levels of radioactive minerals in the water. A median D EC was recorded for this component of the model to represent this reach of river.

Table 14.6 WETLAND IHI for RE - EWR 2

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	**Weighting**	**Score**	**Confidence Rating**	**PES Category**
DRIVING PROCESSES:		**100**	**3.6**		
Hydrology	1	100	4.0	3.3	**E/F**
Geomorphology	2	80	3.5	3.0	**E**
Water Quality	3	30	2.7	0.0	**D**
WETLAND LANDUSE ACTIVITIES:		**80**	**3.3**	**3.0**	
Vegetation Alteration Score	1	100	3.3	3.0	**E**
OVERALL SCORE:			**3.5**	**Confidence Rating**	
	PES %		**30.7**		
	PES Category:		**E**	**2.5**	

14.4.4 Fish (C EC, 62.4%)

All of the fish species expected under reference conditions is expected to still be present within this RU although the FROC of some species have been reduced from reference conditions. The primary change in FROC is probably associated with altered habitats related to flow modification by Klerkskraal Dam (reduced fast habitats and decreased deep habitats). This impact can be expected to influence most of the species to a limited extent. Another potential impact is the expected presence of alien predators MSAL and *Micropterus dolomieu* (MDOL), which would impact on most of the indigenous species (most species small barbs and tilapias). The presence of migration barriers both up- and downstream of the reach may furthermore contribute to the degradation in the FROC of the indigenous species.

14.4.5 Macroinvertebrates (E EC, 36.3%)

September 2007: SASS5 score: 29 No of Taxa: 9 ASPT: 3.1

Very low diversity of macroinvertebrates present, with a total of 9 SASS5 taxa only. The ASPT was very low (3.1) compared to the expected (6.0), and the total SASS5 score (29) was very low to the reference value (143). The highest scoring taxa were blackflies and biting midges. SIC provided reasonable to good biotope for flow-dependent invertebrates, although much of this was covered in benthic filamentous algae during the field survey in August 2007.

14.4.6 Riparian vegetation (D EC, 51%)

Marginal zone: There is a high degree of channel manipulation due to the bridge crossing and some canalization. The zone is dominated by herbaceous non-woody vegetation. There are a high proportion of exotic weeds as well as *S. babylonica*. Non-woody cover is reduced or absent due to habitat loss and species composition indicates a loss of wetland species due to physical disturbance and the presence of exotic species.

Lower zone: The zone is dominated by herbaceous non-woody vegetation with a small woody component. Woody cover is higher than expected, as some terrestrial woodies have gained access due to the road/bridge approach although no indigenous species were recorded. Non-woody cover has been reduced and there has been a loss of wetland species due to the high proportion of exotics.

14.4.7 PES: Causes and sources

The PES for the components as well as the reasons for the PES are summarised in Table 14.7.

Table 14.7 RE-EWR 2: Causes and sources

	PES	Conf	Causes	Sources	F/NF	Conf
Hydro	E	4	Reduction of base flows and moderate floods.	Klerkskraal Dam.	F	2
Physico-chem	C/D		High salinity (sulphates and electrical conductivity) as well as reportedly high radioactivity.	Associated impacts of the Randfontein and Libanon, West Driefontein gold mines.	NF	3
			Increased ammonia and turbidity levels.	Peat and sand mining.		
			Increased nutrient loading and algal growth.	Irrigation return flows.	F	
Rip veg	D	2	Increased exotic species	Physical disturbance	NF	3
Fish	C	2	Some loss of fast habitats.	Flow modification due to upstream dam.	F	3.25
			Potential decreased FROC of small species as result of presence of aggressive alien predators (MSAL and MDOL).	Presence of aggressive alien predatory species (MSAL and MDOL) naturally spreading and introduced for recreation/angling.	NF	
			Presence of migration barriers reduces migration success (breeding, feeding and dispersal) of some species.	Upstream dam limits longitudinal migration in Mooi River and farm dams limit migration into tributaries.		
			Slightly deteriorated water quality influence species intolerant to water quality alterations.	Agricultural and mining activities and upstream dam.		
Inverts	E	3	Very low flows.	Klerkskraal Dam.	F	2
			Deteriorated water quality.	Peat and sand mining, agriculture.	NF	

14.5 PES TREND

An estimate was made whether the components responding to the main drivers (quality and quantity) are stable or still changing. The results are summarised in Table 14.8.

Table 14.8 RE - EWR 2: Trend

	PES	Trend	Trend PES	Time	Reasons	Conf
Physico-chem	C/D	Stable	C/D		Data indicates a slight increase in nitrogen, but this river is highly dependant on how the gold mines managed their water in the next 5 to 10 years.	2

	PES	Trend	Trend PES	Time	Reasons	Conf
Fish	C	Stable	C		It is estimated that the fish species have been exposed to the current impacts over a long period, and that they have adapted to the prevailing conditions.	3
Inverts	E	Stable	E		The macroinvertebrates have already adapted to the changes in the system.	2

14.6 PES ECOSTATUS

To determine the EcoStatus, the macroinvertebrates and fish results must be combined to determine an Instream EC. Results are given in Table 14.9. The Instream EC is a D (46.7%).

Table 14.9 RE - EWR 2: Instream EC

INSTREAM BIOTA	Importance Score	Weight	EC %	EC
FISH				
1.What is the natural diversity of fish species with different flow requirements	2.5	70		
2.What is the natural diversity of fish species with a preference for different cover types	4	100		
3.What is the natural diversity of fish species with a preference for different flow depth classes	3.5	90		
4. What is the natural diversity of fish species with various tolerances to modified water quality	2	70		
FISH ECOLOGICAL CATEGORY	12	330	**62.4**	**C**
MACROINVERTEBRATES				
1. What is the natural diversity of macroinvertebrate biotopes	4	10		
2. What is the natural diversity of macroinvertebrate taxa with different velocity requirements	2	50		
3. What is the natural diversity of macroinvertebrate taxa with different tolerances to modified water quality	4	100		
MACROINVERTEBRATE ECOLOGICAL CATEGORY	**10**	160	**36.3**	**E**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		490	**47.0**	**D**
INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**	
Confidence rating for fish information	2	0.40	24.96	
Confidence rating for macroinvertebrate information	3	0.60	21.78	
	5	1.00	46.74	
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**D**	

To determine the EcoStatus, the VEGRAI EC and confidence is included in the EcoStatus assessment index (Table 14.10). The EcoStatus EC is a D (48.6%).

Table 14.10 RE - EWR 2: EcoStatus

RIPARIAN VEGETATION	EC %	EC	
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	51.0	D	
ECOSTATUS	Confidence rating	Proportions	Modified weights
Confidence rating for instream biological information	2.6	0.57	26.42
Confidence rating for riparian vegetation zone information	2	0.43	22.17
	4.6	1.00	48.59
ECOSTATUS	EC		D

14.7 AECs TO SERVE AS THE RANGE OF ECOLOGICAL RESERVE SCENARIOS

Some very rare constricted areas with small riffles occur in this reach. This site is downstream of the Klerkskraal Dam and about the only site with remnants of wetland intact. This is a short section. The rest of the MRU is very badly degraded and would be in a lower EcoStatus. Downstream of the Wonderfonteinspruit inflow, the bad water quality would be the overriding concern. The PES is a D and the rest of the MRU would be in an E or even lower. It will not be possible to improve the category by improving flows as the fish is already in a C EC and the riparian vegetation EC is due to non-flow related impacts. However, the macroinvertebrate EC might improve to at least a D with some improved flow.

14.8 SUMMARY OF ECOCLASSIFICATION RESULTS

The results for setting EWR scenarios are summarised in Table 14.11.

Table 14.11 RE - EWR 2: Summary of EcoClassification results

Driver Components	PES Category
HYDROLOGY	E
WATER QUALITY	C/D
WETLAND HABITAT INTEGRITY	E
Response Components	**PES Category**
FISH	C
MACRO INVERTEBRATES	E
INSTREAM	D
RIPARIAN VEGETATION	D
ECOSTATUS	D

Diatoms
C

15 SUMMARY OF RESULTS AND CONCLUSIONS

The EcoClassification results are summarised below in Table 15.1.

Table 15.1 EcoClassification Results summary

EWR 1: UITKOMS (VAAL RIVER)

EIS: HIGH
Presence of rare and endangered *Labeobarbus kimberleyensis* and diversity of habitat.
PES: B/C
Combination of flow and non-flow related impacts. Flow related impacts are mainly due to interbasin transfers (Heysope and Zaaihoek). Mining and agricultural activities in area has caused water quality deterioration and erosion.
REC: B/C
The EIS at EWR 1 is **HIGH** and the PES warrants an improvement. An improvement in the PES EcoStatus would mean that fish and macroinvertebrates must improve from a C to a B EC. No improvement in riparian vegetation is needed as the current EC is an A/B. An improvement in the biotic component EC is dependent on **water quality** changes and not flow related issues. It seems that the water quality at this site is problematic as the fish show signs of serious bacterial infection and quality sensitive macroinvertebrates are absent. Diatoms also indicate that water quality is impaired; however, it is not certain what the water quality problems are. To improve the EC therefore, the water quality problems must be identified to determine how it can be addressed. As no improvement in flow is required, no EWR for the REC will be undertaken.
AEC down 1: C
A hydrological regime with **increased** base flows for longer periods of time in the winter (longer than present transfer) as well as fluctuations in temperature.
AEC down 2: C
A hydrological regime with **decreased** base flows below natural (no transfers) with potential for some low flows.
Decreased moderate floods.
Deteriorated water quality due to increased impacts of mining.

IHI			Driver Components	PES and REC Category	Trend	AEC↓1	AEC↓2
INSTREAM	C	RIPARIAN B	HYDROLOGY	C			
			WATER QUALITY	C	Stable	C	C
			GEOMORPHOLOGY	B/C	Negative	C	C
			Response Components	PES Category	Trend	AEC↓1	AEC↓2
			FISH	C (B)	Negative	D	D
			MACRO INVERTEBRATES	C (B)	Stable	C	D
			INSTREAM	C		C	D
			RIPARIAN VEGETATION	A/B	Stable	B/C	B/C
			ECOSTATUS	B/C (B)		C	C

IHI Hydro	Diatoms
E	C

Note: Categories in red relates to a REC based on water quality improvements.

EWR 2: GROOTDRAAI (VAAL RIVER)

EIS: MODERATE
PES: C
Combination of flow and non-flow related impacts. Impacts mostly related to changes in flow regime due to Grootdraai Dam.
REC: C
Maintain the PES due to the **MODERATE** EIS rating. However note that there is rare and endangered *Labeobarbus kimberleyensis* present which warrants improvement of the fish EC.
AEC up: B
This ecological scenario is important due to the presence of *L. kimberleyensis*.
Change in the operation of Grootdraai dam, which includes the release of flows (base flows) with more natural seasonal patterns and the release of moderate floods to remove fines and no bottom releases.
AEC down: C/D
Less spilling (i.e. less floods) and decreased base flows.
Increased bottom releases.

IHI			Driver Components	PES and REC Category	Trend	AEC↑	AEC↓
INSTREAM	D	RIPARIAN C	HYDROLOGY	D			
			WATER QUALITY	B/C	Negative	B	B/C
			GEOMORPHOLOGY	D	Stable	D	D/E
			Response Components	PES Category	Trend	AEC↑	AEC↓
			FISH	C	Stable	B	D
			MACRO INVERTEBRATES	C	Stable	B/C	C/D
			INSTREAM	C		B/C	C/D
			RIPARIAN VEGETATION	B/C	Stable	B	C
			ECOSTATUS	C		B	C/D

IHI Hydro	Diatoms
E	C

EWR 3: GLADDEDRIFT (VAAL RIVER)

EIS: MODERATE
PES: C
Combination of flow and non-flow related impacts. Impacts mostly related to changes in flow regime due to Grootdraai Dam, illegal irrigation, livestock farming and vegetation removal.
REC: C
Maintain the PES due to the **MODERATE** EIS rating. However note that there is rare and endangered *Labeobarbus kimberleyensis* present which warrants improvement of the fish EC.
AEC Up: B
Improved base flows (no zero flows), and increased frequency of moderate floods.
Improved water quality due to improved flow regime.
Removal of cattle grazing in the marginal zone.
AEC Down: C/D
Increased duration of zero flow periods.
Decreased frequency of floods.
Very low base flows in the dry season when flowing.
Associated water quality deterioration.

IHI			Driver Components	PES and REC Category	Trend	AEC↑	AEC↓	IHI Hydro	Diatoms
INSTREAM	C	RIPARIAN C	HYDROLOGY	C				C	C
			WATER QUALITY	C	Stable	B/C	D		
			GEOMORPHOLOGY	C	Stable	C	D		
			Response Components	PES Category	Trend	AEC↑	AEC↓		
			FISH	C	Stable	B	D		
			MACRO INVERTEBRATES	C	Stable	B/C	D		
			INSTREAM	C		B	D		
			RIPARIAN VEGETATION	C	Stable	B	C		
			ECOSTATUS	C		B	C/D		

EWR 4: DE NEYS (VAAL RIVER)

EIS: HIGH
The presence of the rare and endangered *Labeobarbus kimberleyensis*.
The Vaal River being a large river, which is rare in South Africa.
The diversity of riparian and instream habitats which include runs, rocky outcrops and rapids as well as pools.
Important refugia such as pools.
Being the only area between the Vaal Dam and barrage where yellowfish can breed.
PES: C
Impacts are mostly due to flow related problems, especially the presence of Vaal Dam and lack of flow variability. Increased base flows (dry season) occur as well as reduced frequencies of moderate floods due to releases from the Vaal Dam to maintain a target TDS concentration of 600 mg/l downstream of Vaal Barrage. .
REC: B/C
Improvement of PES due to **HIGH** EIS rating. A B EcoStatus could not be attained due to the limited operational possibilities from the Vaal Dam. Scenario includes improvement of seasonal variability (decreased base flows during the dry season and increased wet season flows above the current base flows).
AEC Down: D
Increased constant base flows if salinity problems are exacerbated leading to a loss of variability.
Decreased frequency of floods.

IHI			Driver Components	PES Category	Trend	REC	AEC↓	IHI Hydro	Diatoms
INSTREAM	D	RIPARIAN D	HYDROLOGY	D/E				E	C
			WATER QUALITY	C	Stable	C	C/D		
			GEOMORPHOLOGY	D	Stable	D	D		
			Response Components	PES Category	Trend	REC	REC		
			FISH	C	Stable	B	D		
			MACRO INVERTEBRATES	C/D	Stable	C	C/D		
			INSTREAM	C		B/C	D		
			RIPARIAN VEGETATION	C	Negative	B/C	D		
			ECOSTATUS	C		B/C	D		

EWR 5: SCANDINAVIA (VAAL RIVER)

EIS: HIGH
Presence of rare and endangered *Labeobarbus kimberleyensis,* and Rand Highveld Grassveld vegetation type. Most importantly, this site falls within the Vredefort Dome World Heritage Site and the river is an important feature within this World Heritage Site.
PES: C/D
Combination of flow and non-flow related impacts. Flow related impacts include increased base flows and reduced frequency of moderate floods due to Vaal Dam and Barrage and releases to regulated TDS levels. Non-flow related impacts include agriculture, and urban sewage and industrial waste and the occurrence of gauges, weirs and dams in the system.
REC: C
Improvement of the PES due to **HIGH** EIS rating. A B/C EcoStatus could not be attained due to the limited operational possibilities from the Vaal Dam. Scenario includes decreased base flows for 3 days (during winter) (to improve macroinvertebrates EC) and increased moderate floods in the wet season.
AEC down: D
Increased base flows.
Possibility of further decrease of floods due to the development in tributaries and increased return flows.

IHI			Driver Components	PES Category	Trend	REC	AEC↓	IHI Hydro	Diatoms
INSTREAM	D	RIPARIAN D	HYDROLOGY	D		C/D	D	C	C/D
			WATER QUALITY	E	Negative	D/E	E		
			GEOMORPHOLOGY	C	Negative	C	C/D		
			Response Components	PES Category	Trend	REC	AEC↓		
			FISH	C	Stable	B	D		
			MACRO INVERTEBRATES	C	Stable	C	C/D		
			INSTREAM	C		B/C	D		
			RIPARIAN VEGETATION	D	Negative	C	-D		
			ECOSTATUS	C/D		C	D		

EWR 6: KLIP (KLIP RIVER)

EIS: MODERATE
PES: B/C
Combination of flow and non-flow related impacts. Flow related impacts include reduced base flows and moderate floods due to weirs and farm dams. Non-flow related impacts include agriculture, cattle grazing, and alien vegetation. The sole reason for the PES not being a B EcoStatus is the current vegetation EC (B/C EC) due to the high proportion of exotic species
REC: B/C
The EIS at EWR 6 is **MODERATE** and the REC is to maintain the PES.
AEC up: B
A B EC can be achieved by removal of alien vegetation. Improving flows will not improve the vegetation.
AEC down: C
The scenario includes decreased low flows and zero flows and decreased moderate floods and deteriorated water quality.

IHI				Driver Components	PES and REC Category	Trend	AEC ↓	IHI Hydro	Diatoms
INSTREAM	C	RIPARIAN	C	HYDROLOGY	C			B/C	B/C
				WATER QUALITY	B/C	Negative	C		
				GEOMORPHOLOGY	B	Stable	C		
				Response Components	PES Category	Trend	AEC↓		
				FISH	B	Stable	C		
				MACRO INVERTEBRATES	B	Stable	C		
				INSTREAM	B		C		
				RIPARIAN VEGETATION	B/C	Stable	C		
				ECOSTATUS	B/C		C		

EWR 7: UPPER WILGE (WILGE RIVER)

EIS : HIGH
There are rare and endangered species i.e. the flufftail crowned crane, bald ibis, and 11 red data vegetation species. There is a good diversity of habitats that include wetlands, flood plains, oxbow lakes and peat lands.
PES: A/B
Non-flow related impacts that include small dams for agriculture and exotic fish species (MSAL).
REC A/B
As the PES is also relatively high, the attainable and realistic objective is to maintain the PES even though a **HIGH** EIS would normally warrant improvement.
AEC Down: C
The scenario includes decreased low flows, some periods of zero flows and decreased moderate floods.

IHI				Driver Components	PES and REC Category	Trend	AEC↓	IHI Hydro	Diatoms
INSTREAM	B	RIPARIAN	B	HYDROLOGY	A			A/B	B
				WATER QUALITY	B	Negative B/C	-B		
				GEOMORPHOLOGY	A	Negative B/C	B/C		
				Response Components	PES Category	Trend	AEC↓		
				FISH	B (D)	Negative D/E	C		
				MACRO INVERTEBRATES	B	Stable	C/D		
				INSTREAM	B		C		
				RIPARIAN VEGETATION	A/B	Stable	B/C		
				ECOSTATUS	A/B		C		

EWR 8: BAVARIA (WILGE RIVER)

EIS: MODERATE
PES: C
Flow related impacts include alteration of hydrological regime due to interbasin transfers from Sterkfontein Dam, abstraction and agriculture. Non-flow related impacts include water quality problems, erosion and exotic species invasion.
REC: C.
Maintain the PES due to the **MODERATE** EIS rating.
AEC Up: B/C
Dry season base flow increase and no zero flows.
Ongoing improved management of the Sterkfontein Dam releases.
Reduced grazing, burning and removal of debris.
Removal of MSAL (although highly impractical, without this removal, the fish EC will not improve).
AEC Down: D
Further decrease of base flows (e.g. an additional dam).
Decrease in small moderate floods.
Associated water quality deterioration.

IHI				Driver Components	PES and REC Category	Trend	AEC ↑	AEC↓	IHI Hydro	Diatoms
INSTREAM	C/D	RIPARIAN	C	HYDROLOGY	D				C	C/D
				WATER QUALITY	C	Stable	B/C	C/D		
				GEOMORPHOLOGY	C	Positive	+C	C/D		
				Response Components	PES Category	Trend	AEC ↑	AEC↓		
				FISH	C	Stable	B	D		
				MACRO INVERTEBRATES	C/D	Stable	C	D		
				INSTREAM	C		B/C	D		
				RIPARIAN VEGETATION	C	Stable	B/C	D		
				ECOSTATUS	C		B/C	D		

EWR 9: SUIKERBOS US (SUIKERBOSRAND RIVER)

EIS: HIGH
There are endangered species at this site, which includes *Labeobarbus kimberleyensis* and the Soweto Highveld grassland vegetation type (conservation status: endangered).
PES: C
Combination of flow and non-flow related impacts. Flow related impacts include altered flow regime due to Balfour and Harhoff Dams and non-flow related impacts include deteriorated water quality due to WWTW and agriculture, erosion and alien species (fish and vegetation).
REC: B/C
Improvement of the PES due to **HIGH** EIS rating.
An improvement is based on increased base flows (released from upstream dams) as well as erosion control measures in the tributaries to address erosion and increased sediment loads in the reach and alien woody vegetation control.
AEC Down: D
This scenario was not developed as the macroinvertebrates and fish are already in a D EC. A D AEC would involve the maintenance of the current ECs of fish and macroinvertebrates and a deterioration of the riparian vegetation EC. Any flow related changes will however cause deterioration in the riparian vegetation EC and would result in the instream and biota ECs to drop to an E.

IHI				Driver Components	PES Category	Trend	REC
INSTREAM	C	RIPARIAN	B	HYDROLOGY	E		
				WATER QUALITY	C/D	Negative D	C
				GEOMORPHOLOGY	B/C	Negative C	B
				Response Components	PES Category	Trend	REC
				FISH	D	Stable	C
				MACRO INVERTEBRATES	D	Stable	C
				INSTREAM	D		C
				RIPARIAN VEGETATION	B/C	Negative C/D	B
				ECOSTATUS	C		B/C

IHI Hydro	Diatoms
B	C

EWR 10: SUIKERBOS DS (SUIKERBOSRAND RIVER)

EIS: MODERATE
PES: C/D
Combination of flow and non-flow related impacts. Flow related impacts include elevated base flow and increased floods due to mining, SAPPI, urban runoff and Blesbokspruit input. Non-flow related impacts include deteriorated water quality due to industries, agriculture and urban activities; erosion, and exotic alien invasion (fish and vegetation).
REC: C/D
Maintain the PES due to the **MODERATE** EIS rating.
AEC up: C
Improved water quality management in the Blesbokspruit catchment. The biotic condition of the biota will improve under this scenario although no improvement will be evident in the riparian vegetation component. The riparian vegetation EC is associated with increased flows rather than water quality. **NOTE:** The recommendations at EWR 9 are to improve the low flows in the dry season. This could increase flows to the level that is problematic at EWR 10. This will have to be treated as a scenario in a systems context and evaluated.
AEC down: D
The scenario is increased base flows.

IHI				Driver Components	PES and REC Category	Trend	AEC ↑	AEC↓
INSTREAM	C	RIPARIAN	C	HYDROLOGY	D			
				WATER QUALITY	D/E	Negative	D	D/E
				GEOMORPHOLOGY	C	Negative C	C	-C
				Response Components	PES Category	Trend	REC	AEC↓
				FISH	C/D	Stable	C	D
				MACRO INVERTEBRATES	C/D	Stable	C	D
				INSTREAM	C/D		C	D
				RIPARIAN VEGETATION	C	Negative D	C	D
				ECOSTATUS	C/D		C	D

IHI Hydro	Diatoms
B	C/D

EWR 11: BLESBOKSPRUIT (BLESBOKSPRUIT RIVER)

EIS: LOW
Site is characterised by water quality problems and elevated flows.
PES: D
Mainly non-flow related impacts that include increased base flows and floods due to mine water decants, urban runoff, agriculture and return flows from WWTW. Water quality is also heavily impacted due to these activities and erosion has increased. Alien fish species occur.
REC: D
Maintain the PES due to the **LOW** EIS rating, **with invertebrates improving to D.**

An improved EcoStatus based on a hypothetical flow regime is not feasible at this site. Decreased flows as a scenario is unattainable and will result in deteriorated water quality.

The improvement of the macroinvertebrate EC is only possible with improved water quality. Improved water quality is only possible with better water quality management, which is unlikely, but feasible at a cost. Due to the huge amount of salts in the system, this improvement will only be a long term option.

The implications for setting flows are the following:
Flow requirements to maintain the present state would be based on present flows. Only increased flows can be evaluated as a scenario to determine whether increased flows (with either improved or the same water quality) will maintain the EcoStatus.

IHI				Driver Components	PES Category	Trend	REC
INSTREAM	D/E	RIPARIAN	C	HYDROLOGY	D/E		
				WATER QUALITY	D/E	Negative D/E	D
				GEOMORPHOLOGY	C	Negative C/D	C
				Response Components	PES Category	Trend	REC
				FISH	D	Stable	C
				MACRO INVERTEBRATES	D/E	Stable	D
				INSTREAM	D/E		C/D
				RIPARIAN VEGETATION	D	Negative D/E	D
				ECOSTATUS	D		D

IHI Hydro	Diatoms
E	C/D

RE-EWR 1: KLEIN VAAL

EIS: MODERATE
PES: C
Flow related impacts include interbasin transfer and abstraction altering hydrological regime. Non-flow related impacts include deterioration in water quality, increased erosion due to cattle and agricultural activities. Loss of habitat due to farm dams.
REC: C
Maintain the PES due to the **MODERATE** EIS rating.
The C EcoStatus is due to the riparian vegetation EC of a D as the instream EC is an A/B. The riparian vegetation PES is due to non-flow related impacts (grazing and trampling) and highly likely a very localised impact.
AEC down: C/D
A hydrological regime with decreased base flows.
Increased periods of zero flows during dry season.

IHI			Driver Components	PES and REC Category	AEC↓
INSTREAM	B	RIPARIAN B	HYDROLOGY	A/B	
			WATER QUALITY	B/C	B/C
			GEOMORPHOLOGY	B/C	B/C
			Response Components	PES Category	REC
			FISH	B	C
			MACRO INVERTEBRATES	A/B	C
			INSTREAM	A/B	C
			RIPARIAN VEGETATION	D	D
			ECOSTATUS	C	C/D

IHI Hydro	Diatoms
A/B	B

RE-EWR 2: MOOI RIVER

EIS: LOW
PES: D
This naturally would have been a wetland with a badly defined channel. Wetland tools were used to represent the driver state and the river tools used to assess the responses.

Some very rare constricted areas with small riffles occur. This site is downstream of the dam and about the only one with remnants of wetland intact. This is a short section. The rest of the MRU is very badly degraded and would be in a lower category. Downstream of the Wonderfontein inflow, the bad water quality would be the overriding concern. The PES is in a D and the rest of the MRU would be in an E or even lower. It will not be possible to improve the category by improving flows as the fish is already in a C EC and the riparian vegetation EC is due to non-flow related impacts. However, the macroinvertebrate EC might improve to at least a D with some improved flow.

Driver Components	PES Category
HYDROLOGY	E
WATER QUALITY	C/D
WETLAND HABITAT INTEGRITY	E
Response Components	PES Category
FISH	C
MACRO INVERTEBRATES	E
INSTREAM	D
RIPARIAN VEGETATION	D
ECOSTATUS	D

Diatoms
C

15.1 CONFIDENCE IN RESULTS

The confidence in EcoClassification is provided in Table 15.2. The confidence provided is for data availability and EcoClassification:

- Data availability: The evaluation is based on the adequacy of any available data for interpretation of the Ecological Category and AEC.
- EcoClassification: The evaluation is based on the confidence in the accuracy of the Ecological Category.

Table 15.2 Confidence in EcoClassification

1 (very low confidence) 2 (low confidence) 3 (medium confidence)
4 (high confidence) 5 (very high confidence)

Data availability									EcoClassification								
Hydrology	Physico-chemical	Geomorphology	IHI (instream & riparian	Fish	Macroinvertebrates	Vegetation	Average	Median	Hydrology	Physico-chemical	Geomorphology	IHI (instream & riparian	Fish	Macroinvertebrates	Vegetation	Average	Median
EWR 1																	
3	2	3.5	4	3.5	3	4.5	3.14	3.00	4	1.7	3.5	3	4	4	4	3.46	4.00
Data availability is **MEDIUM** due to physico-chemical (lack of measured data). Confidence in EcoClassification is **HIGH.** There is a good understanding of the biotic components but there are apparently water quality problems as indicated by fish kills and diseases. These impacts are potentially due to the interbasin transfers on water quality but there are no data to support this (hence the low																	

Data availability									EcoClassification								
Hydrology	Physico-chemical	Geomorphology	IHI (instream & riparian	Fish	Macroinvertebrates	Vegetation	Average	Median	Hydrology	Physico-chemical	Geomorphology	IHI (instream & riparian	Fish	Macroinvertebrates	Vegetation	Average	Median
confidence on data availability.																	
EWR 2																	
3	2	3.5	4	3.5	3	4.5	3.36	3.50	4	1.5	3.5	3	4	4	4	3.46	4
Data availability is **MEDIUM.** The confidence in the EcoClassification is **HIGH** due to good understanding of biotic components as well as drivers, although there is uncertainty regarding the impact of Leeuspruit and Blesbokspruit water quality on the trophic status of Grootdraai Dam.																	
EWR 3																	
4	1.5	3.5	4	3.5	3	4.5	3.43	3.00	4	2.3	3.5	3.6	4	3	3.6	3.43	3.60
The confidence in data availability and EcoClassification is **MEDIUM** with physico-chemical data having the lowest confidence. The EWR site is situated upstream of the impacts of the Waterfal River and therefore physico-chemical data is not representative for the site.																	
EWR 4																	
4	4	3.5	4	4	3	4.5	3.86	4.00	4	3	3.5	3.5	4	3	3.2	3.46	3.50
HIGH confidence in data availability with only invertebrate data availability being medium. Geomorphologically the site is unrepresentative and in better condition than the rest of the reach. **MEDIUM TO HIGH** confidence in EcoClassification due to lack of geomorphological cues for assessment and discrepancies between observed hydrological data and the modelled recommendations for releases made from Vaal Dam for dilution of TDS levels. Therefore a medium assessment for geomorphology and physico-chemical drivers.																	
EWR 5																	
3	4	3.5	4	4	3	4.5	3.71	4.00	3	3.9	3.5	3.5	4	3	3.2	3.44	3.50
The data availability confidence is **HIGH**. The EcoClassification confidence is **MEDIUM**. The hydrology issues described for EWR 4 are also valid here and the gauged flow information is problematic due to inaccurate flow data (low and zero flows).																	
EWR 6																	
1	3.6	4	4	3.5	3	4.5	3.37	3.60	2	3.6	3.5	2.9	3	4	3.1	3.16	3.10
The data availability confidence is **MEDIUM TO HIGH**. The reason this confidence is not higher is due to overall medium confidence in driver information especially hydrology as the gauge is far from the site, and the present use in the system is combined and cannot be disaggregated accurately for the actual site. Modelled hydrology indicated more flows than natural in the dry season which is impossible as zero flows are and was observed. It is likely that there is also illegal use of water as well as illegal dams. This inconsistencies with e.g. invertebrates being in an excellent state, has resulting in a low confidence in the EcoClassification.																	
EWR 7																	
2	1.5	4	4	3.5	3	4.5	3.21	3.50	4	3.5	4.5	3.4	3	2	4	3.49	3.50
Data availability is **MEDIUM TO HIGH.** The components with low data availability are hydrology and physico-chemical information due to the lack of measuring stations (hydrology and physico chemical component). The EcoClassification confidence is **MEDIUM TO HIGH.** The macroinvertebrates and fish have a lower confidence than the other components due to only one recent survey.																	
EWR 8																	
1	2.3	3.5	4	4	3	4.5	3.19	3.50	1	2.3	3.5	3.2	4	3	3.4	2.91	3.20
Data availability and EcoClassification confidence is **MEDIUM TO HIGH.** Hydrology and physico-chemical information is low as the hydrology gauge is relatively new and being a rated section, does not measure low flows accurately. There is also the possibility of illegal use which is not being modelled. The physico-chemical data record is short.																	
EWR 9																	
1	2.5	3	4	4	3	4.5	3.14	3.00	2	2.5	3	2.9	3.5	3	3.3	2.89	3.00
Confidence in data availability and EcoClassification is **MEDIUM.** The modelled hydrology initially did not include Balfour Dam and was therefore not of much use. There are no physico-chemical data information relevant to the site. Due to the limited driver information available for this site the EcoClassification confidence is medium.																	
EWR 10																	
2	3	3.5	4	4	4	4.5	3.57	4.00	4	3	3	2.7	3.5	3.5	3.3	3.29	3.30
The data availability confidence is **HIGH** as this is an existing RHP site where many previous biomonitoring surveys were undertaken**.** There are however uncertainties regarding the hydrology due to the complexities of all the urban and industrial upstream activities. The higher than natural flows are difficult to interpret and therefore the EcoClassification confidence is **MEDIUM** i.e. lower than the data availability.																	
EWR 11																	
2	2.6	3.5	4	4	4	4.5	3.51	4.00	5	3	3.5	2.5	4	5	3.4	3.77	3.50
The data availability confidence is **HIGH** as this is an existing RHP site where many previous biomonitoring surveys were undertaken**.** There are however uncertainties regarding the hydrology due to the complexities of all the urban and industrial upstream activities. The higher than natural flows are difficult to interpret and therefore the EcoClassification confidence is **MEDIUM** i.e. lower than the data																	

Data availability									EcoClassification								
Hydrology	Physico-chemical	Geomorphology	IHI (instream & riparian	Fish	Macroinvertebrates	Vegetation	Average	Median	Hydrology	Physico-chemical	Geomorphology	IHI (instream & riparian	Fish	Macroinvertebrates	Vegetation	Average	Median
availability.																	
EWR RE 1																	
1	1.5	2	4	2.5	2	2	2.14	2.00	3	1.7	2	2.8	2	4	3.4	2.70	2.80
The **LOW** data availability and **LOW - MEDIUM** confidence for EcoClassification is acceptable for a RAPID level III determination. Driver information is low due to lack of measuring stations (hydrology and physico chemical component). The Rapid III requirement of one site visit for instream biota only (none for geomorphology and riparian vegetation) resulted in a low confidence.																	
EWR RE 2																	
3				2.5	1	2	2.13	2.25	4 (IHI)				2	3	2	2.75	2.5
The EcoClassification and data availability confidence is **LOW**. The assessment followed the WETLAND - IHI approach with a high confidence. The responses are however low as there was only one set of sampling. The site is highly modified with a changed basic state (i.e. from wetland to river in places and with most changes relating to physical alteration.																	

A summary of the confidences are given below in Table 15.3. The colour coding is as follows:
Green: High to Very High
Yellow: Medium to high
Red: Very low to Medium

Table 15.3 Summary of confidences for all the sites

EWR site	EWR 1		EWR 2		EWR 3		EWR 4		EWR 5		EWR 6		EWR 7		EWR 8		EWR 9		EWR 10		EWR 11		RE – EWR 1		RE – EWR 2	
Confidence	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification	Data availability	EcoClassification
Hydrology	3	4	4	4	4	4	4	4	3	3	1	2	2	4	1	1	1	2	2	4	2	5	1	3		
Physico-chemical	2	1.7	4	1.5	1.5	2.3	4	3	4	3.9	3.6	3.6	1.5	3.5	2.3	2.3	2.5	2.5	3	3	2.6	3	1.5	1.7		
Geomorphology	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	3.5	4	4.5	3.5	3.5	3	3	3.5	3	3.5	3.5	2	2	3	4
IHI (instream & riparian	4	3	4	4	4	3.6	4	3.5	4	3.5	4	2.9	4	3.4	4	3.2	4	2.9	4	2.7	4	2.5	4	2.8		
Fish	3.5	4	3.5	4	3.5	4	4	4	4	4	3.5	3	3.5	3	4	4	4	3.5	4	3.5	4	4	2.5	2	2.5	2
Macroinvertebrates	3	4	3	3	3	3	3	3	3	3	3	4	3	2	3	3	3	3	4	3.5	4	5	2	4	1	3
Vegetation	4.5	4	4.5	3.7	4.5	3.6	4.5	3.2	4.5	3.2	4.5	3.1	4.5	4	4.5	3.4	4.5	3.3	4.5	3.3	4.5	3.4	2	3.4	2	2
Average	3.36	3.46	3.79	3.39	3.43	3.43	3.86	3.46	3.71	3.44	3.37	3.16	3.21	3.49	3.19	2.91	3.14	2.89	3.57	3.29	3.51	3.77	2.14	2.70	2.13	2.75
Median	3.50	4.00	4.00	3.70	3.50	3.60	4.00	3.50	4.00	3.50	3.60	3.10	3.50	3.50	3.50	3.20	3.00	3.00	4.00	3.30	4.00	3.50	2.00	2.80	2.25	2.50

15.2 CONCLUSIONS

15.2.1 Comprehensive Reserve sites: Data availability

The results in Table 15.3 indicate **MEDIUM TO HIGH** data availability at all the sites with **HIGH** data availability for EWR 4, 5 and 10. Driver information was particularly good at EWR 4 and 5. The present modelled hydrology did not reflect the observed hydrology and the monthly format could not be used, therefor the available observed daily data was used at EWR 4 and 5. There was good data and long data records available from the water quality stations at the respective sites as well as Rand Water data.

In general, the only low confidence in data availability was in the hydrology and physico-chemical variable information. Hydrology issues are mainly due to the fact that the modelled present hydrology is only relevant up to 1994, and that the present uses were aggregated for large areas.

15.2.2 Comprehensive Reserve sites: EcoClassification

The results in Table 15.3 indicate **MEDIUM TO HIGH** confidence in EcoClassification results at all the sites with **HIGH** data availability for EWR 1 and 11. Even though data availability is poor at EWR 11, there is no uncertainty about the state of the poor hydrology and there is a good understanding of the biotic components especially fish and macroinvertebrates.

The major issues were the following:

- EWR 1: Limited data record from water quality station. There are fish kills and fish diseases which apparently relate from water quality issues. The links and causes are however unknown.
- EWR 2: There is uncertainty in the water quality data as there is uncertainty regarding the impact of Leeuspruit and Blesbokspruit water quality on the trophic status of Grootdraai Dam.
- EWR 3: Water quality measuring station is far from site and downstream of the Waterval River confluence. Data is therefore not representative of the EWR site.
- EWR 4: There was a discrepancy between modelled hydrology and actual releases being made for dilution purposes. This resulted in observed hydrology being used rather than the modelled hydrology.
- EWR 5: See above. The available gauge is also far from the EWR site and does not measure low flows accurately.
- EWR 6: The hydrological gauge is situated far from the site. The modelled present hydrology did not match observations of flow at the site, i.e. modelled present day hydrology predicted more flows than natural with actual observations of dry season flows being more common. The good aquatic invertebrate state was also in contradiction with the hydrology information observed and available.
- EWR 7: Lack of water quality measuring station and hydrological gauge. C8H002 was far from the site and a 10-year intermittent data base exists. Low confidence in macroinvertebrates data due to limited sampling opportunities.
- EWR 8: Limited data available from water quality measuring station. There were discrepancies between modelled hydrological data and observed flows, and the gauge does not measure low and zero flows accurately.

- EWR 9: Limited data available from water quality measuring station. Hydrological data did not include impact of Balfour and Harrhoff Dams. Biological responses were therefore difficult to interpret, as there was no correlation between the hydrology provided, and observations on site.
- EWR 10: The two hydrological gauges used for the assessment does not measure low and zero flows accurately and there is a 18-year gap in the data. The hydrology of EWR 9 and associated problems affects this site. There are however uncertainties regarding the hydrology due to the complexities of all the urban and industrial upstream activities. The higher than natural flows are difficult to interpret.
- EWR 11: There was only a 4-year flow record available. There are however uncertainties regarding the hydrology due to the complexities of all the urban and industrial upstream activities. The higher than natural flows are difficult to interpret.

15.2.3 Rapid Reserve sites

Data availability in the driver components for RE-EWR 1 was **LOW**. There was no hydrological data available and limited physico-chemical data. The confidence in the EcoClassification results for RE-EWR 1 was **LOW-MEDIUM** due to limited driver information on which biotic responses are based as well as one instream biota survey only.

The confidence at RE-EWR 2 was **LOW** for data availability and EcoClassification. Although there was a good understanding of the driver components, the biotic responses were poor. The situation is complex as this site used to be a wetland and now consists of a very disturbed area, with some small sections of artificial river channel due to anthropogenic changes.

15.3 RECOMMENDATIONS

In general, it does not seem to be practical to undertake any more detailed work to improve confidence in the EcoClassification results. Ecological Water Resource Monitoring should be initiated as quickly as possible. The surveys results undertaken for EcoClassification should be valid for a baseline.

Specific aspects that require attention as part of Ecological Water Resource Monitoring are the following:

- Due to the lack of a nearby water quality monitoring stations at EWR 1, 2, 3, 8, 9 diatom assessments should be undertaken. This will provide good indication of the trend of the physico-chemical variables and if problems are indicated, more detailed physico-chemical analysis can be undertaken; however only based on available data. This is also relevant for 4, 5, 10 and 11.
- EWR 4: It is proposed that TDS levels and flow releases are monitored comprehensively.
- EWR 7: It is assumed that ESKOM will initiate ecological monitoring as part of the EIA recommendations designed for the Braamhoek pump storage scheme and according to Regulations. This should in any case improve base line information and overall confidence in the site evaluation.
- EWR 8, 10 and 11: Inaccurate gauges near these sites need to be serviced and maintained. EWRM will not be successful without the hydrological information being available.
- EWR 9: The impact of Balfour and Harhoff Dams must be included in the system model to ensure that the EWR assessment and specifically the design of operational scenarios include this. This therefore must still be undertaken within the latter phases of this study.

- Water quality management plans are proposed for EWR 1, 10 and 11 as the problems associated with these sites are water quality related and not flow related.
- Alien eradication programme is required at EWR 6.

16 REFERENCES

Chutter, F. M. 1963. Hydro biological studies on the Vaal River in the Vereeniging Area. Part I: Introduction, water chemistry and biological studies on the fauna of habitats other than muddy bottom sediments. Hydrobiology Act Hydrobiology Hydrographical et Protistologica. Vol XXI (1-2): 1-65.

Chutter, F. M. 1967. Hydro biological Studies of the Vaal River. National Institute for Water Research. Council for Scientific and Industrial Research. Special Report Wat 38. Pretoria South Africa.

DEAT (2008) South African Wetlands Conservation Programme: Seekoeivlei Web [http://www.environment.gov.za/soer/nsoer/resource/wetland/seekoeivlei.htm]

Department of Water Affairs and Forestry, South Africa (DWAF). 1999a. Resource directed measures for the protection of water resources. Volume 3: River ecosystems, version 1.0.

Department of Water Affairs and Forestry, South Africa (DWAF). 1999b. Vaal River System Analysis Update: Hydrology of the Upper Vaal Catchment. Report number PC000/00/16296. Prepared by BKS (Pty) LTD, Stewart Scott Inc and Ninham Shand (Pty) LTD.

Department of Water Affairs and Forestry, South Africa (DWAF). 2004. Upper Vaal Water Management Area: Internal Strategic Perspective. Prepared by PDNA, WRP Consulting Engineers (Pty) Ltd, WMB and Kwezi-V3 on behalf of the Directorate: National Water Resource Planning. DWAF Report No P WMA 08/000/00/0304.

Department of Water Affairs and Forestry, South Africa (DWAF). 2006. Study on the Integrated Water Quality Management Plan for the Vaal River System: Task 2. Water Quality Status Assessment of the Vaal River System.

Department of Water Affairs and Forestry, South Africa (DWAF). 2007. Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types by M. Rountree (ed); C.P. Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (DWAF), 2008. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Resource Unit Report. Report produced by Koekemoer Aquatic Services and Rivers for Africa. Authored by Louw, D. Report no: RDM/ WMA8 C000/01/CON/0208.

Department of Water Affairs, South Africa (DWA). 2010a. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Electronic Information. Produced by Koekemoer Aquatic Services and Rivers for Africa. Report no: RDM/ WMA8 C000/01/CON/0610.

Department of Water Affairs and Forestry (DWA), 2010b. Resource Directed Measures: Comprehensive Reserve determination study of the Integrated Vaal River System. Upper Vaal Water Management Area Technical Component: Main Report. Report produced by Koekemoer Aquatic Services and Rivers for Africa. Authored by Louw, D and Koekemoer, S. Report no: RDM/WMA8 C000/01/CON/0510.

EPA, 2000. Stressor Identification Guidance Document, Protection Agency, EPA/822/B-00/025, Washington DC, USA.

Eskom (1999) Environmental impact report for the proposed Braamhoek pumped storage scheme. Volume I of IV: Environmental impact report: 97-3111-09a.

Kleynhans, C.J. 2007. Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 330/08.

Kleynhans, C.J., Louw, M.D., Thirion, C., Rossouw, N.J., and Rowntree, K. 2005. River EcoClassification: Manual for EcoStatus determination (Version 1). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. KV 168/05.

Kleynhans, C.J. and Louw, M.D. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT329-08.

Kleynhans, C.J., Louw, M.D. and Moolman, J. 2007. Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Louw, M.D., and Hughes, D.A. 2002. Resource Directed Measures for Protection of Water Resources: River Ecosystems - Revision of the quantity component. Unpublished report. Prepared for the Department of Water Affairs and Forestry, South Africa by IWR Source to Sea.

Rivers Database. 2007. Database on fish distribution in South African Rivers.

Scott, L.E.P., Skelton, P.H., Booth, A.J., Verheust, L., Harris, R. and Dooley, J. 2006. Atlas of Southern African Freshwater Fishes. Smithiana Publication, Monograph 2. The South African Institute for Aquatic Biodiversity, Grahamstown, South Africa.

Taylor, .J. C. 2004. The Application of Diatom-Based Pollution Indices in The Vaal Catchment. Unpublished M.Sc. thesis, North-West University, Potchefstroom Campus, Potchefstroom.

Tooth, S., McCarthy, T.S., Brandt, D. and Hancox, P.J. (2002). A guide to the geology and geomorphology of the Klip River valley. Contribution to 'Bird and Nature Guide to the Memel District', Birdlife South Africa, Johannesburg. Web [http://users.aber.ac.uk/set/].