



INKOMATI-USUTHU

CATCHMENT MANAGEMENT AGENCY

ECOSTATUS OF THE CROCODILE RIVER CATCHMENT

INKOMATI RIVER SYSTEM PHASE II (2017)

www.iucma.co.za

VISION

The vision of the Inkomati-Usuthu CMA is: ***“Water for all in Inkomati-Usuthu”***.

MISSION

The mission of the Inkomati-Usuthu Catchment Management Agency (IUCMA) is of a pioneering catchment management system that empowers stakeholders to engage in consensual and adaptive decision making, to achieve reform, and to promote persistent social, economic and environmental justice across the Inkomati-Usuthu WMA.

- The IUCMA supports the co-operative management of the international INCOMATI basin as an internationally shared water course;
- The decision-making environment of the IUCMA, including delegated functions, enables collaborative action which supports transformation and redressing of the past towards equity, sustainability and efficiency in a continually evolving socio-economic system; and
- The IUCMA manages the resources adaptively, co-operatively and progressively to achieve social, economic and environmental justice, and promote healthy living.

VALUES

The IUCMA values are:

- Integrity
- Customer orientation (Batho Pele)
- Efficiency
- Accountability
- Diversity
- Transparency

CROCODILE RIVER CATCHMENT INKOMATI RIVER SYSTEM PHASE II (2017)



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List of Abbreviations

AEV	=	Acute Effects Value
CD: WE	=	Chief Directorate: Water Ecosystems
DO	=	Dissolved Oxygen
DWA	=	Department of Water Affairs
DWAF	=	Department of Water Affairs and Forestry (pre-April 2010)
DWS - RQIS	=	Department of Water and Sanitation - Resource Quality Information Services
DWS	=	Department of Water and Sanitation
EC	=	Ecological Category
EI	=	Ecological Importance
ES	=	Ecological Sensitivity
EWR	=	Ecological Water Requirements
FRAI	=	Fish Response Assessment Index
GPS	=	Global Positioning System
IHI	=	Index of Habitat Integrity
IUA	=	Integrated Unit of Analysis
IUCMA	=	Inkomati-Usuthu Catchment Management Agency
KNP	=	Kruger National Park
m.a.s.l.	=	metres above sea level
MIRAI	=	Macro-invertebrate Response Assessment Index
MTPA	=	Mpumalanga Tourism and Parks Agency
NMMP	=	National Microbial Monitoring Programme
PAI	=	Physico-chemical driver Assessment Index
P-C	=	physico-chemical
PES	=	Present Ecological State
PES-EIS	=	Present Ecological State - Ecological Importance and Sensitivity
RC	=	Reference Condition

REC	=	Recommended Ecological Category
REMP	=	River Ecostatus Monitoring Programme
RHP	=	River Health Programme
RIVDINT	=	River Data Integration
RQO	=	Resource Quality Objectives
RU	=	Resource Unit
SASS5	=	South African Scoring System, Version 5
SQR	=	Sub-quadernary Reach
TEC	=	Target Ecological Category
TIN	=	Total Inorganic Nitrogen
TWQR	=	Target Water Quality Range
VEGRAI	=	Riparian Vegetation Response Assessment Index
WMA	=	Water Management Area
WMS	=	Water Management System
WWTW	=	Waste Water Treatment Works

1. INTRODUCTION

Aquatic ecosystems all over the world are severely stressed by the ever-increasing demand for water, linked to growing industrial and agricultural developments as well as large-scale urbanization. This situation is exacerbated in South Africa by our dry climatic conditions, resulting in most of our rivers being small non-perennial rivers with erratic flow. Although aquatic ecosystems are frequently subjected to extreme events such as floods or droughts it can recover, which suggests that rivers can be used without causing permanent damage or change to its physical and chemical properties. However, a water resource is an aquatic ecosystem that comprises the physical aquatic habitat with its biota (both instream and riparian), linked to its physical, chemical and ecological processes. An understanding of its natural structure and function and its responses to development and exploitation are therefore essential to conserve it in a state where it can maintain its natural biodiversity. A recent analysis of the long-term trends in the water quality of rivers in the Olifants-Limpopo and Inkomati catchments, indicated a general decrease in “water quality at sites in mid to low catchments” (Griffin et al. 2014). Indeed, the quality of South Africa’s water resources are deteriorating (CSIR 2010). Some of the main known challenges include:

- Over abstraction;
- habitat alteration (e.g. sedimentation, bank and bed scouring, flow regulation, and more);
- eutrophication;
- acid mine drainage;
- sewage effluents;
- anthropogenic salinization;
- toxic organic compounds, and
- invasive species (fauna and flora).

(Dallas & Day 2004; Davies et al. 1993; Davies & Day 1998; Griffin et al. 2014)

A world-wide trend since the 1980’s has been the introduction of in-stream biomonitoring as part of water resources management. This type of monitoring commonly referred to as biomonitoring is increasingly being recognized as an important component in the overall assessment of water resources. The use of biological field assessments of fish and/or macro-invertebrate communities provides an integrated and sensitive measurement of environmental problems and represents progress in the assessment of ecological impacts and in the management of aquatic ecosystems (Karr et al., 1986).

A national bio-monitoring program for South African Rivers, the River Health Program (RHP) was implemented and launched in September 1996 to monitor and thus improve and manage the health of South African freshwater ecosystems. The RHP has been established to provide water managers with relevant information to manage the resource. The RHP focuses on selected ecological indicators that are

representative of the larger ecosystem and are practical to measure (http://www.dwa.gov.za/iwqs/rhp/rhp_background.aspx). In 2016 the RHP programme was replaced with the River Ecstatus Monitoring Programme (REMP) as captured in the Department of Water and Sanitation Business plan also stipulated as a function of the Catchment Management Agencies (CMA's) (<http://www.dwa.gov.za/iwqs/>).

The Inkomati – Usuthu Catchment Management Agency (IUCMA) appointed the Mpumalanga Parks and Tourism Agency (MTPA – Scientific Services: Aquatic Systems) as service provider to conduct follow-up biomonitoring surveys (first surveys in 2012, ICMA Report October 2013) within the Crocodile River catchment during the 2017/2018 financial year to determine the Present Ecological State of this river system.

Biomonitoring in the Crocodile River was conducted during the months June to September 2017. During this survey forty (40) sites were sampled in the Crocodile River and its tributaries, including the Lunsklip, Alexanderspruit, Buffelskloofspruit, Leeuspruit, Ngodwana River, Swartkoppiespruit, Houtbosloop, Visspruit Nelsriver, Gladdespruit and Elands River, White River and tributaries in the Kaap sub-Catchment. Original RHP (River Health Programme) sites were used as far as possible to be able to make use of existing data for comparison. Standard river biomonitoring techniques were used and data collected were analysed using the:

- Fish Response Assessment Index (FRAI)
- Macro-Invertebrate Response Assessment Index (MIRAI)
- Riparian Vegetation Response Assessment Index (VEGRAI)
- Index of Habitat Integrity (IHI) models
- Water quality data were analysed using standard methods and an integrated present state for water quality derived using the Physico-chemical driver Assessment Index (PAI) model.

(DWAF 2008; Kleynhans, 2008; Thirion, 2008; Kleynhans et al., 2009).

1.1 Objectives of the Survey

The objective of this study is to determine the current Ecstatus (2017) of the Crocodile River and some of its main tributaries based on the rapid assessment of aquatic macro-invertebrates using the South African Scoring System version 5 (SASS5) with the Macro-invertebrate Response Assessment Index (MIRAI) (Thirion, 2008), the Fish Response Assessment Index (FRAI) (Kleynhans, 2008), Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et al., 2007), Index for Habitat Integrity (Kleynhans et al., 2009), the Physico-chemical driver Assessment Index (PAI) model (DWAF 2008), and the integration of these indices to provide an integrated Ecstatus per sub-quaternary reach (SQR)(Kleynhans & Louw, 2008). This study will provide useful ecological information through an aquatic assessment, the determination of the Present Ecological State of the associated aquatic habitat of the Crocodile River and trends in aquatic health over time, as well as a comparison with previous surveys (2012) to inform on management interventions

required to address systemic and point specific impacts. Monitoring is only a valid term to use if the results of this survey is measured against targets (Greenwood & Robinson, 2006.)

The results of this survey should therefore be compared to the gazetted Target Ecological Categories (TECs) and associated Resource Quality Objectives (RQOs) defined for water quantity and quality, and habitat and biota. TECs and RQOs are defined for each prioritised Resource Unit (RU) within every Integrated Unit of Analysis (IUA) (Government Gazette No 40531, 30 December 2016; DWA, 2014b).

1.2. Study Area

Inkomati River catchment description

The Inkomati River drains parts of Mpumalanga, Swaziland and Mozambique between the Limpopo River system in the north and the Pongola River system in the south (Figure 1). The Inkomati River basin is one of the most important river basins in South Africa and it consists of three adjacent sub-basins, the Komati, **Crocodile** and Sabie (Figure 1). The Inkomati River basin incorporates the Mpumalanga Province in southern Africa, part of northern Swaziland and a part of southern Mozambique. The main river descends from the highland plateau in Mpumalanga and Swaziland and flows through the coastal plains of Mozambique towards the Indian Ocean. The river flows eastwards through the Lowveld region of Mpumalanga and Swaziland where it is heavily used for agricultural purposes before finally flowing into Mozambique where it discharges into the Indian Ocean just north of Maputo at Villa Laisa. The total basin area is about 46,800 km² of which 63% is in South Africa, 5% in Swaziland and 32% in Mozambique. The average discharge of the Inkomati Water Course at the estuary is about 100 m³s⁻¹ to 200 m³s⁻¹, corresponding to about 3,600 million m³ per year, to which South Africa contributes 82%, Swaziland about 13% and Mozambique about 4% (Darwall et al., 2009; DWS, 2015).

There are several dams in the basin which can be classified as large and most of them are in South Africa. Dams with more than 2,060 million m³ combined storage capacity have been built in the Inkomati basin in South Africa and Swaziland, these dams are primarily used for irrigation. Two of these major dams are in the lower komati basin, the Driekoppies Dam in South Africa and the Maguga Dam in Swaziland. These dams disrupt the natural flow regimes of the rivers and are managed by Komati Basin Water Authority (KOBWA) which is responsible for the Komati River Basin Development Plan (Roux, 2013). Both these dams have no provision for fish ways and are completely obstructing the upstream movement of fish. Other large dams in the Komati River include the Nooitgedacht and Vygeboom Dams. Water use is intense, with 50% of the water generated in the basin being abstracted. Water scarcity has been evident since the mid – 1980's, and has become more severe, as well as the effects of droughts and floods. The intensive use of water of the Inkomati system for irrigation has impacted on the health of the river system. Loss and degradation of

habitats also threaten the health of the river system, particularly as a result of excessive sedimentation and eutrophication, flow modification and the introduction of alien invasive species. In addition, extensive coal mining in the headwaters is a further threat, with high risks of pollution from acid mine waters (Darwall et al. 2009).

The most unique topographical feature of the drainage area is the Drakensberg Escarpment that follows a winding course across the area, its general trend being from north to south. From the escarpment steep slopes trail down eastwards and merge with the granite hills of the typical Middleveld. The land west at the Great Escarpment is mountainous and deeply dissected. From west to east, the basin comprises the Precambrium granites and gneiss of the primitive systems, the Cretaceous (west of the Lebombo) and Karroo lavas of the Mesozoic period followed by Cretaceous basins east of the Lebombo (Darwall et al., 2009).

The fish fauna is dominated by Zambezian elements and is characterized by relative high endemism with many restricted range species. The Inkomati support an estimated 56 species of fish (16% of the regional total), 120 species of Odonata (73% of the national total) have been recorded to date, 202 of the selected aquatic plants (39% of the regional total), and 24 Molluscs (21% of the regional total) (Darwall et al., 2009).

Crocodile River

The Crocodile River is from an ecological point of view one of the most important rivers in South Africa. This is due to the broad range of riverine habitats, ranging from cold mountain streams in the Drakensberg to slow flowing temperate waters where the river meanders through the Lowveld. As a result of this, the Crocodile River is also one of the most biological diverse systems in the country, with at least 49 fish species (Roux et al., 1999). The Crocodile River catchment has an area of 10 440 km² and rises at an altitude 2000 m above sea level in the Steenkampsberg Mountains near Dullstroom. The Upper Catchment consists of steep sided valleys, with sharply defined cliff slopes on the eastern edge of the Escarpment. From the Escarpment the river levels out in the Kwena Dam Basin, from where the Crocodile River winds along the valley of the Schoemanskloof down to the Montrose Falls and the confluence of the Elands River (Roux et al., 1999).

Between Montrose Falls and the town of Nelspruit the Crocodile River is slightly incised into a broad, flat bottomed valley. Further downstream the steep sided river banks are densely covered with riparian vegetation and reed beds. Downstream of its confluence with the Kaap River, the gradient of the Crocodile River flattens out until its confluence with the Komati River at the town of Komatipoort. The river in this zone is meandering, incised into a wide sandy river bed and in some sections the river flows through multiple bedrock channels (Roux et al., 1999). This river segment can be described as 40 m to 50 m wide, with

mostly large sandy pools, occasional rapids and few riffles. This stretch is further characterised by a gentle slope with Lebombo riparian thickets and limited rhyolite bedrock patches.

The Crocodile River is a slow flowing river with mainly bedrock (dolerite intrusions and basaltic lava) or sandy pools; it has an average width of 45 m, and a low gradient. The area below 250 m altitude falls within the typical Bushveld with types of *Acacia*, *Combretum*, *Sclerocarya*, *Terminalia* etc. as dominant trees. The Lowveld area has developed rapidly and agricultural activities have greatly increased. These developments abstract large volumes of water from the river, resulting in a decline of the flow especially during the dry season. Extensive reed (*Phragmites*) banks dominate the riparian zone of this river.

Based on the Level 1 River Ecoregional Classification System for South Africa (Kleynhans et al., 2005) which is founded on the premise that ecosystems and their components display regional patterns that are reflected in spatially variable combinations of causal factors such as physiology, climate, geology, soils and natural vegetation, the Crocodile Catchment falls within the following Ecoregions.

- Ecoregion 3: Lowveld

This hot and dry region can be characterised by plains with a low to moderate relief and vegetation consisting mostly of Lowveld Bushveld types (Mopane Bushveld; mixed Lowveld Bushveld). Towards the west on the boundary with the North Eastern Highlands, open hills and low mountains with high relief are present. The mean annual precipitation tends to be moderate towards the west, but low over most of the region (200 mm to 1000 mm). The stream frequency is mostly low to medium, but high in some of the central areas with slopes < 5% to >80% of the area (Kleynhans et al., 2005).

- Ecoregion 4: North Eastern Highlands

This is a mountainous area characterised by closed hills and mountains with moderate to high relief. The vegetation type comprises of North-Eastern Highveld Grassland and Lowveld Bushveld types although patches of Afromontane Forest is scattered throughout the region. This Ecoregion is a transitional zone between the Lowveld and Northern Escarpment. The mean annual precipitation varies between 400mm to 1000mm and is described as moderate to high. The stream frequency varies between low, medium, and medium high with slopes <5%: varying between <20% to 25% – 50 % (Kleynhans et al., 2005).

- Ecoregion 9: Eastern Bankenveld

The ecoregion covers portions of eastern escarpment, with most of the upper Crocodile catchment falling within this ecoregion. North-eastern Highveld Grassland and Mixed Bushveld represent the dominant vegetation types. The terrain morphology is variable, but generally described as closed hills and mountains with moderate to high relief. The mean annual precipitation is high to moderately high, ranging between 300 mm to 1,000 mm. The stream frequency is mostly medium/high with low/medium areas limited (Kleynhans et al., 2005).

- Ecoregion 10: Northern Escarpment Mountains

The topography of this high lying region consist of closed hills and mountains with moderate to high relief. A well-defined escarpment is present towards the east stretching the majority of the region's length. The dominant vegetation type is North-eastern Mountain Grassland with areas of Sour Lowveld Bushveld towards the east. Small areas of Afromontane Forest occur regularly as a thin band towards the eastern boundary. The mean annual precipitation is high in most areas and range between 500mm to 1000mm. The stream frequency is mostly medium to high with slopes <5% consisting <20 % of the ecoregion (Kleynhans et al., 2005).

Table 1: Natural vegetation types occurring in the Crocodile River catchment based on Mucina & Rutherford (2006).

Upper reaches	Middle reaches	Lower Reaches
<ul style="list-style-type: none"> • Lydenburg Montane Grassland; • Lydenburg Thornveld; • Northern Escarpment Dolomite Grassland, and; • Northern Escarpment Quartzite Sourveld. 	<ul style="list-style-type: none"> • Legogote Sour Bushveld; • Pretoriuskop Sour Bushveld • Malelane Mountain Bushveld and; • Scrap Forest. 	<ul style="list-style-type: none"> • Granite Lowveld; • Delagoa Lowveld; • Tshokwane-Hlane Basalt Lowveld, • Malelane Mountain Bushveld, and; • Northern Lebombo Bushveld.

Table 2: Geomorphological zonation of River Channels according to Rowntree and Wadeson (1999).

Longitudinal zone	Macro-reach characteristics			Characteristic channel features
	Valley form	Gradient class	Zone class	
<i>A. Zonation associated with a "normal" profile</i>				
Source zone	V10	Not specified	S	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	V1. V3	>0.1	A	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascade.
Mountain stream	V1. V3	0.04 – 0.039	B	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool. Approximate equal distribution of "vertical" and "horizontal" components.
Transitional	V2. V3. V4. V6	0.02 – 0.039	C	Moderately steep stream dominated by bedrock and boulder. Reach types include plain-bed, pool-rapid or pool-riffle. Confined or semi-confined valley floor with limited flood plain development.
Upper Foothills	V4. V6	0.005 – 0.019	D	Moderately steep, cobble-bed or mixed bedrock-cobble, bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles rapids similar. Narrow flood plain of sand, gravel or cobble often present.
Lower Foothills	V8. V10	0.001 – 0.005	E	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids of riffles. Floodplain often present.
Lowland river	V4. V8. V10	0.0001 – 0.001	F	Low gradient alluvial fine bed channel, typically regime reach type. May be confined but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks.

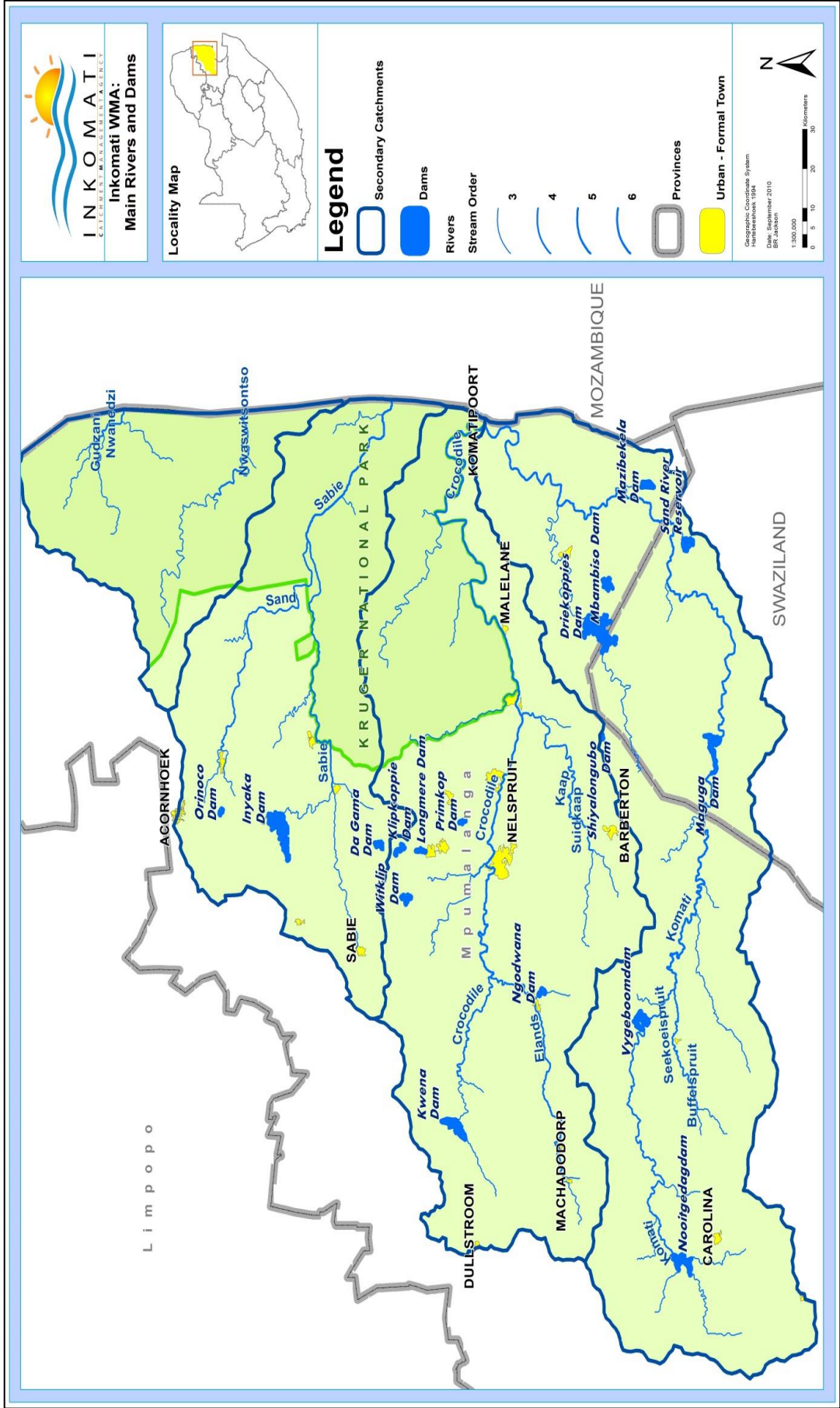


Figure 1: Map of the Inkomati Basin.

Conservation areas, trout-rearing, -dams and -fishing are the main land-use in the headwaters of the Crocodile River. The main dam on the Crocodile River is the Kwena Dam (X21C-00909) comprising of 7.53% of the total surface area of the catchment, supplying drinking water to Mbombela Municipality. Other larger dams are located on the Ngodwana, and White River. Several large dams on the White River negatively affects flow, with the river stagnant during the 2017 site visit. The major dams on the system are the Kruisfontein Dam, Klipkoppie, Longmere, and Primkop (GEOTERRAIMAGE, 2015).

There are numerous small farm dams within the system, especially in the upper reaches. A total of 400 dams and weirs were counted on Google Earth in quaternary sub-catchment X21A (upper Crocodile).

Commercial forestry plantations are mostly restricted to the headwaters of tributaries such as Alex-se-Loop, Swartkoppiespruit, middle Elands, Ngodwana, Houtbosloop, Visspruit, Gladdespruit, Nelsriver, White River, Noord-Kaap, Suid-Kaap, and Queens.

The major towns along the Crocodile River includes Dullstroom, Nelspruit, Kamagugu, Malelane, and Komatipoort. On the Elands River, Machadodorp, Waterval Boven, and Ngodwana. The Kaap catchment drains past Barberton through agricultural and mining areas towards the Crocodile River at Kaapmuiden.

Sappi's Pulp and Paper Mill represents a major industrial site on the Elands River, with storm-water from large industrial areas in Nelspruit draining towards the Crocodile River.

2. REACH AND SITE DESCRIPTION

A total of 40 sites were sampled in the Crocodile Catchment (Figure 2 and 3), of which 17 sites were sampled on the main Crocodile River comprising of 13 SQ reaches. In the Crocodile River Tributaries ten (10) sites were sampled in total comprising of nine (9) SQ reaches with one (1) Not on Reach. For the Elands River sub-Catchment ten (10) biomonitoring sites were sampled covering eight (8) SQ reaches on the Elands River mainstem and three (3) SQ reaches on tributaries of the Elands River. In the Kaap River sub-Catchment four sites were monitored including one (1) SQ reach on the Kaap River and three (3) SQ reaches on tributaries of the Kaap River. The Crocodile River catchment to its boundary with Mozambique (quaternary sub-catchments X21, X22, X23 & X24) drains a total area of approximately 10 400 km², with a mainstem length of 326km (Midgley et al. 1994). Table 3 lists the biomonitoring points surveyed in the Crocodile River Catchment.

2.1. Crocodile River Mainstem

The Crocodile River has been divided into 19 SQ reaches with the starting point on Verloren Vlei Nature Reserve at an elevation of 2,260 m.a.s.l. running in a general easterly direction towards the town of Komatipoort (118 m.a.s.l.) and ending on South Africa's eastern border with Mozambique. A feature of the Crocodile River is the picturesque gorge, between Nelspruit and Malelane, with its spectacular granite plutons estimated to have formed between 2,700 and 3,000 million years ago (McCarthy & Rubidge 2005).

The total length of the 19 reaches covers a length of 326 km of river. Only one major impoundment, the Kwena Dam (built in 1984), is located in the Crocodile River where the Crocodile, Lunsklip, Alex-se-Loop, Wilgekraalspruit, Elanspruit and Badfonteinloop rivers converge.

2.2. Crocodile Tributaries

The Elands River and Kaap River are two large sub-Catchments of the Crocodile River system and is discussed separately in 2.3 and 2.4. Of the smaller tributaries of the Crocodile River eight (8) were sampled and they are Lunsklip River, Alexanderspruit, Buffelskloofspruit, Houtbosloop, Visspruit, Nelsriver, Gladdespruit and Whiteriver. One site per tributary was sampled except for the Lunsklip River where three sites were done and two sites each in Sterkspruit and Nelsriver. The tributaries downstream from Kaapmuiden are seasonal streams with very little or no water and they were not sampled.

2.3. Elands River and Tributaries

The Elands River rises in a gentle sloping Highveld zone near the town of Machadodorp. Downstream of its source the Elands River have a steeper gradient for most of its length. It joins the Crocodile River 2km downstream of the Montrose falls. The water fall at Waterval Boven is an outstanding geomorphological feature of this river reach. It forms a natural, physical barrier to upstream migrating fish species. The section from Waterval Boven to Ngodwana can be characterised by exceptional riffle and rapid habitats. Tributaries of the Elands River also sampled included Leeuspruit, Swartkoppies spruit and Ngodwana.

2.4. Kaap River and Tributaries

The Noord-Kaap River, Suid-Kaap River and the Queens River are relatively large tributaries of the Kaap sub-catchment and one site on each of these tributaries was sampled. Five smaller tributaries, Hyslop's Creek, Oratava Creek, Figtree Creek, Honeybird Creek and Louw's Creek originating from the Barberton Mountainlands, do not fall within a specific reach but are important refugia for this sub-catchment.

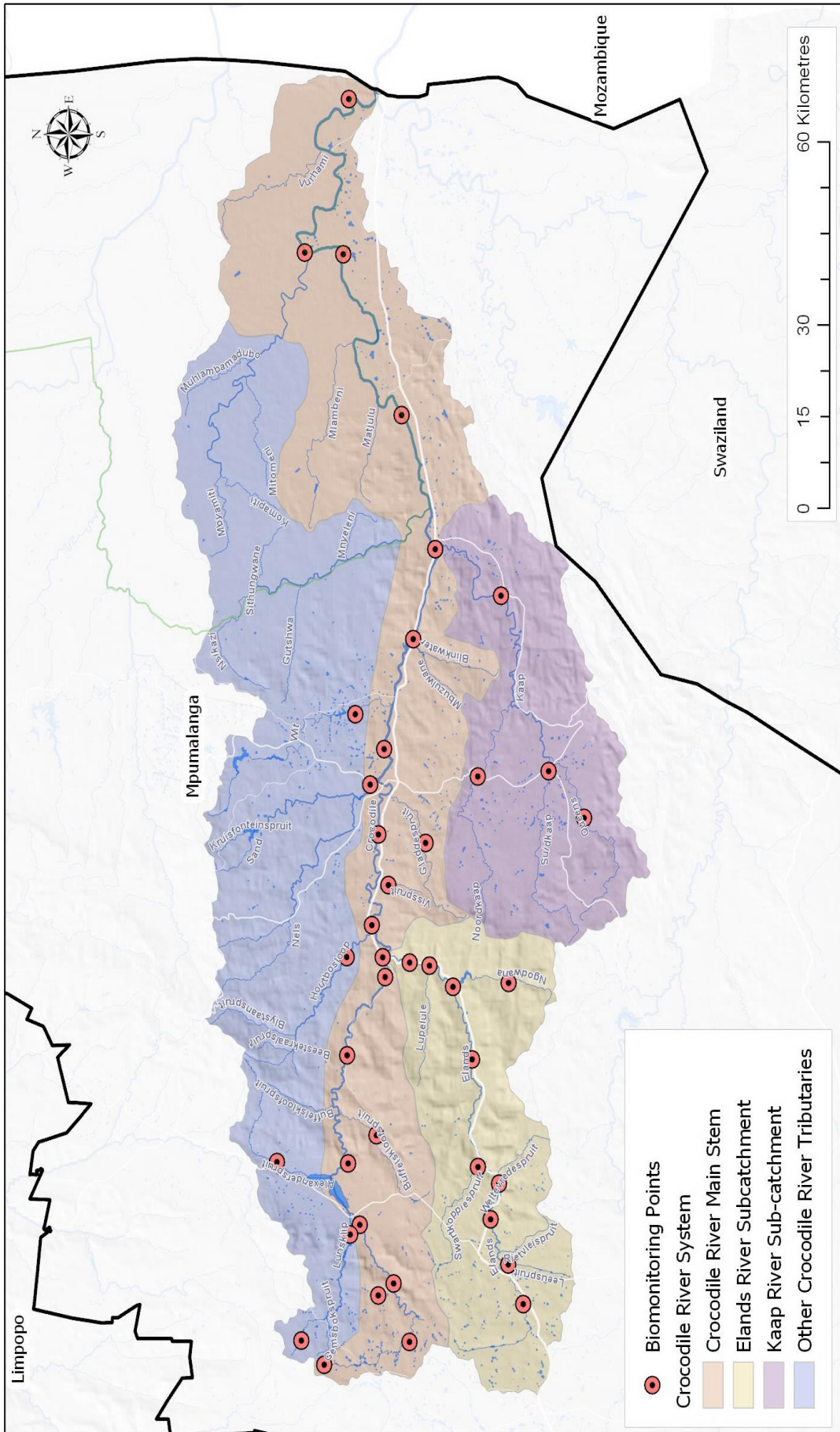


Figure 2: Map of Crocodile Catchment indicating all biomonitoring points

CROCODILE CATCHMENT Sampled Reaches

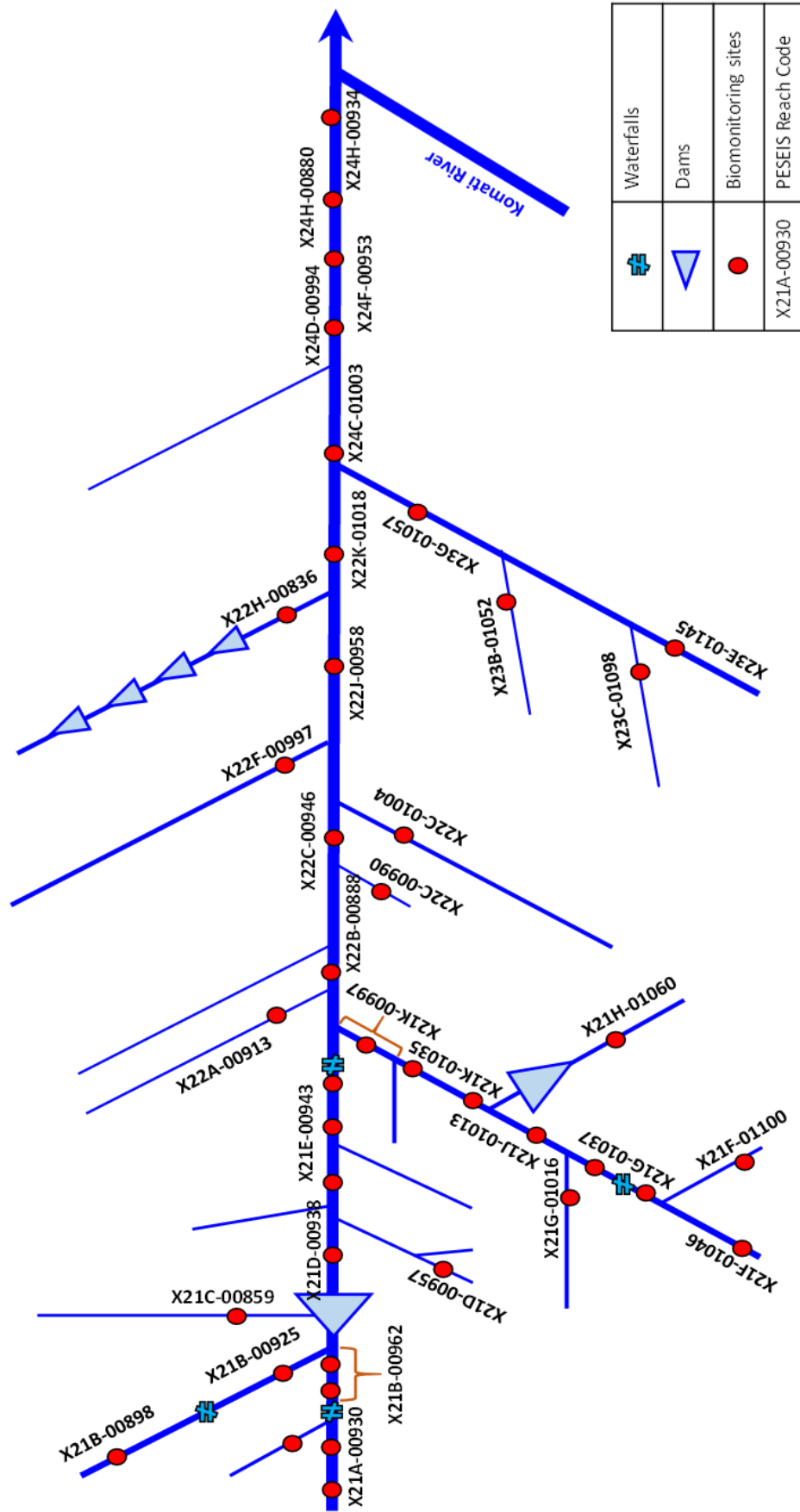


Figure 3: Diagrammatic representation of the Crocodile River catchment including the Elands River and Kaap River sub-catchments.

Table 3: A list of sites sampled on the Crocodile River Catchment during the 2017 survey, including details such as aquatic ecoregion, site code, quaternary sub-catchment (QC), PESEIS Reach Code, River, GPS location and elevation. EWR sites 1 to 6 indicated in light orange.

Aquatic Ecoregion	Reach Code	Site Code	QC ¹	SQR Length (km)	River	GPS ² (dd.ddddd)		Elevation ³	
						S	E		
Crocodile River Mainstem									
Eastern Bankenveld	X21A-00930	X2CROC-VERLO	X21A	30.8	Crocodile		-25.34926	30.10994	2 098
		X2CROC-VALY1* EWR 1					-25.49407	30.14357	1 854
	X21B-00962	X2CROC-DONKE	X21B	30.1		-25.46712	30.22968	1 331	
		X2CROC-GOEDE* EWR 2				-25.40967	30.31609	1 206	
	Northern Escarpment Mountains	X21D-00938	X2CROC-DOORN	X21D		18.7	-25.38984	30.40647	1 115
			X2CROC-RIETV				-25.38818	30.56574	921
X21E-00943		X2CROC-POPLA* EWR 3	X21E	38.0	-25.45275	30.68099	817		
North Eastern Highlands	X22B-00888	X2CROC-MONTR	X22B	14.6	-25.44861	30.71010	808		
		X2CROC-RIVUL			-25.43013	30.75744	737		
	X22J-00958	X2CROC-STRKS	X22C	18.9	-25.44128	30.89103	670		
		X2CROC-KAMAG			-25.45103	31.01669	570		
	X22K-01018	X2CROC-N4ROA* EWR 4	X22K	15.2	-25.50050	31.17869	475		
Lowveld	X24D-00994	X2CROC-KAAPM	X24C	7.2	-25.53779	31.31124	330		
		X2CROC-MALEL* EWR 5			-25.48066	31.50873	278		
Lebombo Mountains	X24H-00880	X2CROC-MARO2	X24F	31.0	-25.38159	31.74561	209		
		X2CROC-MYAMB			-25.31625	31.74811	196		
	X24H-00934	X2CROC-NKONG* EWR 6	X24H	21.0	-25.39113	31.97425	129		

¹ QC = Quaternary Sub-catchment code

² Map Datum = WGS84

³ The elevation was obtained from a Garmin Dakota, with Garmap's Southern Africa TOPO 2013 PRO, run on Garmin Base Camp Version 4.4.7.

Aquatic Ecoregion	Reach Code	Site Code	QC ¹	SQR Length (km)	River	GPS ² (dd.ddddd)		Elevation ³
						S	E	
Crocodile River Tributaries								
Eastern Bankenveld	Not on reach	X2KARE-GOLFC	X21A		Kareekraalspruit	-25.44106	30.21203	1 606
	X21B-00898	X2LUNS-VERLO	X21B	11.0	Lunsklip	-25.31040	30.14557	2 075
	X21B-00925	X2LUNS-UJTWA	X21C	21.5	Alex-se-Loop	-25.39339	30.30177	1 227
Northern Escarpment Mountains	X21C-00859	X2ALEX-RIETF	X21D	6.9	Buffelskloofspruit	-25.26896	30.40847	1 267
	X21D-00957	X2BUFF-SOMER	X21F	27.1	Elands	-25.43802	30.44810	1 168
Eastern Bankenveld	X21F-01046	X2ELAN-DEGOE		33.4	Leeuspruit	-25.68720	30.19924	1 587
	X21F-01100	X2LEEU-GELUK	X21G	12.9	Elands	-25.66180	30.25766	1 517
Northern Escarpment Mountains	X21G-01037	X2ELAN-WATER		19.7	Swartkoppiespruit	-25.63188	30.32415	1 390
	X21G-01016	X2ELAN-DOORN	X21J	28.3	Elands	-25.64619	30.37677	1 213
Northern Escarpment Mountains	X21J-01013	X2SWAR-KINDE	X21H	35	Elands	-25.61036	30.40119	1 163
	X21H-01060	X2ELAN-HEMLO	X21K	25.4	Ngodwana	-25.60042	30.55969	991
North Eastern Highlands	X21K-01035	X2NGOD-NOOIT		9.4	Elands	-25.66244	30.67236	1 071
	X21K-00997	X2ELAN-ROODE	X22B	11.0	Houtbosloop	-25.56797	30.66669	910
	X22A-00913	X2ELAN-GOEDG	X22C	28.3	Gladdespruit	-25.52798	30.69781	852
	X22C-00990	X2HOUT-SUDWA	X22J	10.0	Nelsriver	-25.49440	30.70222	832
	X22C-01004	X2VISS-ALKMA	X22H	36.7	White River	-25.38747	30.71042	804
	X22F-00977	X2GLAD-HERMA	X23E	6.7	Queens	-25.45834	30.81643	742
	X22H-00836	X2NELS-R40RO	X23F	59.2	Noord-Kaap	-25.52147	30.87853	899
	X23E-01154	X2WITR-VALLIE	X23B	43.4	Kaap	-25.42728	30.96444	645
	X23C-01098	X2QUEE-HILVE	X23H	44.3		-25.40214	31.06811	671
	X23B-01052	X2SUID-DAISY		53.8		-25.79068	30.91542	745
	X23G-01057	X2NOOR-RIVER		48.1		-25.73033	30.98429	646
		X2KAAP-HONEY				-25.61009	30.97639	664
						-25.64947	31.24286	453

3. METHODS

The general approach used for this study was based on the rapid appraisal methods accepted by the Department of Water and Sanitation (DWS) in their guidelines for Resource Directed Measures for the Protection of Water Resources (MacKay, 1999). Aquatic bio-assessment is an essential component of ecological risk assessment. It aims to measure present biological conditions and trends in an aquatic ecosystem and relate the observed variation to changes in available habitat (Figure 4) (Kleynhans & Louw, 2008). The availability of suitable habitat for aquatic biota is dictated by the physical drivers of the aquatic ecosystem such as water quality, geomorphology and hydrology. Aquatic biodiversity provides an integrative perspective of rivers as ecosystems by integrating pattern (structure) with processes (function). Biodiversity can also serve as a link between spatial and temporal phenomena and can explain the roles of functional processes in ecosystems. Several of the aquatic species and taxa that have been recorded in the Crocodile River are considered highly sensitive to changes in the above-mentioned physical drivers and are expected to respond rapidly to any changes. The purpose of this study is to use resident aquatic biota to characterize the existence and severity of impairments in the Crocodile River and to attempt to identify any sources and causes of impairment related to the catchment.

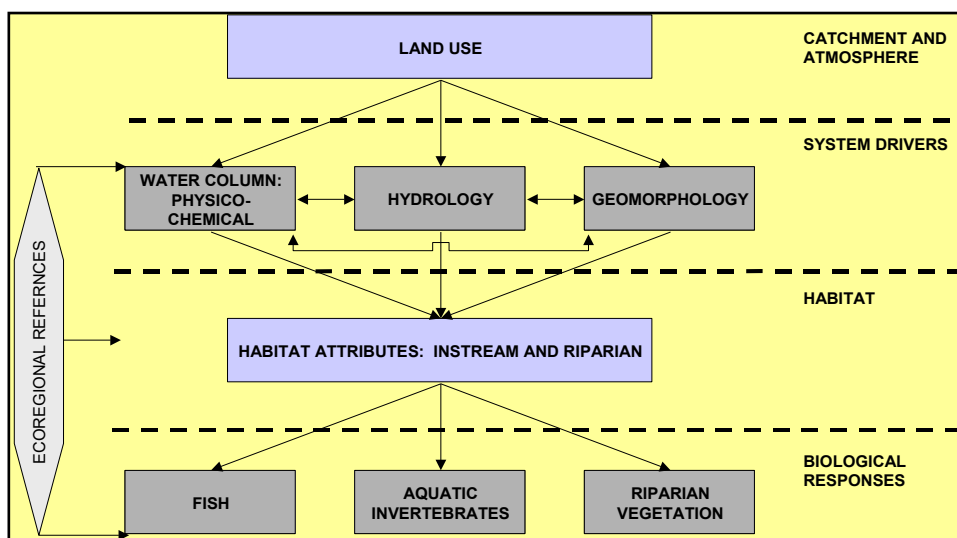


Figure 4: A simplified integration of influence of land use on physical driver determinants, habitats and the associated biological responses (Kleynhans & Louw, 2008).

3.1. Fish assemblage

Fish are good indicators of long-term (several years) effects and broad habitat conditions, and changes in the available habitat conditions (Karr, 1981). This is because fish are close to the “top of the food chain”, relatively long-lived and mostly highly mobile. Assemblages often include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, and piscivores). They tend to integrate effects of lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health, as well as requirements for different habitat types, cover requirements and sensitivity to flow and physio-chemical modifications.

The PESEIS Front End Model was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2014a). A list of fish species collected during the 2017 biomonitoring, as well as photos of the fish species recorded at sampling sites (Scott et al., 2004) are attached in the Appendix A. All scientific fish species name changes were done in accordance to Skelton (2016).

Fish were sampled using a 10mm-mesh scoop-net and a SAMUS DC electro shocking device. Electro shocking is highly effective and entails the use of an electronic device to rapidly catch fish. The sampling of fish by using an electro shocker is based on the flow of direct electric current (DC) in water causing an anode reaction (galvanotaxis) in fish. Apart from the critical electric parameters to be considered, the electrical conductivity of waters (salinity), temperatures, surface of electrodes, species and the size of fish are also important parameters. These parameters can only be determined on site with a considerable degree of experience (Cowx, 2001). All fish species were identified and anomalies and general age structure were recorded. Sampling effort (time electricity applied in water) per site was kept to about 30 minutes.

The presence, absence or abundance of fish species in comparison to the expected reference condition was based on all baseline data obtained and available habitat at each site during the survey. Fish assemblage diversity and abundance vary depending on the season and the integrity of the available habitat. This data was used in the Fish Response Assessment Index (FRAI) and Reference Frequency of Occurrence (FROC) (Kleynhans *et al.*, 2008) to evaluate changes from reference conditions. The FRAI is a rule-based model recently developed by DWAF (Kleynhans, 2008) and is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers.

These intolerance and preference attributes are categorized into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species. Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements. Usually the FRAI is based on a combination of fish sample data and fish habitat data (Kleynhans, 2008).

Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation and to determine the “Present Ecological Category” of the fish assemblage.

3.2. Aquatic Macro Invertebrates

Macro invertebrate assemblages are good indicators of localized conditions in rivers. Because many benthic macro invertebrates have limited migration patterns, or a sessile mode of life, they are particularly well-suited for assessing site-specific impacts (upstream/downstream studies). Benthic macro invertebrates are abundant in most streams. Many small streams (1st and 2nd order) naturally support a diverse macro invertebrate fauna, but only support a limited fish

fauna. Benthic macro invertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects.

Aquatic macro invertebrates have therefore been used to assess the biological integrity of stream ecosystems with reasonably good success throughout the world (Rosenberg & Resh 1993, Resh et al., 1988, Barbour et al., 1996). Aquatic macro invertebrates are more commonly used for this purpose than any other biological group (O'Keeffe & Dickens, 2000) and aquatic macro-invertebrate communities offer a good reflection of the prevailing flow regime and water quality in a river.

Aquatic invertebrates were collected using a standard net and taxa were identified to at least family level per the SASS5 sampling technique (Dickens & Graham, 2001). Taxa collected from streams were analysed per the standard SASS technique. Chutter (1968) developed the SASS protocol as an indicator of water quality.

The interpretation of values can differ significantly for different eco-regions in the country (Davies & Day, 1998). Because SASS was developed for application in the broad synoptic assessment required for the River Health Program (RHP), it does not have a particularly strong cause-effect basis. The MIRAI (Macro Invertebrate Assessment Index) was used to interpret the Ecological Condition of the macro invertebrate for the sites. The MIRAI is a rule-based model developed by DWAF (Thirion, 2008) considering water quality, flow preferences and habitat requirements of invertebrates. It integrates the ecological requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions.

3.3. Riparian Vegetation

The riparian vegetation (riparian habitat) is described as the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas, clearly distinguished from wetland areas. The Riparian Vegetation Response Assessment Index (VEGRAI) is an impact-based, rapid, cause-and-effect assessment index, detecting changes in vegetation condition. The model compares the present day riparian vegetation condition to that in its reference state and determines the Ecological Category (Kleynhans *et al.*, 2007). The products of VEGRAI are more than a measure of Ecological Category as the process and data are valuable in and of themselves. It is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results. Results are defensible because their generation can be traced through an outline process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

The metrics in the VEGRAI first describe the status of riparian vegetation in both its current and reference states and second, compare differences between the two states as a measure of vegetation response to an impact regime. The riparian zones (Marginal, Lower and Upper) were used as the metric groups. For the simplified Level 3 version, the Lower and Upper Zones were combined to form the Non-marginal metric group. The metrics are then rated and

weighted and an Ecological Category (A – F) determined which represents the Ecological Category for the riparian vegetation state (Kleynhans, et al., 2007).

3.4. Habitat Integrity

The habitat integrity of an aquatic water body refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, et al., 2009). Assessment of habitat integrity using the Index of Habitat Integrity (IHI) model is based on an interpretation of the deviation from the reference condition. Specification of these reference condition follows an impact based approach where the intensity and extent of anthropogenic changes are used to interpret the impact on the habitat integrity of the system. Habitat integrity assessment is considered from an instream and riparian zone perspective. Metric groups are formulated, each with a number of metrics that enables the assessment of habitat integrity. The model functions in an integrated way, using the results from the assessment of metric groups. Interpretation of the severity of impacts is based on the natural characteristics of the river (Kleynhans, et al., 2009)

3.5. Water Quality

Information from the PESEIS study (DWS 2014a), i.e. a qualitative desktop assessment of water quality impacts in the area as one of the metric assessed, is the first information source used to inform a water quality assessment for rivers. This overview is then built on through information and data collection and analysis. Note that the assessment presented here is based on both the Inkomati Reserve and Classification studies previously completed. The gazetted water quality RQOs are the outcome of the EcoSpecs produced from the Reserve study (DWA, 2010) and the RQOs from the Classification study completed in 2015 (DWS, 2014b).

Methods as outlined in DWAF (2008) were used for the present state assessment, i.e. data analysis to provide summary statistics, and use of the PAI model to provide an integrated water quality category for the High Priority water quality sites (as outlined in DWS, 2014b).

Water quality data were collected from the following sources:

- At each biomonitoring site *in situ* water samples were collected in treated plastic bottles using standard methods and for analysis at Regen Waters Laboratory⁴. Note that only one water sample was collected per site; mostly in July 2017 and a few sites in January – March 2018. Variables measured are shown in Table 4.

Table 4: List of chemical and physical variables measured and analysed.

Variable	Measure	Units
Physical		
Colour	Absorbance of light	
Specific conductance (EC)	Electric carrying capacity	mS/m
Dissolved Solids (TDS)	Concentration of solids < a given filter pore size	mg/L
Temperature	Thermal energy	°C

⁴Regen Waters Laboratory, 4 Woltemade Street, Emalahleni, 1035, Tel: 013-690-1487; Email: regenlab@mweb.co.za

Transparency	Light transmission		cm
Chemical			
Aggregate	Hardness	□(divalent cations) □ [Ca ²⁺]+[Mg ²⁺]	mg/L as CaCO ₃
Inorganic	Major cations	Calcium	mg/L as Ca ²⁺
		Magnesium	mg/L as Mg ²⁺
		Sodium	mg/L as Na ⁺
		Potassium	mg/L as K ⁺
	Major anions	Sulphate	mg/L as SO ₄ ²⁻
		Chloride	mg/L as Cl ⁻
	Minor ions	Aluminium	mg/L as Al
		Fluoride	mg/L as F
	Hydrogen (H ⁺ - pH)		
Dissolved Gasses	Oxygen		mg/L & % O ₂
Nutrients	Ammonium (NH ₄)		mg/L as N
	Ammonia (NH ₃)		mg/L as N
	Nitrite (NO ₂)		mg/L as N
	Nitrate (NO ₃)		mg/L as N
	Orthophosphate (H ₂ PO ₄)		mg/L as P
	Silica (Si(OH) ₄)		mg/L as Si

- Field water quality parameters were measured at the time of biomonitoring using a Eutech Cyberscan PC10 water quality meter (temperature, pH, and electrical conductivity), and an AZ8403 dissolved oxygen (DO) meter (concentration in mg/L and % saturation). *In situ* measurements and water quality samples were taken and collected in straight reaches with uniform flow and where constituents were considered to be well mixed along the cross section, as described in standard methods (US Geological Survey, 2006).
- Data were collected from DWS's Water Management System's (WMS) database for rivers of X2. Water quality monitoring points were linked to biomonitoring sites using information from the Inkomati Classification study and Google Earth, and data available per monitored SQR listed on Tables 5 to 7. Note the points where representative DWS data are not available for a water quality present state assessment are listed below. It is assumed that data as collected by the IUCMA and other organizations in the area have been incorporated into WMS.

Once analysed, data were compared to gazetted water quality RQOs as follows:

- Step 1: Focus on the present state of the EWR sites in the system, i.e. EWR C1 to EWR C6 – Crocodile River main stem; EWR K7 (X23G-01057) – Kaap River; and the two EWR sites on the Elands River – EWR ER1 (X21G-01037) and EWR ER 2 (X21K-01035). Note that as EcoSpecs and Thresholds of Probable Concern (TPCs) were produced for the Elands River sites during the Reserve studies, these two sites fall under water quality High Priority sites in the 2016 gazette.
- Step 2: Focus on water quality High Priority sites in the system.
- Step 3: Assess present state against RQOs set for these sites. Indicate RQOs that are met by shading in green (√), and those not met by shading in red (x). Shading in pink indicates a slight elevation above the RQO. No colouring indicates the RQO could not be measured (e.g. data were not available or confirmation may be required by the biological monitoring team. Note that only aquatic ecosystem parameters have been evaluated.

Maps and RQO information is taken from DWS (2014b), i.e. the RQO report of the Inkomati Classification study and the gazetted RQOs of December 2016.

No suitable water quality data could be accessed near the following biomonitoring sites:

- X21A-01008 (small tributary joining the Crocodile downstream X21A-00930)
- Buffelskloofspruit: X21D-00957
- Swartkoppiespruit: X21G-01016
- Visspruit: X22C-00990. Data from X2H029 at Alkmaar old.
- X22C-00946: Main stem of the Crocodile River. Data from X2H075 old.
- X24C-01003: Main stem of the Crocodile River downstream of the Kaap River confluence.
- X21F-01046

Table 5: Biomonitoring sites and associated DWS water quality monitoring points in the Crocodile River and selected tributaries.

Station/ Monitoring point no.	Place	Latitude	Longitude	Number of samples	Date start	Date end	Biomonitoring site SQ
190744	Dullstroom - @ 540 road bridge on Crocodile River	-25.4142	30.11178	166	2008/02/26	2017/12/05	X21A-00930 (EWR C1)
X2H006	Crocodile River @ Karino	-25.4694	31.1	701	1962/03/05	2017/05/02	X22J-00958
X2H094	Crocodile River @ Friedenheim Lions Club	-25.4558	31.01333	147	2008/02/20	2017/12/05	X22J-00958
X2H013	Crocodile River @ Montrose	-25.4472	30.71167	1590	1966/04/24	2017/12/05	X21E-00943 (EWR C3)
X2H016	Crocodile River @ Tenbosch	-25.3622	31.95667	2038	1970/02/20	2017/05/24	X24H-00934 (EWR C6)
X2H017	Crocodile River @ Thankerton/KNP	-25.4378	31.63472	1279	1969/11/27	1992/05/12	X24F-00958
X2H032	Crocodile River @ Weltevrede	-25.5139	31.22444	1597	1972/03/26	2017/08/21	X22K-01018 (EWR C4)
X2H033	Crocodile River @ Sterkdoorn	-25.3767	30.44639	344	1977/04/20	1992/04/27	X21D-00938
X2H048	Crocodile River @ Malelane Bridge	-25.4597	31.53556	599	1983/10/17	2017/12/08	X24D-00994 (EWR C5)
X2H050	Crocodile River @ Crocodile River Bridge, KNP	-25.3603	31.89444	228	1983/10/17	2005/02/18	X24H-00880
190745	Roodewal 117 jt - @ R36 road bridge on Crocodile river u/s of Kwena Dam	-25.3991	30.33106	147	2008/02/27	2017/12/05	X21B-00962 (EWR C2)
191437	Crocodile River @ Rivulets @ Road bridge	-25.4301	30.75744	166	2008/01/21	2017/12/05	X22B-00888
190746	Roodewal 117 JT @ R36 road bridge on Lunskliprivier u/s of Kwena Dam	-25.3967	30.33003	138	2008/02/26	2017/12/05	X21B-00898; X21B-00925
X2H014	Houtbosloop spruit @ Sudwalaaskraal	-25.3814	30.70083	594	1966/08/02	2017/05/22	X22A-00913
191449	Sudwalaaskraal 271 JT - @ road bridge on Houtbosloop	-25.3772	30.69169	158	2008/01/21	2017/12/05	X22A-00913
191450	Elandshoogte 270 JT - @ road bridge, u/s of Elandshoogte mine on Houtbosloop	-25.357	30.66586	128	2008/01/21	2017/12/05	X22A-00913
1-9826	Gladdespruit Pappas Quarry	-25.4619	30.95167	124	2006/06/27	2016/12/05	X22C-01004
19836	Goedehoop 128 JU @ Karino road bridge on White River u/s of confluence with Crocodile River	-25.465	31.08323	20	2016/01/25	2016/12/05	X22H-00836
X2H023	Wit River at Goede hoop	-25.4617	31.08333	377	1968/01/11	1992/04/28	X22H-00836
192544	Longmere Dam @ down stream	-25.2804	31.00072	139	2008/02/21	2017/12/05	X22H-00836

Table 6: Biomonitoring sites and associated DWS water quality monitoring points in the Kaap River.

Station	Place	Latitude	Longitude	Number of samples	Date start	Date end	Biomonitoring site SQ
X2H024	Suidkaap River @ Glenthorpe	-25.7108	30.83222	217	1972/03/27	Only date until 1982 so not suitable	X23C-01098
X2H031	Suidkaap River @ Bornmans Drift	-25.7292	30.97889	564	1966/08/03	2017/10/19	X23C-01098
X2H032	Daisy Kopje-Nelspruit/Barberton bridge (Queens River)	-25.7392	30.99861	156	2007/01/24	Monitoring no longer active so not suitable	X23E-01145
X2H008	Queens River at Sassenheim	-25.7856	30.92417	559	1969/11/26	2017/05/17	X23E-01145
X2H022	Kaap River @ Dolton	-25.5422	31.31722	1075	1962/06/20	2017/05/24	X23G-01057 (EWR K7)
X2H087	Bon Accord – d/s of Eureka	-25.6797	31.18194	163	2006/09/18	2017/11/01	X23G-01057 (EWR K7)
X2H010	Noord-Kaap River at Bellevue	-25.6094	30.87528	484	1972/10/11	2017/07/12	X23B-01052
X2H080	Segalla – u/s of Consort Gold Mine	-25.6522	31.06056	154	2007/01/24	2016/11/22	X23B-01052

Table 7: Biomonitoring sites and associated DWS water quality monitoring points in the Elands River.

Station/ Monitoring point no.	Place	Latitude	Longitude	Number of samples	Date start	Date end	Biomonitoring site SQ
1-3177	Leeuspruit @ bridge 50 m d/s Emthonjeni s/w	-25.6926	30.25568	289	2004/01/29	2016/12/05	X21F-01100
X2H012	Leeuspruit @ Geluk on (Dawson S)	-25.6578	30.26056	437	1972/03/23	2017/05/15	X21F-01100*
192552	Bambi at road bridge on Elands River near Ngodwana	-25.5691	30.66147	140	2008/01/21	2017/12/05	X21K-01035 (EWR ER2)
X2H015	Elands River @ Lindenau	-25.4878	30.6975	1407	1972/03/23	2017/08/21	X21K-00997
	At Lindenau 5 km d/s Sappi Ngodwana on Elandsrivier	-25.4906	30.69993	148	2004/01/29	2016/12/05	X21K-00997
	At Hemlock u/s Sappi Ngodwana on Elandsrivier	-25.5983	30.57917	134	2003/11/26	2016/12/05	X21J-01013
187647	Doornhoek at N4 bridge d/s Watervalboven SW on Elandsrivier	-25.6463	30.35897	142	2004/02/24	2017/03/27	X21G-01037
X2H011	Elands River @ Geluk	-25.6458	30.27778	657	1972/03/23	2009/03/02	X21G-01037
	Elands River 100m u/s Watervalboven SW	-25.6358	30.3416	151	2004/01/29	2016/12/05	X21G-01037 (EWR ER1)
X2H034	Ngodwane River @ Coetzeestroom	-25.6008	30.67833	201	1972/03/23	Only date until 1983 so not suitable	X21H-01060

*Also evaluate data from 1-3176, i.e. Leeuspruit D/S Assmang Chrome Bridge

3.6. Hydrology Flow

Hydrology is considered one of the most important drivers of riverine ecological conditions (Gordon et al. 2008; Mims, 2013). The water resources of the Crocodile River catchment are managed under the custodianship of the IUCMA, with two key features that ensure flows in the river are maintained above a minimum threshold, these are: the ecological reserve (environmental water requirements, EWR) and international flow obligations to Mozambique. The former is mandated through the Management Class II, Recommended Ecological Category C as gazetted during 2016. These flows vary month by month and are dependent on the antecedent catchment conditions. Meanwhile the international flows are based on the Interim-Inco Maputo Agreement, which specifies a minimum contribution of $0.9 \text{ m}^3\cdot\text{s}^{-1}$ at the Tenbosch Weir (X2H016) added to the Komati's $1.1 \text{ m}^3\cdot\text{s}^{-1}$ at Komatipoort/Ressano Garcia. In reality the gazetted ecological flows are greater than the specified international obligations, ensuring that if the ecological reserve is achieved then so too are the international obligations.

There is an intricate system established by the IUCMA through the Crocodile and Sabie River Operations Committee, CROCOC (Jackson, 2015). This is achieved through close co-ordination of river operations from key water use sectors in the Crocodile River notably, the Crocodile River Major Irrigation Board and other irrigation boards, the Kruger National Park, Mbombela and Nkomazi Local Municipalities, Sembcorp-Silulumanzi and Rand Water. The focus of this co-ordination is to manage the catchment adaptively to medium & long term climate variability, ensuring that releases from the upstream Kwena Dam achieve required outcomes for low flow management and bulk water users (irrigation and municipal supplies) in the eastern Lowveld region. This is achieved through real-time tracking of flows and where necessary restricting irrigation users downstream using a decision support system based on Thresholds of Potential Concern for river flow targets (McGloughlin et al, 2011). Using flows at Tenbosch as a benchmark the assumption is made that if ecological reserve requirements are met here then they will also be achieved at the EWR sites upstream. Whilst this process has ensured progressive compliance with the ecological reserve over the past ten years (Harwood et al, 2017, Jackson, 2015, Riddell et al, 2014), it has inevitably created a dependence on counter seasonal releases from Kwena Dam upstream during late winter and early spring (noted as a concern in the Phase 1 report). It is therefore of utmost importance that the links between operational management of the water resource are able to reflect on ecological responses in the aquatic environment, as is the intention of the ecological reserve, and to which this report provides those means.

3.7. Present Ecological State

The Present Ecological State (PES) of the river is expressed in terms of various components that incorporate drivers (physicochemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates). The scale used for river health describes five different states of health, from an A category (natural) to an F category (critically modified). The results of applying the biological and habitat indices during a river survey provide the context for determining the degree of ecological modification at the monitoring

site. Thus, the degree of modification observed at a particular site translates in to Present Ecological State (Table 8) (Kleynhans & Louw, 2008).

The PESEIS Front End Model for the Crocodile Secondary drainage area (X2) was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2014a). Data compilation was done according to models that were developed to determine the Ecstatus (Kleynhans, 2008). The River Data Integration Application (RIVDINT) was developed in a project between RQS and MTPA (Kleynhans et al., 2017) and was also utilised during the data compilation and analysis process.

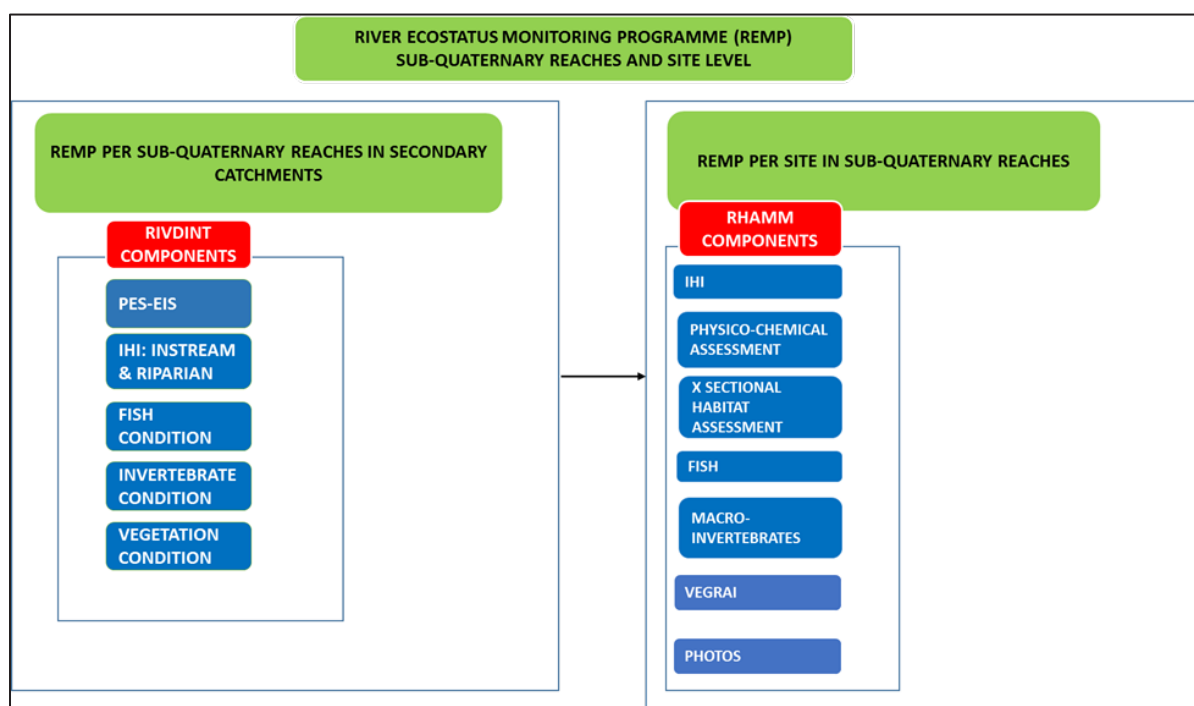


Figure 5: Diagrammatic representation of the River Ecstatus Monitoring Programme (REMP) at Sub-quaternary reaches and site level.

The River Eco-status Monitoring Programme (REMP) has evolved from the River Health Programme (RHP) and REMP replaced the RHP. It is a component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP). The REMP focuses on the monitoring of the ecological conditions in River ecosystems as it is reflected by the system drivers and biological responses (instream and riparian). The basis of the REMP is the establishment of a relative reference condition, usually a natural or close to natural condition, derived from the best available information. In its formulation and characterization the relative reference condition considers the characteristics of the abiotic drivers of the system, namely, the hydrology, geomorphology and physico-chemical conditions that determine the habitat template for instream and riparian biota. It furthermore considers the characteristics of the instream and riparian biota as a response to the system drivers (<http://www.dwa.gov.za/iwqs/rhp/rhp>).

The REMP (River Ecostatus Monitoring Programme) (Figure 5, 6 and 7) is built upon the use of particular models incorporating existing approved Eco-status models: River Data Integration (RIVDINT), Rapid Habitat Assessment Method and Model (RHAMM) and Fish Invertebrate Flow Habitat Assessment (FIFHA) (<http://www.dwa.gov.za/iwqs/rhp/rhp>; DWA, 2016).

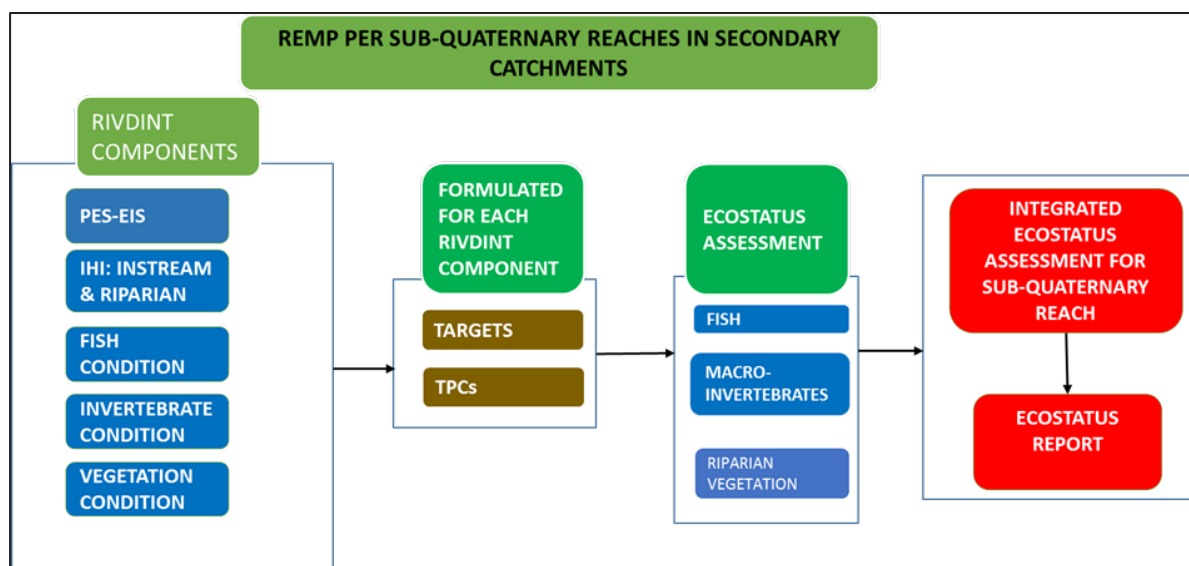


Figure 6: Diagrammatic representation of the REMP per sub-quaternary reaches in secondary catchments

River Data Integration (RIVDINT): Assessment is done on a Sub-Quaternary Reach (SQR) level and includes use of the Index of Habitat integrity model (Instream and Riparian), Fish Assemblage, Invertebrate Assemblage, Vegetation (Riparian) condition. Based on the available and approved RQOs, Targets for the various components are set (as well as TPCs) for a Sub-Quaternary reach (or a subdivision of the SQR where necessary). Where RQOs for a SQR have not been set according to the EWR-site approach, it is still possible to set ecological targets based on specific ecological considerations. The eventual result of this process is the Fish, Invertebrate, Vegetation and integrated Ecostatus for a SQR. The RIVDINT has been developed as data storage and retrieval system that allows the comparison of various components over time. The model includes the development of relative reference conditions for all components. The first detailed assessment of a SQR will be considered the baseline against which future assessments will be evaluated (Kleynhans, 2016 pers.comm).

Rapid Habitat Assessment Method and Model (RHAMM): Assessment is done on a site level where a site should be representative of a SQR or a subdivision thereof. Ecostatus models are incorporated into the RHAMM is IHI, FRAI, MIRAI, VEGRAI and the Integrated Ecostatus. Specific information for setting targets for indicator fish species (in terms of FRAI) and invertebrate taxa (e.g. in terms of SASS5) are provided for. The formulation of relative reference conditions is provided for in the RHAMM. Targets and TPC's can be set for available and approved RQOs (i.e. at EWR sites) in terms of biota and habitat requirements (also including the use of cross

sections and habitat measurements). Where EWR-site data is not available, biological targets and TPCs can still be set for the site. Only a very limited number of physico-chemical measurements are included in the RHAMM.

Fish Invertebrate Flow Habitat Assessment (FIFHA): This model originates from the Fish Flow Habitat Assessment (FFHA) model that was used in some applications of the HFSR. The primary aim of the FIFHA is not to do instream flow requirements per se, but to use the data generated by the HFSR model (e.g. Hydrology and HABFLO) and the categories and flows that were set during the HFSR process to establish a basis for rapid assessment of fish and invertebrate habitat conditions at a EWR cross section. It follows that the FIFHA can only be used where a EWR site with the necessary hydraulic and hydrology are available.

It is evident from this explanation that the REMP logically includes the monitoring of ecological and specific biological components that have been established and approved (i.e. Gazetted) as Resource Quality Objectives or RQOs (DWA, 2016).

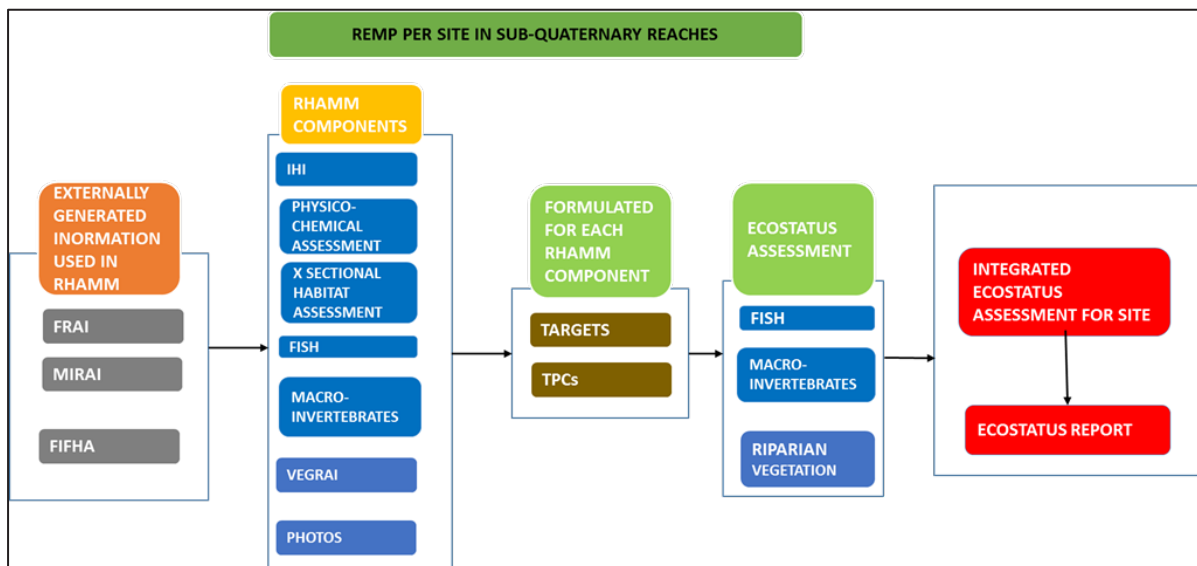


Figure 7: Diagrammatic representation of the REMP per site in Sub-quaternary Reaches.

Monitoring is only a valid term to use if the results of this survey is measured against targets (Greenwood & Robinson, 2006). The results of this survey is therefore compared to the Target Ecostatus Categories (TEC) as Gazetted and documented for the Resource Quality Objectives (RQO's) defined for each prioritised resource unit (RU) within every Integrated Unit of Analysis (IUA) in terms of water quantity and quality, as well as habitat and biota (DWA, 2014b; Government Gazette No 40531, 30 December 2016; Kleyhans, 2016 pers.comm).

Table 8: Guidelines used to delineate Generic ecological categories for Ecological Integrity Categories (based on Kleynhans 1996, 1999 & Government Gazette, 30 December 2016, No. 1616, Department of Water and Sanitation).

ECOLOGICAL CATEGORY	GENERIC DESCRIPTION OF ECOLOGICAL CONDITIONS	ARBITRARY GUIDELINE SCORE (% OF MAXIMUM THEORETICAL TOTAL)
A	Unmodified/natural, close to natural or close to predevelopment conditions within the natural variability of the system drivers: hydrology, physico-chemical and geomorphology. The habitat template and biological components can be considered close to natural or to pre-development conditions. The resilience of the system has not been compromised.	>92 - 100
A/B	The system and its components are in a close to natural condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a B category.	>88 - <= 92
B	Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions and resilience are essentially unchanged.	>82 - <=88
BC	Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category.	>78 - <=82
C	Moderately modified. Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The resilience of the system to recover from human impacts has not been lost and it is ability to recover to a moderately modified condition following disturbance has been maintained.	>62 - <=78
CD	The system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category.	>58 - <=62
D	Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions have occurred. The resilience of the system to sustain this category has not been compromised and the ability to deliver Ecosystem Services has been maintained.	>42 - <=58
DE	The system is in a close to largely modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of an E category. The resilience of the system is often under severe stress and may be lost permanently if adverse impacts continue.	>38 - <=42
E	Seriously modified. The change in the natural habitat template, biota and basic ecosystem functions are extensive. Only resilient biota may survive and it is highly likely that invasive and problem (pest) species may dominate. The resilience of the system is severely compromised as is the capacity to provide Ecosystem Services. However, geomorphological conditions are largely intact but extensive restoration may be required to improve the system's hydrology and physico-chemical conditions.	20 - <=38
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete change of the natural habitat template, biota and basic ecosystem functions. Ecosystem Services have largely been lost This is likely to include severe catchment changes as well as hydrological, physico-chemical and geomorphological changes. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible. Restoration of the system to a synthetic but sustainable condition acceptable for human purposes and to limit downstream impacts is the only option.	<20

4. RESULTS

A total of 40 sites were sampled in the Crocodile Catchment, of which 17 were sampled on the main Crocodile River (Figure 8) and ten (10) on smaller Crocodile River tributaries (e.g. Kareekraalspruit, Lunsklip, Alexanderspruit, Buffelskloofspruit, Houtbosloop, Visspruit, Gladdespruit, Nelsriver and White River) (Figure 9). In the Elands River sub-Catchment and tributaries ten (10) sites were surveyed (Figure 10), four (4) sites in the Kaap River Catchment (Figure 11). At all these sites fish, invertebrate and habitat integrity assessments were conducted (Appendix A and B). The riparian and vegetation assessment (VEGRAI) was carried out on ten (10) sites in the Crocodile River Catchment (Appendix C). Biomonitoring results of EWR sites 1 to 7, as well as EWR ER1 and ER2, in comparison to RQO's for fish, macro-invertebrates and riparian vegetation in the Crocodile River, as well as the Target Ecological Category as published in the Government Gazette No 40531, 30 December 2016 is indicated in Table 9. The Ecostatus ratings derived from the RIVDINT model are presented in Table 10 for each of the SQ reaches monitored during the 2017 survey.

In Appendix A the fish species are listed in alphabetical order and illustrations of fish species from the Atlas of Southern African Freshwater Species - SAIAB (Scott et al., 2004) recorded at all the sampling sites are furthermore included. In Appendix B invertebrate data recorded on SASS5 data sheets are captured. Photos of each site is captured in Figures A01 to A83.

Table 9: Biomonitoring results of EWR sites 1 to 6 in comparison to RQO's for fish, macro-invertebrates and riparian vegetation in Crocodile River (X2), as well as the Target Ecological Category (TEC) as published in Government Gazette No 40531, 30 December 2016.

EWR SITE	SQ REACH	SITE NAME	FISH ECOSTATUS		TEC FISH	INVERTEBRATES ECOSTATUS		TEC INVERTEBRATES	RIPARIAN VEGETATION ECOSTATUS		TEC RIPARIAN	INTEGRATED ECOSTATUS		TARGET ECOLOGICAL CATEGORY
			2012	2017		2012	2017		2012	2017		2012	2017	
EWR 1	X21A-00930	X2CROC-VALY1	C	BC	A	B	AB	B	C	B	A	BC	B	AB
EWR 2	X21B-00962	X2CROC-GOEDE	C	BC	B	B	B	B	C	B	AB	C	B	B
EWR 3	X21E-00943	X2CROC-POPLA	C	BC	B	C	BC	C	D	C	C	C	C	BC
EWR 4	X22K-01018	X2CROC-N4ROA	BC	BC	B	C	C	C	C	C	C	C	C	C
EWR 5	X24D-00994	X2CROC-MALEL	BC	BC	C	C	C	C	C	C	C	C	C	C
EWR 6	X24H-00934	X2CROC-NKONG	C	C	C	C	C	C	C	C	C	C	C	C
EWR 7	X23G-01057	X2KAAP-HONEY	C	C	B	C	C	B	D	C	CD	C	C	C
EWR ER1	X21G-01037	X2ELAN-WATER	C	C	B	AB	C	B	C	C	C	BC	C	B
EWR ER2	X21K-01035	X2ELAN-ROODE	B	BC	B	B	C	B	D	C	C	BC	C	B

Table 10: Biomonitoring results derived from the RIVDINT model, summarised for each reach in the Crocodile River and its tributaries as well as the Target Ecological Category (TEC) as published in Government Gazette No 40531, 30 December 2016. EWR sites indicated in light orange.

Reach Code	Site Code	River	Fish Ecstatus	Invertebrate Ecstatus	Instream Ecstatus	Riparian Vegetation Ecstatus	Integrated Ecstatus	TEC
Crocodile River Mainstem								
X21A-00930	X2CROC-VERLO	Crocodile	BC	AB	B	B	B	AB
	X2CROC-VALY1* (EWR 1)							
X21B-00962	X2CROC-DONKE	Crocodile	BC	B	B	B	B	B
	X2CROC-GOEDE* (EWR 2)							
X21D-00938	X2CROC-DOORN	Crocodile	BC	B	B	BC	BC	C
X21E-00943	X2CROC-RIETV	Crocodile	BC	BC	BC	C	C	BC
	X2CROC-POPLA* (EWR 3)							
X22B-00888	X2CROC-MONTR	Crocodile	C	C	C	C	C	C
X22C-00946	X2CROC-RIVUL	Crocodile	C	C	C	C	C	C
X22J-00958	X2CROC-STRKS	Crocodile	B	C	C	C	C	C
X22K-01018	X2CROC-KAMAG	Crocodile	BC	C	C	C	C	C
X22K-01018	X2CROC-N4ROA* (EWR 4)	Crocodile	C	C	C	C	C	C
X24C-01033	X2CROC-KAAPM	Crocodile	CD	C	C	C	C	C
X24D-00994	X2CROC-MALEL* (EWR 5)	Crocodile	BC	C	C	C	C	C
X24F-00953	X2CROC-MARO2	Crocodile	C	C	C	C	C	C
X24H-00880	X2CROC-MYAMB	Crocodile	C	C	C	C	C	C
X24H-00934	X2CROC-NKONG* (EWR 6)	Crocodile	CD	C	C	C	C	C
Crocodile River Tributaries								
Not on reach	X2KARE-GOLFC	Kareekraalspruit	BC	C	C	C	C	BC
X21B-00898	X2LUNS-VERLO	Lunsklip	B	BC	B	C	BC	CD
X21B-00925	X2LUNS-UITWA	Lunsklip	C	BC	C	C	C	C
X21C-00859	X2ALEX-RIETF	Alex-se-Loop	C	C	C	BC	C	C
X21D-00957	X2BUFF-SOMER	Buffelskloofspruit	B	B	B	B	B	BC
X22A-00913	X2HOUT-SUDWA	Houtbosloop	C	BC	C	BC	C	B
X22C-00990	X2VISS-ALKMA	Visspruit	C	B	BC	B	BC	BC
X22C-01004	X2GLAD-HERMA	Gladdespruit	CD	CD	CD	C	C	BC
X22F-00977	X2NELS-R40RO	Nelsriver	C	C	C	C	C	CD
X22H-00836	X2WITR-VALLE	White River	D	C	CD	C	CD	D
Elands River & Tributaries								
X21F-01046	X2ELAN-DEGOE	Elands	C	AB	C	B	BC	C
X21F-01100	X2LEEU-GELUK	Leeuspruit	C	C	C	BC	C	C
X21G-01037	X2ELAN-WATER (EWR ER1)	Elands	C	C	C	C	C	B
	X2ELAN-DOORN							
X21G-01016	X2SWAR-KINDE	Swartkoppiespruit	C	B	BC	B	BC	C
X21J-01013	X2ELAN-HEMLO	Elands	C	C	C	C	C	BC
X21H-01060	X2NGOD-NOOIT	Ngodwana	B	C	C	B	C	B
X21K-01035	X2ELAN-ROODE (EWR ER2)	Elands	C	C	C	C	C	B
	X2ELAN-GOEDG							
X21K-00997	X2ELAN-EHOEK	Elands	C	C	C	C	C	C
Kaap River & Tributaries								
X23E-01154	X2QUEE-HILVE	Queens	C	C	C	C	C	BC
X23C-01098	X2SUID-DAISY	Suid-Kaap	C	C	C	C	C	BC
X23B-01052	X2NOOR-RIVER	Noord-Kaap	C	BC	C	C	C	C
X23G-01057	X2KAAP-HONEY (EWR 7)	Kaap	C	C	C	C	C	C

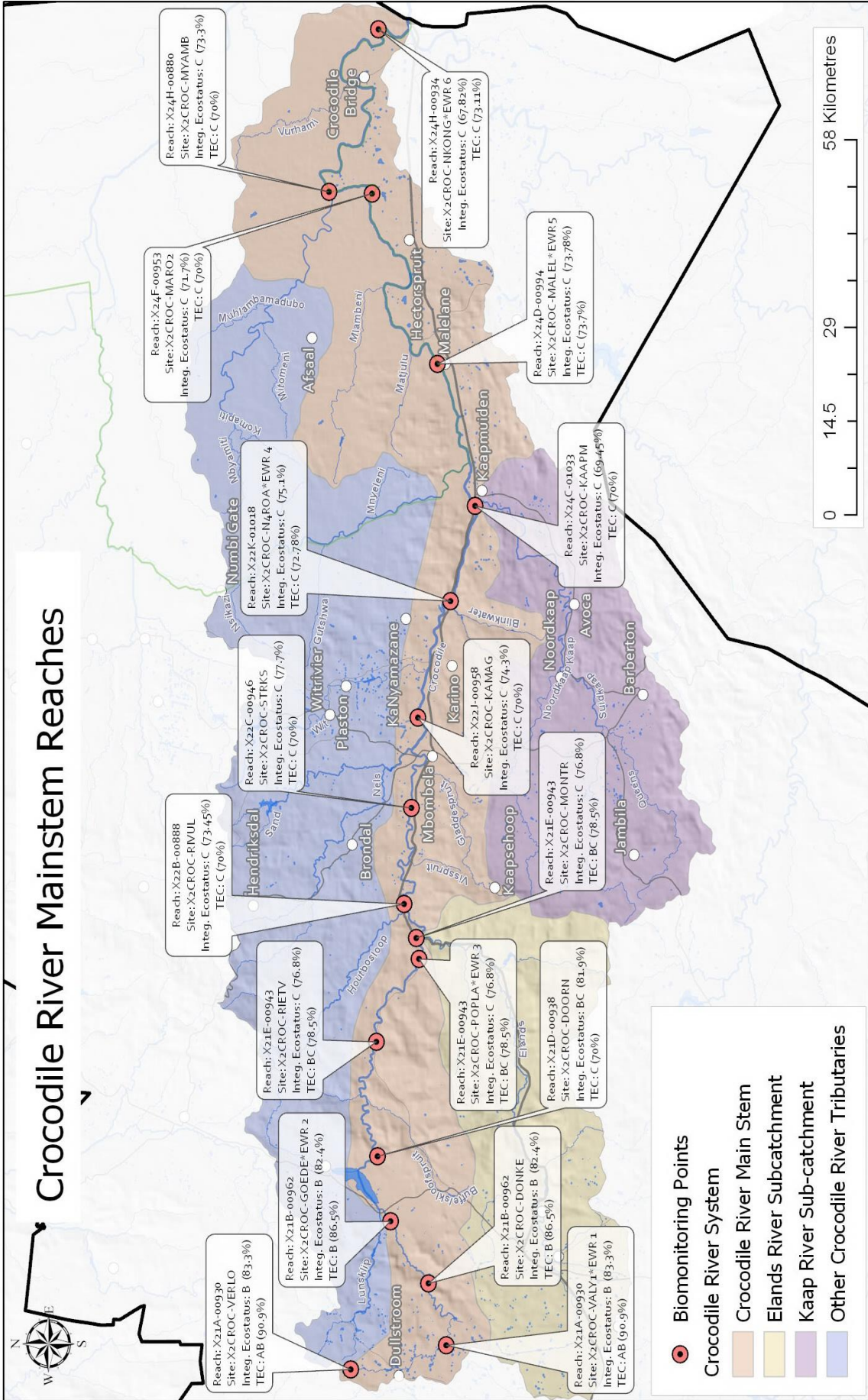


Figure 8: Map of the Crocodile River Mainstem indicating all biomonitoring points.

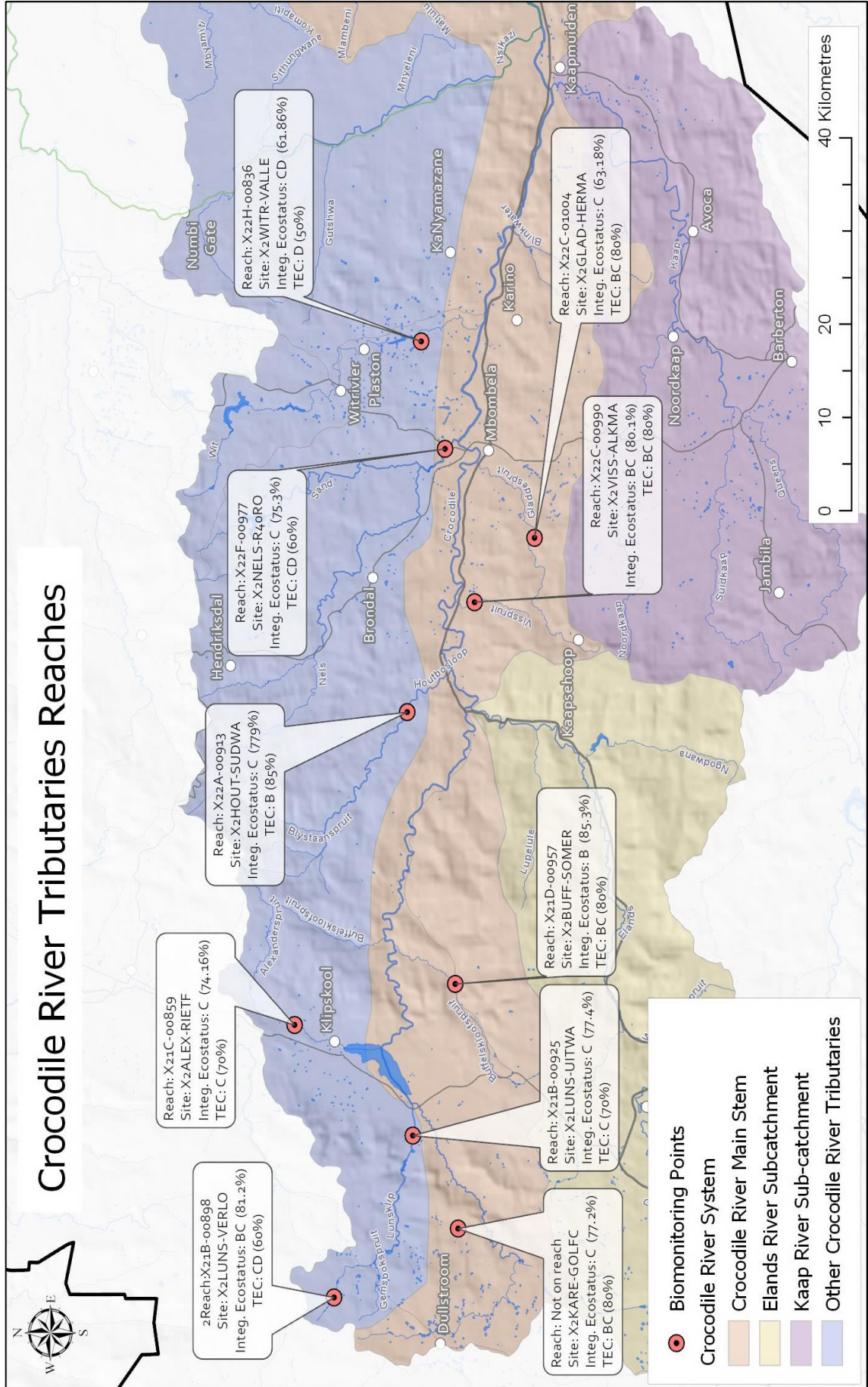


Figure 9: Map of the smaller Crocodile River Tributaries indicating all biomonitoring points.

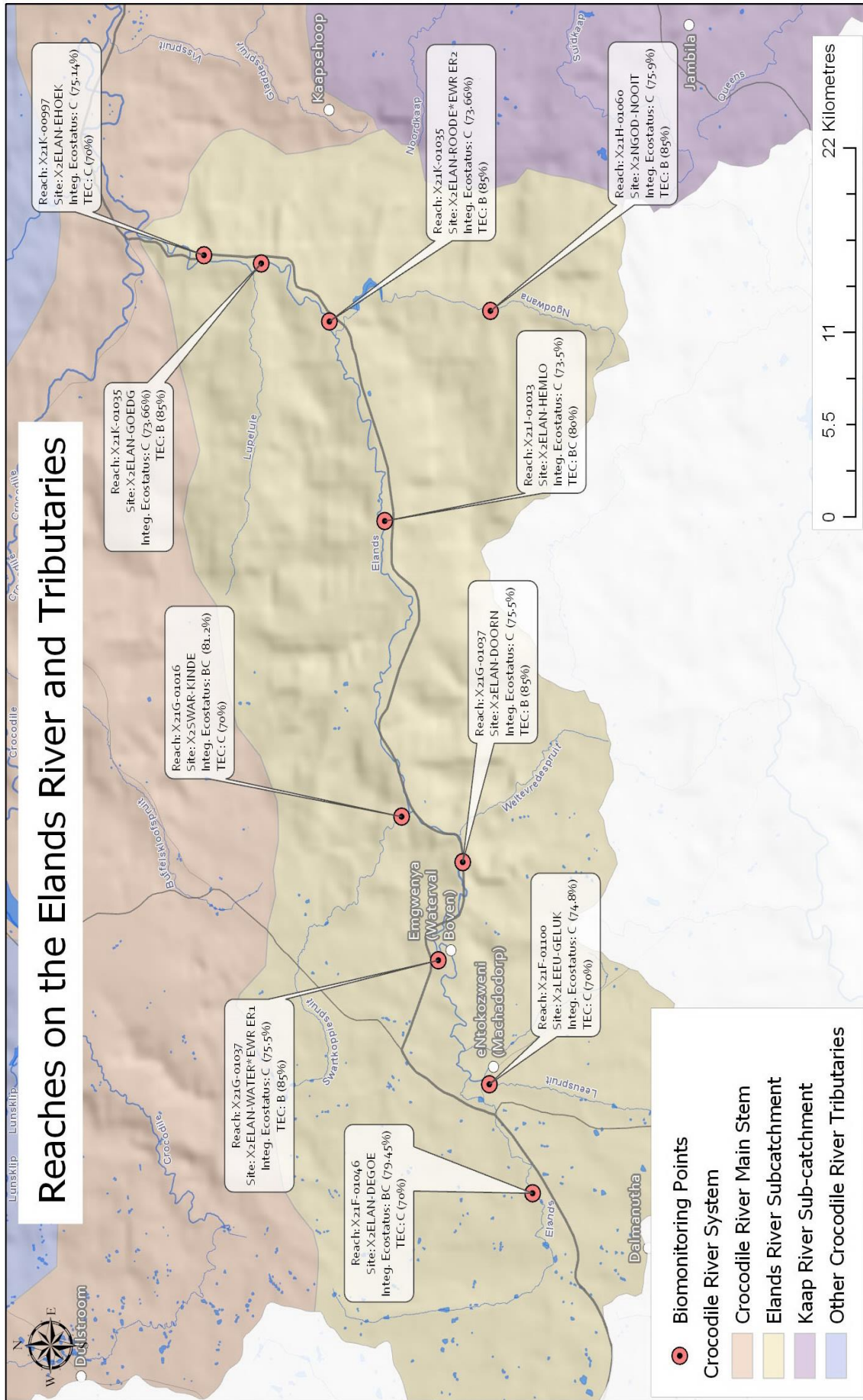


Figure 10: Map of the Elands River Catchment indicating all biomonitored points.

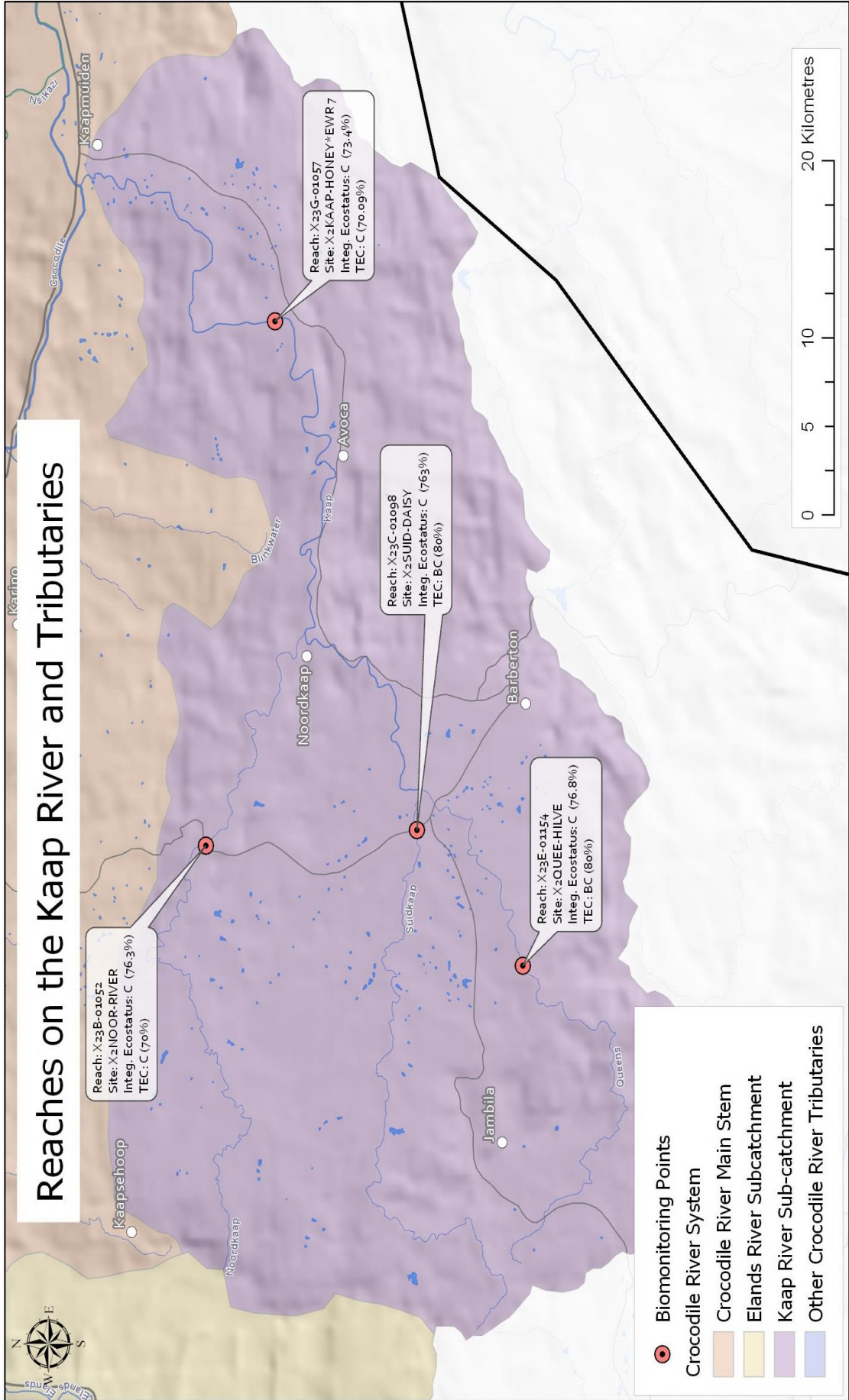


Figure 11: Map of the Kaap River Catchment indicating all biomonitoring points

Crocodile River Mainstem Reaches

The Crocodile River catchment originates in the Eastern Bankenveld aquatic ecoregion, and then flows through four additional aquatic ecoregions before entering Mozambique. A total of 17 biomonitoring points representing 13 SQ reaches on the Crocodile River mainstem were sampled during 2017.

SQ REACH NUMBER X21A-00930 (EWR 1)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21A-00930	X2CROC-VERLO	Crocodile	S-25.34926 E 30.10994	2 098	30.8	C	C 76.5%	B 87.1%	BC 81.80%	C 70%	BC 79.44%	AB 90.9%	2012
	X2CROC-VALY1* EWR 1		S-25.49407 E 30.14357	1 854			BC 78.8%	AB 89.5%	B 84.2%	B 82.5%	B 83.3%		2017

General description

Reach X21A-00930: Verlorenvlei – Roodekrans

The Crocodile River originates at an elevation of 2,260 m a.s.l from where it seeps and eventually converges in partial sub-surface stream channels. This then becomes a small mountain stream that flows out of the Verlorenvlei Nature Reserve, through private land characterised by small farm dams and domestic cattle grazing land before entering the town of Dullstroom. Farm dams and trout stocking is common characteristic of the river directly above Dullstroom downstream towards the Highland Golf & Trout Estate, where the river plunges over a waterfall.

The reach starts at the origin of the Crocodile River and ends a few kilometres upstream from where the river plunges from the montane grasslands into Thornveld. Monitoring points sampled in the Crocodile River within this reach included the Verlorenvlei (X2CROC-VERLO), and Valyspruit (X2CROC-VALY1, EWR 1) sampling points. Both monitoring points are located within Mucina's Lydenburg Montane Grassland (Gm 18) and the Eastern Bankenveld aquatic ecoregion. The Crocodile River at the Verlorenvlei site (X2CROC-VERLO) is <1 m wide, dominated by cobble, gravel, boulders, and sand with hydraulic biotopes that include riffles, runs and glides. At the Valyspruit site (X2CROC-VALY1) the Crocodile River is 1 - 4 m wide, dominated by cobble, gravel, boulders, sand, and mud, and the hydraulic biotopes include riffles, runs, glides, and pools. This site is an Ecological Water Requirement site, EWR 1. There are few exotic weeds present in the riparian zone, with mostly pine trees and wattle (*Acacia mearnsii*) in isolated spots along the reach. The land cover is dominated by grasslands (93.4%) with isolated dense bush thickets or tall dense shrubs (1.6%) (GEOTERRAIMAGE, 2015).



Figure 12: Headwaters of the Crocodile River.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21A-00930 was calculated at 78.04% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

Two sites were sampled (X2CROC-VERLO; X2CROC-VALY1) on this headwater reach. Fish velocity depth classes for fish was mostly in the form of fast shallow and slow shallow habitats with the slow habitat moderately present and fast riffle habitat in abundance. The only slow deep habitat sampled was at the X2CROC-VALY1 site where all of the *Enteromius anoplus* for that site was collected. Cover was moderately present as overhanging vegetation with undercut banks and the substrate offered good cover for fish.

Table: 11 Fish species expected based on the PESEIS Reach Code (X21A-00930) X2CROC-VERLO; X2CROC-VALY1; is listed, and the numbers of fish species present during the different surveys are indicated.

X21A-00930	Expected Species	X2CROC-VERLO		X2CROC-VALY1	
		09/2012	07/2017	09/2012	07/2017
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
<i>Enteromius anoplus</i>	x	14	2	5	21
<i>Enteromius neefi</i>	x	-	-	-	-
Cichlidae (Cichlids)					
<i>Pseudocrenilabrus philander</i>	x	-	-	-	-
<i>Tilapia sparrmanii</i>	x	-	-	-	3
Number of species expected	4				
Number of species recorded		1	1	1	2
Number of individuals		14	2	5	24
Electro-fishing time (minutes)		12	19	16	24
Catch/Unit Effort (CPUE)		1.17	0.11	0.31	1.0

Four indigenous species of fish are expected to occur in this reach of which two were collected during the present survey (Table 11). The limnophilic *Enteromius anoplus*, a fish species with a preference for lentic habitats (pools), was the most abundant species collected. *Tilapia sparrmanii*, also a limnophilic species, was only collected during the recent survey at the X2CROC-VALY1 site where also a trout, most probably rainbow trout (*Oncorhynchus mykiss*), was observed. This introduced alien and invasive species (NEMBA) are regularly stocked for recreational fishing as this reach falls within a proclaimed fly-fishing zone. Presence of this predatory species can be related to the absence or low abundance of expected fish species.

The catch per unit effort (CPUE) for the X2CROC-VERLO site was slightly lower in 2017 (CPUE 0.11: 2 individuals; 19 minutes) than the 2012 survey (CPUE 1.17 with 14 individuals; 12 minutes). At the X2CROC-VALY1 site the CPUE of 1.0 (24 individuals; 24 minutes) during the present survey was slightly higher than the 2012 survey CPUE 0.31 (5 individuals; 16 minutes).

A mean Fish Ecstatus rating of 78.75% was calculated for the SQR based on all available information, placing this reach in an Ecological Category BC (slightly impaired with a low abundance of fish) which is a higher category than determined during the 2012 survey (Ecological Category C).

Invertebrates


Five SASS sampling events are on record for the Verlorenvlei site (X2CROC-VERLO), located on the Crocodile River. These sampling events occurred in October 1996, July and September 1999, September 2012, and July 2017. These represent two winter sampling and three spring sampling events. A total of 30 SASS taxa have been recorded during these five sampling events, of which 25 taxa in total were recorded during winter surveys and 26 in spring. Only Chironomidae (tolerant taxa) were recorded during all five sampling events. Of the total number of SASS taxa recorded at the site, 33 – 53% was recorded during spring surveys and 63 – 73% during winter surveys. Within the five sampling events, taxa associated with fast to moderate flows were dominant except during July and

September 1999. The average SASS5 rated sensitive taxa expressed as a percentage was 45% for winter and 38% for spring surveys. Based on the available data, taxa diversity and the percentage of sensitive taxa are greater in winter than during spring surveys. Flow conditions are generally lower in spring than during winter, which could influence instream habitat and environmental variables (e.g. water temperature, dissolved oxygen, etc.) (Dodds & Whiles 2010; Gordon et al. 2008).

Three SASS sampling events are on record for the Valyspruit site (X2CROC-VALY1) on the Crocodile River, carried out October 1996, September 2012, and July 2017. These represent one winter sampling and two spring sampling events. A total of 30 SASS taxa have been recorded during these three sampling events, of which 26 taxa in total were recorded during winter surveys and 27 in spring.

Taxa diversity is commonly low in the headwaters, with low nutrients and food availability the main drivers of the community composition (Davies & Day 1994). The limited available results (n = 5, and n = 3) indicate a greater percentage of sensitive taxa during winter than summer surveys. Lower flows are generally experienced in spring before the onset of the rainy season, with low flows commonly associated with less habitat and some environmental variable are more extreme (e.g. water temperature, dissolved oxygen).

Table 12: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21A-00930.

X21A-00930	X2CROC -VERLO	2012	2017	
	Total SASS Score	99	137	
	No. of SASS Families	16	22	
	Average Score Per Taxon	6.2	6.2	
	MIRAI Value	Category B 86.1%	Category B 87.8%	
	X2CROC -VALY1	2012	2017	
	Total SASS Score	185	220	
	No. of SASS Families	27	35	
	Average Score Per Taxon	6.9	6.3	
	MIRAI Value	Category B 86.1%	Category A/B 91.1%	Change
SQ REACH SUMMARY Invertebrate Ecostatus	Category B 87.1%	Category A/B 89.5%		

The 2017 SASS5 results (Table 12) indicates slightly improved conditions at both sampling sites when compared to 2012. Conditions in the PESEIS reach based on MIRAI were rated as largely natural (Category B – 87.1%) in September 2012 improving to natural and largely natural (Category AB – 89.5%) in July 2017. The slight improvement is mainly attributed to flow conditions and its effects on instream habitat conditions and other environmental variables at the time of sampling.

Riparian Vegetation

Two sites were assessed in this SQ reach namely X2CROC-VERLO and X2CROC-VALY1 (EWR1)

Marginal Zone: The marginal zone at the X2CROC-VERLO site is dominated by grass, sedge and forb species. Sedges occur in scattered clumps consisting mostly of *Cyperus* spp. Forbs include *Erica alopecurus*, *Helicrysum* species and fern species like *Catha dregei*. *Cliffortia linearifolia* and *Asparagus* specie were often encountered as well. This zone has good grass cover and abundance and seems to be close to the reference state. The species composition resembles the reference state with no or little changes. No signs of trampling or footpaths were observed. The water quantity is low but normal for the year and the quality is good. No exotics were observed in this zone.

This zone at the X2CROC-VALY1 (EWR1) site is dominated by grass, sedge, shrubs and herb species. This include species like *Miscanthus junceus*, *Fuirena hirsuta*. *Plantago major*, *Helicrysum* species and *Cliffortia linearifolia*. This zone has good grass and shrub cover and abundance and seems to be close to the reference state. The species composition resembles the reference state with no or little changes. No signs of trampling or footpaths were observed. The water quantity is low but normal for the year and the quality is good. No exotics were observed in this zone.

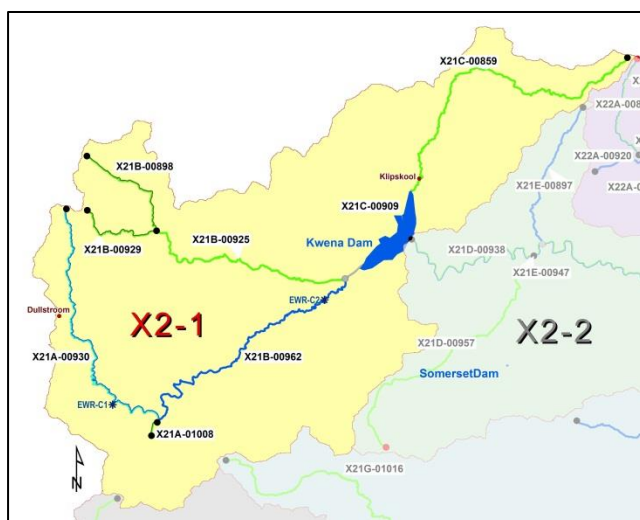
Non Marginal Zone: At the X2CROC-VERLO site the non-marginal zone is grass dominated. Both banks are mostly level to gently sloped. The grass cover is high with a high abundance as well. The species composition resembles the reference state with no or little changes. Dominant grass species include *Themedia triandra*, *Loudetia simplex* and *Alloteropsis semialata*. Exotics invasion was limited to a single *Rubus cuneifolius* plant.

The non-marginal zone at the EWR1 site (X2CROC-VALY1) is grass dominated. Both banks form terraces that are mostly level to gently sloped. The grass cover is high with a high abundance as well. The species composition resembles the reference state with no or little changes. Dominant grass species include *Themedia triandra*, *Miscanthus junceus* and *Eragrostis* spp. Exotics invasion was limited to a few individuals of *Eucalyptus grandis* down stream of site.

The mean Level III VEGRAI Assessment range for the two sites assessed is 99.6% and is consistent with a Category A – largely unmodified and natural. The Riparian IHI was calculated at 82.8% rating this reach as a Category B indicating a largely natural reach with few modifications. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Water Quality

IUA X2-1 - CROCODILE U/S OF KWENA DAM



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
MRU Croc A	X21A-00930 EWR C1	Crocodile	A/B	A/B	
	X21B-00962 EWR C2	Crocodile	B	B	
RU C1	X21B-00929	Gemsbokspruit	C/D*	C/D	
	X21B-00898	Lunsklip	C/D*	C/D	2
	X21B-00925	Lunsklip	C	C	
RU C2	X21C-00859	Alexanderspruit	C	C	2

* The RQOs are set for the PES as it was felt that the actions required to improve to a C is not attainable.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.015 mg/L PO ₄ -P (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).	✓

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H074Q01.

Monitoring at site X2H047Q01 ceased in 1994. Data used for the assessment for **EWR 1** was therefore taken from DWS monitoring point number 190744: *Dullstroom - @ 540 road bridge on Crocodile River.*

Summarized results for EWR 1: Water quality at this site is a **B category, 86.4%**. The TEC for water quality has not been met, *based on the current evaluation with its inherent limitations*, including a change in data monitoring point. The change in status is primarily linked to elevated phosphate levels (a 50th percentile of 0.05 mg/L was recorded, vs the 0.01 mg/l measured during 2010) and elevated manganese levels. The PO₄-P on-site result during the 2017 survey (Regen laboratory) indicated that the phosphate level was <0.1 mg/L, which is the detection limit for the test. This is not sensitive enough for aquatic ecosystems as 0.1 mg/L is already showing an impact (a B category, assuming a natural RC for phosphate).

Note that no site-specific Reference Condition data are available, and the water quality data used for the assessment has changed from the site used during the Reserve study. Site X2H074Q01 previously used is no longer operational and is well downstream of this Resource Unit. The water quality monitoring point now used for the assessment is upstream of the EWR site but is located at Dullstroom, so may be picking up nutrients and possibly some toxics from urban run-off.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. If biota scores are lower than expected, institute more regular testing for ortho-phosphate. This recommendation is based on a change in monitoring point which will now detect urban impacts.
3. Improve on the detection limit used by the testing laboratory for ortho-phosphate. This point is relevant to all sites evaluated.

Impacts for SQR

- Stream bank trampling
- Removal of riparian vegetation
- Sedimentation from roads
- Presence of exotic fish

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category B (83.3%)	Category AB (90.9%)
Largely natural ecosystem with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions and resilience are essentially unchanged	The system and its components are in a close to natural condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a B category.

TARGET NOT MET



Possible reasons:

Impact of alien and invasive fish species

Numerous instream dams resulting in a change of the natural flow regime

Loss of available instream fish habitat due to sedimentation and removal of riparian vegetation as well as stream bank trampling


RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2CROC-VERLO		X21A	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude	Longitude	X21A-00930	
S -25.34926	E 30.10994	Transitional	
AQUATIC ECOREGION		Geomorphological Zone	
Level I		Level II	
9. Eastern Bankenveld		9.02	



Figure A-01. Upstream view of the Verloren Valei site, X2CROC-VERLO, on the Crocodile River (July 2017, G Diedericks).



Figure A-02. Downstream view of the Verloren Valei site, X2CROC-VERLO, on the Crocodile River (July 2017, G Diedericks).

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2CROC-VALY1		X21A	X21A-00930
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Elevation (m. a.s.l.)	Geomorphological Zone
	S -25.49407	E 30.14357	Upper Foothills
AQUATIC ECOREGION		Level I	Level II
9. Eastern Bankenveld			9.02
			
<p>Figure A-03. Upstream view of the Valyspruit site, X2CROC-VALY1, on the Crocodile River (July 2017, G Diedericks).</p>		<p>Figure A-04. Downstream view of the Valyspruit site, X2CROC-VALY1, on the Crocodile River (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X21B-00962 (EWR 2)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecosatus	Invertebrate Ecosatus	Instream Ecosatus	Riparian Vegetation Ecosatus	Integrated Ecosatus	TEC	Biomonitoring Year
X21B-00962	X2CROC-DONKE	Crocodile	S-25.46712 E 30.22968	1 331	30.1	C	C 70.4%	B 87%	BC 78.70%	C 70%	C 76.96%	B 86.5%	2012
	X2CROC-GOEDE* EWR 2		S-25.40967 E 30.31609	1 206			BC 78.8%	B 85.8%	B 82.3%	B 82.5%	B 82.4%		2017

General description

Reach X21B-00962: – Roodekrans - Goedenhoop

The reach starts about 1.3 km upstream from the Roodekrans sampling point. The Crocodile River flows in a north-easterly direction through the Lydenburg Montane Grasslands towards the Highlands Gate Golf Estate. The Crocodile River drops for approximately 25 meters down a waterfall into a gorge from where it flows in an incised floodplain towards Kwena Dam. The Kareekraalspruit, flowing from the Highlands Gate Golf Estate merges with the Crocodile River below the waterfall, and a few meters further downstream with the Krokodilspruit. The vegetation type below the waterfall is categorised as the Lydenburg Thornveld (Mucina et al. 2006). Two sampling points were sampled in this reach, namely the X2CROC-DONKE and X2CROC-GOEDE sites. The Goedenhoop site is also listed as an Ecological Water Requirement site, EWR 2. Up- and downstream photos of each site is included below. The growth of exotic weed species in the riparian zone increases considerably downstream from the waterfall.

Large numbers of small farm dams, located on small tributaries of the Crocodile River, dominates the area above the falls. After the falls, small-scale crop and live-stock farming dominates the area to above the Kwena Dam. The vegetation type is described as the Lydenburg Thornveld with grasslands (63.8%) forming the main land cover (GEOTERRAIMAGE, 2015).

The length of the reach is 30.05 km, and the elevation ranges from 1,766 above Roodekrans to 1,200 m a.s.l., at the Crocodile-Lunsklip confluence. Below the falls and the Kwena Dam, irrigated crops and small scale live-stock farming is the main land use.

The Crocodile River at the Donkerhoek site is 3 - 6 m wide and is dominated by cobble, gravel, boulders, sand, silt, and mud. The hydraulic biotopes include rapids, riffles, runs, glides, and to a lesser extent pools. At the Goedenhoop site in the Crocodile River, the river width ranged from 1 – 10 m wide and is dominated by cobble, gravel, boulders, sand, and mud. The hydraulic biotopes include riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21B-00962 was calculated at 76.64% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

Two sites were sampled (X2CROC-DONKE; X2CROC-GOEDE) on this reach. Fast and shallow riffles and runs were abundant with overhanging vegetation abundantly present as cover. Rocks and cobbles also offered good substrate cover for fish.

Table13: Fish species expected based on the PESEIS Reach Code (X21B-00962) X2CROC-DONKE; X2CROC-GOEDE; is listed, and the numbers of fish species present during the different surveys are indicated.

X21B-00962	Expected Species	X2CROC-DONKE		X2CROC-GOEDE	
		09/2012	07/2017	09/2012	07/2017
Kneriidae (Knerias)					
<i>Kneria auriculata</i>	x	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
<i>Enteromius anoplus</i>	x	1	-	-	-
<i>Enteromius crocodilensis</i>	x	-	-	-	-
<i>Enteromius neefi</i>	x	-	22	16	27
Amphiliidae (Mountain Catfishes)					
<i>Amphilius natalensis</i>	x	-	-	2	-
<i>Amphilius uranoscopus</i>	x	-	3	-	1
Mochokidae (Squeakers, suckermouth catlets)					
<i>Chiloglanis bifurcus</i>	x	-	-	-	-
<i>Chiloglanis pretoriae</i>	x	3	21	76	29
Cichlidae (Cichlids)					
<i>Pseudocrenilabrus philander</i>	x	-	1	6	1
<i>Tilapia sparrmanii</i>	x	-	-	-	4
Number of species expected	10				
Number of species recorded		2	4	4	5
Number of individuals		4	47	100	62
Electro-fishing time (minutes)		21	32	27	46
Catch/Unit Effort (CPUE)		0.19	1.47	3.7	1.35

Ten indigenous species of fish are expected to occur in this reach and a maximum of five species were collected during the present survey, one species more than the 2011 survey (Table 13). *Enteromius neefi* and *Chiloglanis pretoriae*, both intolerant to no flow conditions, were the most abundant species collected during the 2017 survey, whilst during the 2012 survey it was *Chiloglanis pretoriae* which was very abundant. *Amphilius uranoscopus* and the cichlid, *Tilapia sparrmanii*, were only found during the 2017 survey. The critically endangered red data species

Chiloglanis bifurcus were expected to occur in this reach and the absence of this species is of concern. Their absence can possibly be related to flow regulation as well as decreasing water quality. Furthermore the presence of two rainbow trout, an alien and invasive predatory species observed at the X2CROC-DONKE site, could also relate to the low abundance and loss of certain indigenous fish species. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of instream habitat alteration as well as the presence of alien and invasive species (trout).

The catch per unit effort (CPUE) calculated for the two sites remained very much the same at 1.47 and 1.35 individuals caught per minute. During the 2012 survey a large number of *C. pretoriae* collected at downstream site influenced the CPUE effort resulting in a greater difference between the two sites (0.19 and 3.7 individuals per minute).

A mean Fish Ecstatus rating of 78.8% was calculated for this reach based on all available information, placing this reach in an Ecological Category BC (slightly impaired with a low abundance of species). The Fish Category during the 2012 survey was at a lower Category C (70.4%) (Moderately impaired).

Invertebrates

Three SASS sampling events are on record for the Donkerhoek site (X2CROC-DONKE) on the Crocodile River, carried out October 1996, September 2012, and July 2017. These represent one winter and two spring sampling events. A total of 41 SASS taxa have been recorded during these three sampling events, of which 33 taxa in total were recorded during winter surveys and 38 in spring. Sensitively rated SASS taxa recorded during all three sampling events included Baetidae >2 sp., Tricorythidae, Aeshnidae, Elmidae, and Psephenidae.

There are 12 SASS sampling events on record for the Goedenhoop site (X2CROC-GOEDE) on the Crocodile River, ranging from July 1993 to July 2017 (Table 1). These represent one autumn, six winter, and five spring sampling events. A total of 52 SASS taxa have been recorded during these 12 sampling events, of which 24 taxa in total were recorded during the one autumn survey, 42 during winter surveys and 49 in spring. Based on the seasonal results, sensitive taxa are more dominant during spring surveys, and more abundant. The family Heptageniidae was the only sensitive taxa recorded during all 12 surveys.

Table 14: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21B-00962.

X21B-00962	X2CROC -DONKE	2012	2017	
	Total SASS Score	192	219	
	No. of SASS Families	31	33	
	Average Score Per Taxon	6.2	6.6	
	MIRAI Value	Category B 86.4%	Category B 87.7%	
	X2CROC -GOEDE	2012	2017	
	Total SASS Score	202	220	
	No. of SASS Families	30	31	
	Average Score Per Taxon	6.7	7.1	
	MIRAI Value	Category B 86.4%	Category B 83.9%	Change
	SQ REACH SUMMARY Invertebrate Ecstatus	Category B 87%	Category B 85.8%	→

The 2017 SASS5 results (Table 14) indicates slightly improved conditions at both sampling sites when compared to 2012. Conditions in the PESEIS reach based on MIRAI were rated as largely natural (Category B - 86%) in September 2012 and in July 2017.

Riparian Vegetation

Two sites assessed in this SQ reach namely X2CROC-DONKE and X2CROC-GOEDE (EWR 2).

Marginal Zone: This zone at the X2CROC-DONKE site is dominated by grass and sedge species. This include species like *Cyperus marginatus*, *Miscanthus junceus*, *Fuirena hirsute* and *Typha capensis*. This zone has good grass and sedge cover and abundance. The species composition resembles the reference state with no or little changes. No signs of trampling or footpaths were observed but *Typha capensis* was grazed. The water quantity is low but normal for the year and the quality is good. Some exotics were noted consisting mainly of *Acacia mearnsii*.

At the X2CROC-GOEDE site the marginal zone is dominated by grass, shrub and tree species. This include species like *Cyperus marginatus*, *Miscanthus junceus*, *Fuirena hirsute* and *Typha capensis*. Non woody plants include *Combretum erytrophylum*, *Ziziphus micronata* and *Searsia gerrardii*. This zone has good grass and sedge cover and abundance. The species composition resembles the reference state with no or little changes. No signs of trampling or footpaths were observed. The water quantity is low but normal for the year and the quality is good. Some alien and invasive plant species were noted consisting mainly of *Acacia mearnsii*.

Non Marginal Zone: At the X2CROC-DONKE site this zone is grass dominated with some trees and shrubs present. The left bank forms backwater areas that flood seasonally. The right bank forms a steep bank in some areas. The non woody cover is high with a high abundance as well as the woody cover was low with a low abundance. Dominant grass species include *Themedia triandra*, *Miscanthus junceus* and *Eragrostis spp.* Various shrubs and trees are present including *Diospyros leiocodes*, *Cliffortia linearifolia*, *Dias continifolia*. The species composition resembles the

reference state with no or little changes. Exotics invasion was limited to a few individuals of *Acacia mearnsii* and *Solanum mauritanum*.

The non-marginal zone at the X2CROC-GOEDE is dominated by grass, trees and shrubs. The left bank is dominated by shrubs and trees whereas the right bank by grass and non woody plants. The non woody cover is high with a high abundance as well as the woody cover. The species composition resembles the reference state with no or little changes. Dominant grass species include *Themedia triandra*, *Miscanthus junceus* and *Setaria megaphylla*. Various shrubs and trees are present including *Diospyros leiocodes*, *Cliffortia linearifolia*, *Dias continifolia*. Exotics invasion was limited to a few individuals of *Acacia mearnsii*, *Gleditsia triacantha* and *Solanum mauritanum*.

The Level III VEGRAI Assessment range for the two sites assessed in this reach is 99.8% and is consistent with a Category A – largely unmodified and natural. The Riparian IHI was calculated at 82.8% rating this reach as a Category B indicating a largely natural reach with few modifications. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Water Quality

IUA X2-1 - CROCODILE US OF KWENA DAM



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
MRU Croc A	X21A-00930 EWR C1	Crocodile	A/B	A/B	
	X21B-00962 EWR C2	Crocodile	B	B	
RU C1	X21B-00929	Gemsbokspruit	C/D*	C/D	
	X21B-00898	Lunsklip	C/D*	C/D	2
	X21B-00925	Lunsklip	C	C	
RU C2	X21C-00859	Alexanderspruit	C	C	2

* The RQOs are set for the PES as it was felt that the actions required to improve to a C is not attainable.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.015 mg/L PO ₄ -P (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).	✓

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H074Q01. Monitoring at site X2H047Q01 ceased in 1994. Data used for the assessment for **EWR 2** was taken from DWS monitoring point number 190745: *Roodewal 117 jt - @ R36 road bridge on Crocodile River u/s of Kwena Dam.*

Summarized results for EWR 2: Water quality at this site is a **B category, 86.4%**, which indicates a stable integrated state since the 2010 Reserve study. The TEC for water quality has therefore been met. Although the overall state is maintained at a B category, phosphate is elevated as at EWR C1 (a 50th percentile of 0.05 mg/L was recorded, vs the 0.01 mg/l measured during 2010). Elevated levels of iron and manganese were also noted. The PO₄-P on-site result during the 2017 survey (Regen laboratory) indicated that the phosphate level was <0.1 mg/L, which is the detection limit for the test. This is not sensitive enough for aquatic ecosystems as 0.1 mg/L is already showing an impact (a B category, assuming a natural RC for phosphate).

Note that no site-specific Reference Condition data are available, and the water quality data used for the assessment has changed from the site used during the Reserve study as site X2H074Q01 previously used is no longer operational.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. If biota scores are lower than expected, institute more regular testing for ortho-phosphate, Fe and Mn.
3. Improve on the detection limit used by the testing laboratory for ortho-phosphate.

Impacts for SQR

- Stream bank trampling
- Presence of exotic fish
- Bank scouring and bank instability
- Numerous instream dams

See appendix E



Figure13: Bank instability in the Crocodile River at EWR 2: X2CROC-GOEDE.

Integrated Ecostatus Category and Target Ecological Category (TEC)



INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category B (82.4%)	Category B (86.5%)
Largely natural ecosystem with few modifications	Largely natural with few modifications

TARGET MET 

Discussion:

Although Ecological target is met the Category can improve to a Category A :

- Through proper management of alien and invasive fish species in the upper catchment

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2CROC-DONKE		X21B	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	
Latitude		Geomorphological Zone	
S -25.46712		Upper Foothills	
Longitude		Level II	
E 30.22968		9.02	
AQUATIC ECOREGION			
9. Eastern Bankenveld			
			
<p>Figure A-05 Upstream view of the Donkerhoek site, X2CROC-DONKE, on the Crocodile River (July 2017, G Diedericks).</p>		<p>Figure A-06. Downstream view of the Donkerhoek site, X2CROC-DONKE, on the Crocodile River (July 2017, G Diedericks).</p>	

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2CROC-GOEDE (EWR2)		X21B	X21B-00962
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Elevation (m. a.s.l.)	Geomorphological Zone
	S -25.40967	E 30.31609	Upper Foothills
AQUATIC ECOREGION		Level I	Level II
9. Eastern Bankenveld			9.04

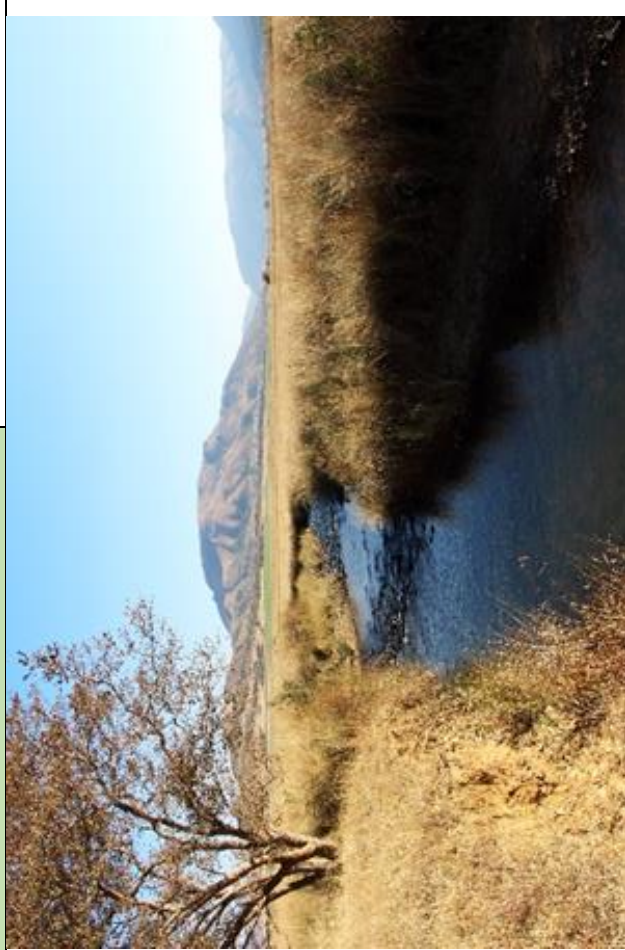


Figure A-07 Upstream view of the Goedenhoop site, X2CROC-GOEDE, on the Crocodile River (July 2017, G Diedericks).

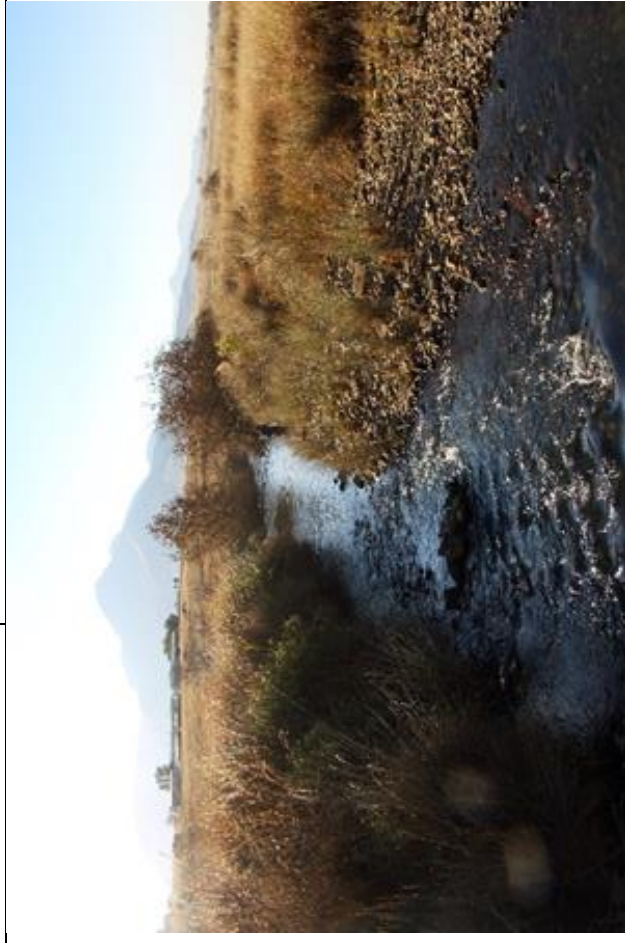


Figure A-08. Downstream view of the Goedenhoop site, X2CROC-GOEDE, on the Crocodile River (July 2017, G Diedericks).

SQ REACH NUMBER X21D-00938

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21D-00938	X2CROC-DOORN	Crocodile	S-25.38984 E 30.40647	1 115	18.7	C	C 72.3%	D 55%	CD 61.92%	C 70%	C 64.16%	C 70%	2012
							BC 78.6%	B 86.3%	B 82.4%	BC 80%	BC 81.9%		2017

General description

Reach X21D-00938: - Kwena Dam Buffelskloof South

This reach covers approximately 18.7 km of the Crocodile River from below Kwena Dam-wall up to point where the Crocodile merges with the Buffelskloofspruit. The elevation in the reach ranges from 1,150 below the dam-wall to 1,030 m a.s.l. where it merges with the Buffelskloofspruit (south). The river below the dam is severely influenced by flow regulation, with the riparian vegetation generally comprising dense stands of trees and shrubs. The vegetation type is classified as Lydenburg Thornveld consisting of 42.5% thickets of dense bush, 22.4% woodlands and open bush, with 19.6% grasslands. (GEOTERRAIMAGE, 2015). The area directly below the dam falls into the Eastern Bankenveld aquatic ecoregion merging into the Northern Escarpment Mountains further downstream. Land-use is restricted to small holdings with limited agricultural activities. Of concern is a Trout Aquaculture facility below the dam wall. At this rearing-facility large quantities of trout is cultivated resulting in instream pollution relating to nutrients and ammonia. Only one site is located on this reach namely, X2CROC-DOORN.

The Kwena Dam, situated in the upper boundary of this reach, was constructed in 1984 for irrigation purposes. Known impacts of large dams include flow regulation, habitat alteration, migration barriers, altered physical and chemical water quality, and more (Davies et al. 1993; Davies & Day 1998). Stream bank scouring is common throughout the reach, with the riparian zone dominated by large trees.

The Crocodile River at the Doornhoek site is 6 – 15 m wide, dominated by boulders, cobble, gravel, silt, and mud. Hydraulic biotopes include rapids, riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21D-00938 was calculated at 45.86% rating this SQ reach as a D category indicating that the instream habitat integrity is largely modified. A large loss of natural habitat, biota and basic

ecosystem functions has occurred. (RIVDINT model Crocodile River System, 2017). This low rating can be attributed to severe stream flow regulation by the upstream Kwena Dam.

Fish

Only one site (X2CROC-DOORN) was sampled on this reach downstream from Kwena Dam which could not be sampled during the 2012 survey because of water releases from Kwena Dam. Very high flow conditions were present during this survey of 2017 and the habitat for fish surveyed at the site was mostly in the form of very fast habitat with the slow shallow habitat sparsely present and no slow deep habitat. Rapids and riffles provided fast deep and shallow habitat in abundance with good substrate cover provided by boulders and rocks. Cover for the fish was also moderately present as overhanging vegetation at only the fast shallow habitat. Undercut banks and root wads were sparse.

Table 15: Fish species expected based on the PESEIS Reach Code (X21B-00938) X2CROC-DOORN; is listed, and the numbers of fish species present during the survey is indicated.

X21D-00938	Expected Species	X2CROC-DOORN	
		09/2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Kneriidae (Knerias)			
<i>Kneria auriculata</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	-
<i>Enteromius crocodilensis</i>	x	-	21
<i>Enteromius neefi</i>	x	-	9
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	-	3
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	-	1
<i>Chiloglanis pretoriae</i>	x	-	26
Cichlidae (Cichlids)			
<i>Pseudocrenilabrus philander</i>	x	-	2
<i>Tilapia sparrmanii</i>	x	-	4
Number of species expected	10		
Number of species recorded		Not Sampled	7
Number of individuals			66
Electro-fishing time (minutes)			29
Catch/Unit Effort (CPUE)			2.28

Seven of the ten indigenous species of fish expected to occur in this reach were collected during the present survey (Table 15). The small barb species, *Enteromius crocodilensis* and the rheophilic *Chiloglanis pretoriae* were the most abundant species collected. A single specimen of the endangered endemic, *Chiloglanis bifurcus*, was also collected. This red listed species was not recorded at this site for a number of years. Both of the Cichlids species (*Pseudocrenilabrus philander* and *Tilapia sparrmanii*) expected were found at the limited slow shallow habitat

present. . Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of instream habitat alteration and flow regulation.

The catch per unit effort (CPUE) was recorded as 2.28 individuals per minute indicating a relative low abundance of fish which can be expected with the very high flows found during the survey.

A FRAI score of 78.6% was determined placing the reach in an Ecological Category BC (slightly impaired with low abundance of fish).

Invertebrates

Two SASS sampling events are on record for the Doornhoek site (X2CROC-DOORN) on the Crocodile River, carried out October 1996, and July 2017. These represent one winter and one spring sampling event. A total of 30 SASS taxa have been recorded during these two sampling events, of which most taxa were recorded during the winter survey. Sensitively rated SASS taxa recorded during both sampling events included Baetidae >2 sp., and Hydropsychidae >2 sp.

Table 16: 2017 SASS5 results for SQ reach X21D-00938.

X21D-00938	X2CROC -DOORN	2012	2017	Change
	Total SASS Score	Not sampled	180	
	No. of SASS Families		27	
	Average Score Per Taxon		6.7	
	MIRAI Value		Category B 86.3%	Not applicable
SQ REACH SUMMARY Invertebrate Ecostatus		Category B 86.3%		

Based on the 2017 SASS5 results (Table 16), MIRAI indicates unchanged conditions compared to the site located upstream from Kwena Dam, X2CROC-GOEDE. Conditions in the PESEIS reach based on MIRAI were rated as largely natural (Category B - 86%) in July 2017.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 80% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 79.28% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach is close to largely natural with a few modifications most of the time.

Impacts for SQR

- Invasive plant species
- Bank scouring
- Severe river regulation below Kwena Dam
- Loss of instream habitat
- Aquaculture facility with impact on water quality

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category BC (81.9%)	Category C
Close to largely natural most of the time.	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged



TARGET MET



Discussion:

Although the set target is met, the Ecological Category can improve to a category B:

- through proper dam regulation management
- management of sediment deposits from dam and upper reaches

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2CROC-DOORN	X21D	X21D-00938	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Elevation (m. a.s.l.)	Geomorphological Zone	
S -25.38984	1 115	Upper Foothills	
		Level II	
AQUATIC ECOREGION		Level I	
	10. Northern Escarpment Mountains	10.1	
			
Figure A-09. Upstream view of the Doornhoek site, X2CROC-DOORN, on the Crocodile River (July 2017, G Diedericks).	Figure A-10. Downstream view of the Doornhoek site, X2CROC-DOORN, on the Crocodile River (July 2017, G Diedericks).		

SQ REACH NUMBER X21E-00943 (EWR 3)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21E-00943	X2CROC-RIETV	Crocodile	S-25.38818 E 30.56574	921	38.0	C	C 75.9%	C 73%	C 74.45%	D 50%	C 69.56%	BC 78.5%	2012
	X2CROC-POPLA* EWR 3		S-25.45275 E 30.68099	817			BC 81.4%	BC 80.9%	BC 81.2%	C 72.5%	C 76.8%		
	X2CROC-MONTR		S-25.44861 E 30.71010	808									



Montrose waterfall by T Steyn, October 2017

General description

Reach X21E-00943: – Buffelskloof North – Montrose Falls

The PESEIS reach starts at the Crocodile's confluence with the northern Buffelskloofspruit to downstream from Montrose Falls, at the confluence with the Elands River. Three sampling points, X2CROC-RIETV, X2CROC-POPLA; and X2CROC-MONTR, are in this 37.97 km reach. The Poplar Creek (X2CROC-POPLA) site is also listed as an Ecological Water Requirement site, EWR 3. The elevation in this reach ranges from 1,017 at its start to 768 m a.s.l. at the Elands-Crocodile confluence. The vegetation type of the reach is classified as Legogote Sour Bushveld, comprising of 6.5% indigenous forest, 32.8% thickets of dense bush with 19% grasslands. Most of the reach falls

within the Northern Escarpment Mountains aquatic ecoregion. There are several cultivated orchards (4.6%) and irrigated lands along the main river with large portions of crops established in riparian zones. (GEOTERRAIMAGE, 2015). The flow in the Crocodile River is still affected by regulation from the upstream dam.

The Crocodile River at the Rietvlei site is 15 - 20 m wide, dominated by large boulders, cobble, gravel, sand, silt, and mud. Hydraulic biotopes include rapids, riffles, runs, and glides. Backwater pools are present but limited. At the Poplar Creek site in this SQ reach, the river is 15 - 20 m wide, dominated by large boulders, cobble, gravel, boulders, sand, silt, and mud. Hydraulic biotopes include rapids, riffles, runs, glides, and backwater pools. The Crocodile River at the Montrose site is 15 - 25 m wide, dominated by large boulders, bedrock, cobble, gravel, boulders, sand, and mud. Hydraulic biotopes include rapids, riffles, runs, glides, and large glide-pool areas.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21E-00943 was calculated at 80.32% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

Three sites (X2CROC-RIETV, X2CROC-POPLA, and X2CROC-MONTR) were sampled on this reach of which two was also sampled during the 2012 survey (X2CROC-RIETV and X2CROC-MONTR). This section of the river provides a high diversity of fast habitat types, both shallow and deep habitat, ideal for flow dependant species. Substrate cover, although covered by algae, was provided by boulders and rocks. Cover was also moderately present as overhanging vegetation with rarely to sparsely found undercut banks.

A total of nine indigenous species of fish are expected to occur in this reach of which seven were collected during the present survey (Table 17). Four species namely, *Enteromius crocodilensis*, *Amphilius uranoscopus*, *Chiloglanis pretoriae* and *Pseudocrenilabrus philander*, were found at all three of the sites. *Enteromius crocodilensis* and *Chiloglanis pretoriae*, both flow dependant species, were the most abundant species representing all age classes (juveniles, sub-adults and adults) indicating that the breeding functions for this species is presently not disrupted. The IUCN red data endemic, *Chiloglanis bifurcus*, were not found during the 2012 survey, but recorded at low abundance (0.02 CPUE at X2CROC-POPLA and 0.04 CPUE at X2CROC-MONTR) for the present survey. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has

been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation and loss of instream habitat.

Table 17: Fish species expected based on the PESEIS Reach Code (X21E-00943) X2CROC-RIETV; X2CROC-POPLA; X2CROC-MONTR; is listed, and the numbers of fish species present during the different surveys are indicated.

X21E-00943	Expected Species	X2CROC-RIETV		X2CROC-POPLA		X2CROC-MONTR	
		2012	07/2017	2012	07/2017	2012	07/2017
Anguillidae (Freshwater Eels)							
<i>Anguilla mossambica</i>	x	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
<i>Enteromius anoplus</i>	x	-	-	-	-	-	-
<i>Enteromius crocodilensis</i>	x	21	54	-	60	21	80
<i>Enteromius neefi</i>	x	-	14	-	-	-	-
Amphiliidae (Mountain Catfishes)							
<i>Amphilius uranoscopus</i>	x	28	9	-	7	9	24
Mochokidae (Squeakers, suckermouth catlets)							
<i>Chiloglanis bifurcus</i>	x	-	-	-	1	-	2
<i>Chiloglanis pretoriae</i>	x	91	58	-	16	23	32
Cichlidae (Cichlids)							
<i>Pseudocrenilabrus philander</i>	x	16	4	-	9	5	3
<i>Tilapia sparrmanii</i>	x	-	-	-	-	-	3
Number of species expected	9						
Number of species recorded		4	5	Not Sampled	5	4	6
Number of individuals		156	139		93	58	144
Electro-fishing time (minutes)		22	50		43	31	49
Catch/Unit Effort (CPUE)		7.1	2.78		2.16	1.87	2.94

The CPUE differed considerably when comparing the 2012 survey with the 2017 survey for the X2CROC-RIETV site: the CPUE during the 2012 survey calculated at 7.1 compared to a CPUE of 2.78 for the 2017 survey. For the other two sites (X2CROC-POPLA; X2CROC-MONTR) the CPUE remained consistent.

For the 2012 survey a FRAI score of 75.9% was determined placing the reach in an Ecological Category C (moderately impaired with low diversity and abundance of species). During the current survey a mean Fish Ecstatus rating of 81.37% was calculated for this reach based on all available information, placing this reach in an Ecological Category BC (slightly impaired).


Invertebrates

Three SASS sampling events are on record for the Rietvlei site (X2CROC-RIETV) in the Crocodile River. These represent one winter and two spring sampling events. A total of 34 SASS taxa have been recorded during these three sampling events, of which 25 taxa in total were recorded during winter surveys and 32 in spring. Sensitive taxa recorded during all three sampling events included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, and Tricorythidae, and Aeshnidae.

Five SASS sampling events are on record for the Poplar Creek site (X2CROC-POPLA) on the Crocodile River. These represent one winter and two spring sampling events. A total of 39 SASS taxa have been recorded during these five sampling events, of which 34 taxa in total were recorded during winter surveys and 35 in spring. Sensitive SASS taxa recorded during all five sampling events included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, and Tricorythidae.

There are 12 SASS sampling events on record for the Montrose site (X2CROC-MONTR) on the Crocodile River. These represent one autumn, six winter, and five spring sampling events. A total of 47 SASS taxa have been recorded during these 12 sampling events, of which 31 taxa in total were recorded during the one autumn survey, 41 during winter surveys and 44 in spring. Based on the seasonal results, sensitive taxa are more dominant during spring surveys, and more abundant. Over all 12 surveys, the families Baetidae >2 sp., Heptageniidae, Leptophlebiidae, Tricorythidae, and Chlorocyphidae was the SASS rated sensitive taxa recorded at a FROC⁵ of >82%.

Table 18: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21E-00943.

X21E-00943	X2CROC -RIETV	2012	2017	
	Total SASS Score	173	159	
	No. of SASS Families	29	25	
	Average Score Per Taxon	6.0	6.4	
	MIRAI Value		Category B 84.0%	
	X2CROC -POPLA	2012	2017	
	Total SASS Score	177	154	
	No. of SASS Families	27	26	
	Average Score Per Taxon	6.6	5.9	
	MIRAI Value		Category B 83.3%	
	X2CROC -MONTR	2012	2017	
	Total SASS Score	195	168	
	No. of SASS Families	32	27	
	Average Score Per Taxon	6.1	6.2	
	MIRAI Value	Category C 71.9%	Category C 75.3%	Change
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 73%	Category BC 80.9%		

The 2017 SASS5 results (Table 18) indicates slight improved conditions when compared to 2012. There is noticeable deterioration in 2017 between the MIRAI results for Rietvlei, Poplar Creek, and Montrose, changing from slightly (B) modified at Rietvlei and Poplar Creek to moderately impaired (C) at Montrose. Conditions in the PESEIS reach based on MIRAI were rated as slightly to moderately impaired (Category BC - 81%) in July 2017.

⁵ FROC = Frequency of Occurrence

Riparian Vegetation

In this SQ reach, three (3) sites were assessed namely X2CROC-RIETV; X2CROC-POPLA (EWR 3) and X2CROC-MONTR.

Marginal Zone: This zone at the X2CROC-RIETV site is dominated by, reed, shrub and tree species. This include species like *Cyperus marginatus*, *Cyclosorus interruptus*, *Fuirena hirsute*, and *Phragmites mauritianus*. Woody plants include *Combretum erytrophylum*, *Salix micrunata*. This zone has good woody and non woody cover as well as abundance. The species composition resembles the reference state with no or little changes. Some signs of trampling or footpaths were observed mostly from hippo. The water quantity was normal for this time of the year and the quality was good. Some exotics were noted consisting mainly of *Ageratum conyzoides*.

The marginal zone at EWR 3 site (X2CROC-POPLA) is dominated by, reed, shrub and tree species. This include species like *Cyperus marginatus*, *Cyclosorus interruptus*, *Imperata cylindrica*, *Fuirena hirsuta* and *Phragmites mauritianus*. Woody plants include *Combretum erytrophylum*, *Salix micrunata*. This zone has good woody and non woody cover as well as abundance. The species composition resembles the reference state with no or little changes. Gardening above the bridge has changed a small area into sort mowed grass. The water quantity was normal for this time of the year and the quality was good. Some exotics were noted consisting mainly of *Ageratum conyzoides*.

At the X2CROC-MONTR site this zone is dominated by open rocky areas with reed, shrub and tree species. This includes species like *Breonadia salicina*, and *Phragmites mauritianus*. Woody plants include *Combretum erytrophylum* and *Salix micrunata*. This zone has low woody and non woody cover as well as abundance due to the dominated bedrock. The species composition resembles the reference state with no or little changes. The water quantity was normal for this time of year and the quality was good. Some exotics were noted consisting mainly of *Ageratum conyzoides*.

Non-marginal Zone: At the X2CROC-RIETV site this zone is dominated by grass, trees and shrubs. Both banks have high tree cover with shrubs and grass as understory. Abundance is fair among the woody species and high among the non-woody species. The species composition resembles the reference state with no or little changes. Dominant non-woody species include *Dietes iridioides*, *Themedia triandra* and *Setaria megaphylla*. Various shrubs and trees are present including, *Combretum erytrophylum*, *Cliffortia linearifolia*, *Acacia sieberiana*, *Dombeya burgessi*, *Dalbergia armata* and *Ficus ingens*. Exotics invasion was limited to a few individuals of *Lantana camara*, *Morus alba*, *Melia azedarach* and *Solanum mauritanum*.

The X2CROC-POPLA (EWR 3) site is dominated by grass, trees and shrubs in the non-marginal zone. Both banks have high tree cover with shrubs and grass as understory. Abundance is fair among the woody species and high

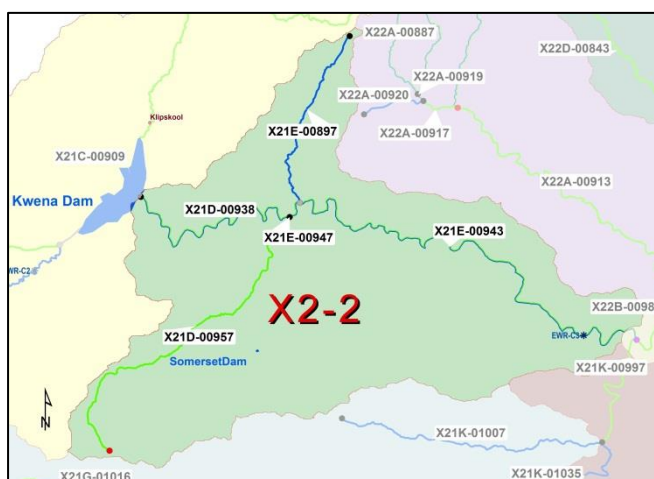
among the non-woody species. The species composition resembles the reference state with no or little changes. Dominant non-woody species is mostly grass species including *Setaria megaphylla*. Various shrubs and trees are present including, *Combretum erythrophylum*, *Acacia caffra*, *Breonadia salicina*, *Morrella serrata* and *Salix micrunata*. Some exotics were noted consisting mainly of *Lantana camara*, *Gleditschia triacanthos*, *Morus alba*, *Populus deltoides* and *Solanum mauritanum*.

The non-marginal zone at the X2CROC-MONTR site is dominated by open rocky areas with reed, shrub and tree species. Non-bedrock areas have high tree cover with shrubs and grass as understory. Abundance is moderate among the woody species and low among the non-woody species. The species composition resembles the reference state with no or little changes. The dominant non-woody species include *Imperata cylindrical*, *Setaria megaphylla* and *Gerbera jansinii*. Various shrubs and trees are present including, *Combretum erythrophylum*, *Acacia ataxacantha*, *Breonadia salicina*, *Ficus ingens*, *Ficus sycomorus*, and ***Bauhenia galpinii***. Some exotics were noted consisting mainly of *Lantana camara*,

The Level III VEGRAI Assessment range for the three sites assessed is 78.3% and is consistent with a Category BC – close to largely natural with few modifications most of the time. The Riparian IHI was calculated at 69.73% rating this reach as a Category C indicating a moderately modified habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified

Water Quality

IUA X2-2 - CROCODILE DS OF KWENA DAM TO ELANDS RIVER: PRIORITY RATINGS EWR C3 X21E-00943; INCLUDING X21D-00938, X21E-00947



RUs	SQ number	River	PES	TEC	PR
RU C3	X21D-00957	Buffelskloof-spruit	C	B/C	2
RU C4	X21E-00897	Buffelskloof-spruit	B	B	2
MRU Croc B	X21D-00938*	Crocodile			3
	X21E-00947*	Crocodile			
	X21E-00943 EWR C3	Crocodile	B/C	B/C	

* Where SQ does not have a EC the EC is different from the EWR site. But because the EWR site has a higher priority rating, the EWR site is the driver for the other sites in this RU.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.015 mg/L PO ₄ -P (aquatic ecosystems: driver).	Slight elevation
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).	✓
Ensure that toxics are within Ideal limits or A categories.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	Fe needs investigation; other parameters in A categories

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H013Q01.

Summarized results for EWR 3: Water quality at this site has been maintained at present state, despite a slight elevation in phosphate over the RQO. The TEC for water quality has therefore been met. A stable integrated water quality state since the 2010 Reserve study is indicated. However, an elevated level of iron is again noted, which should be investigated.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. If biota scores are lower than expected, institute more regular testing and investigations for Fe.

Impacts for SQR

- Invasive plant species
- Cultivation in riparian zone
- Bank scouring
- Domestic waste in stream and riparian zone
- Loss of instream habitat due to river regulation and sedimentation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (76.8%)	Category BC (78.5%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural with few modification.

TARGET NOT MET



Possible reasons:

- Low riparian instream habitat integrity (IHI) as a result of exotic and invasive plant species


RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2CROC-RIETV		X21E	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude	Longitude	X21E-00943	
S -25.38818	E 30.56574	Geomorphological Zone	
Level I		Upper Foothills	
Level II		Level II	
10. Northern Escarpment Mountains		10.02	
			

Figure A-11. Upstream view of the Rietvlei site, X2CROC-RIETV, on the Crocodile River (July 2017, G Diedericks).

Figure A-12. Downstream view of the Rietvlei site, X2CROC-RIETV, on the Crocodile River (July 2017, G Diedericks).

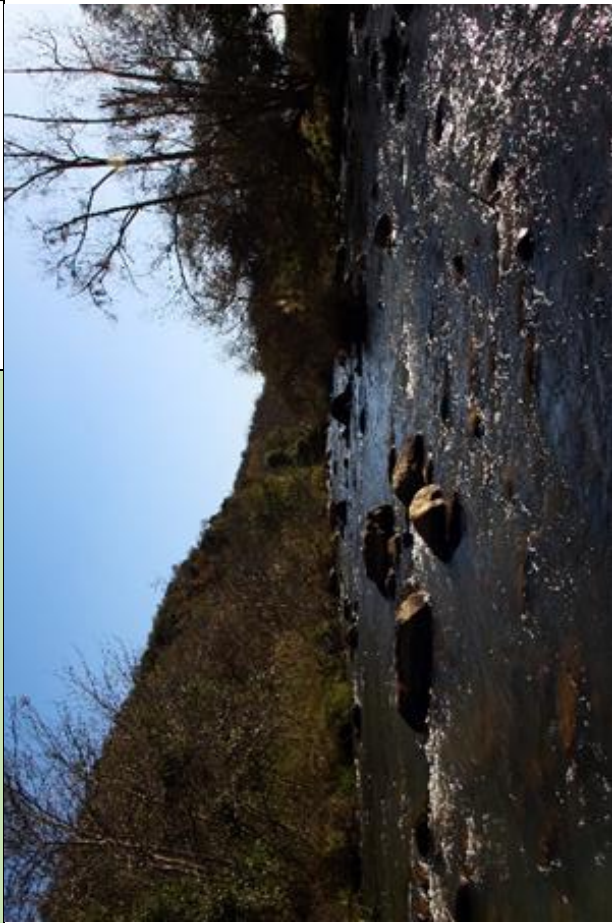



RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2CROC-POPLA (EWR 3)		X21E	
X21E-00943		REACH	
X21E-00943		X21E-00943	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	
Latitude		817	
S -25.45275		Upper Foothills	
Longitude		Level II	
E 30.68099		Level II	
AQUATIC Ecoregion		Level II	
10. Northern Escarpment Mountains		10.02	
			

Figure A-13. Upstream view of the Poplar Creek site, X2CROC-POPLA, on the Crocodile River (July 2017, G Diedericks).

Figure A-14. Downstream view of the Poplar Creek site, X2CROC-POPLA, on the Crocodile River (July 2017, G Diedericks).

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2CROC-MONTR		X21E	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.s.l.)
	S -25.44861	E 30.71010	808
AQUATIC ECOREGION		Geomorphological Zone	
10. Northern Escarpment Mountains		Upper Foothills	
		Level II	
		10.02	
			
<p>Figure A-15. Upstream view of the Montrose site, X2CROC-MONTR, on the Crocodile River (July 2017, G Diedericks).</p>		<p>Figure A-16. Downstream view of the Montrose site, X2CROC-MONTR, on the Crocodile River (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X22B-00888

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecosystem	Invertebrate Ecosystem	Instream Ecosystem	Riparian Vegetation Ecosystem	Integrated Ecosystem	TEC	Biomonitoring Year
X22B-00888	X2CROC-RIVUL	Crocodile	S-25.43013 E 30.75744	737	14.6	C	B 83.4%	BC 78.1%	BC 80.75%	C 70%	BC 78.60%	C 70%	2012
							C 71.1%	C 75%	C 73.05%	C 75%	C 73.44%		2017

General description

Reach X22B-00888: Houtbosloop – Visspruit

The PESEIS reach length is listed as 14.6 km, with the Houtbosloop confluence the upstream boundary, and the Visspruit confluence the downstream boundary. Elevation ranges from 744 to 703 m a.s.l. The reach is categorised by slower flowing pool areas with occasional rapids and riffles. The Elands River, Houtbosloop and Stats rivers are the major tributaries flowing into this reach.

One site was sampled in this reach (X2CROC-RIVUL). Most of the reach falls within the 4.04 level II aquatic ecoregion of the North-Eastern Highlands (Kleynhans et al. 2008). The main vegetation is described representative of the Legogote Sour Bushveld (Mucina & Rutherford 2006) comprising of 26.3% thickets and dense bush, woodlands and open bush (6.8%). Citrus crops are the main land-use (cultivated orchards 7.8%) along the reach, with crops planted close to the edge of the river in many places. (GEOTERRAIMAGE, 2015) At the confluence with the Houtbosloop major clearing of the riparian zone occurred as part of new developments. To compound this, invasive exotic weed species dominate the riparian zone, suppressing the growth of the indigenous vegetation and undermining the ecological integrity of the riparian zones.

The Crocodile River at the Rivulets site is 20 - 30 m wide, dominated by large cobble, gravel, boulders, sand, silt, and mud. Diverse hydraulic biotopes include riffles, runs, glides, and shallow pools, riffles and runs in side channels.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22B-00888 was calculated at 67.68% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

One site (X2CROC-RIVUL) was sampled for this reach. All fish velocity depth classes were present at this site with slow deep habitat in abundance. The fast deep and fast shallow fish velocity depth classes were moderate to abundant with the slow shallow only sparse. The most prominent cover was the substrate with some overhanging vegetation and undercut banks present.

Table 19: Fish species expected based on the PESEIS Reach Code (X22B-00888) X2CROC-RIVUL; is listed, and the numbers of fish species present during the different surveys are indicated.

X22B-00888	Expected Species	X2CROC-RIVUL	
		09/2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	-
<i>Enteromius crocodilensis</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	81	54
<i>Labeobarbus polylepis</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	70
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	6	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	19	4
<i>Chiloglanis pretoriae</i>	x	26	14
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	11	10
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	13		
Number of species recorded		5	5
Number of individuals		143	152
Electro-fishing time (minutes)		30	49
Catch/Unit Effort (CPUE)		4.77	3.10

During both the 2012 and 2017 surveys only five of an expected 13 indigenous fish species were recorded, but with different assemblages (Table 19). During this survey the most abundant species was *Micralestes acutidens*, an extralimital species not recorded for the 2012 survey. The absence of the rheophilic species *Amphilius uranoscopus* and the low abundance of *Chiloglanis pretoriae* indicate limited instream habitat for these habitat specialists. Alterations of instream habitat occurs due to loss of interstitial spaces between rocks and cobble as a result of increased siltation and sedimentation following impacts in the riparian zone. The presence of *Chiloglanis bifurcus*, although in low abundance is significant. The species is endemic to the Inkomati River system and within this system it is restricted to altitudes between 900m to 1200m.a.s.l. It historically occurs in the Crocodile and Elands River and certain of its sub-tributaries (Elands, Ngodwana, Gladdespruit and Stadspruit) (Kleynhans, 1984). This mainstem

species is naturally found at relatively low population densities and based on comprehensive population studies on *C. bifurcus* (Kleynhans, 1984) the historic relative density in relation to other associated fish species was calculated to be 2,8% with a CPUE trend of 0.18 (individuals per minute collected). This species inhabit the interstitial spaces of loose rocks with a diameter ranging from 0.1m to 0.5m. They occur together with several other fish species which include *Amphilius uranoscopus* and *Chiloglanis pretoriae* (Kleynhans, 1984). Based on the absence and low abundance of certain fish species not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered. The reason for this is sedimentation and siltation caused by bank instability and land use practices within this reach.

The CPUE of 3.10 for the present survey (152 individual; 49 minutes) was lower than the effort for the 2012 survey with a CPU of 4.77 (143 individuals; 30minutes) indicating a lower abundance within the fish community.

A Fish Ecstatus rating of 71.1% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired). This rating is lower compared to the 2012 survey results with a Category B (83.4%). This decline can be related to loss of instream habitat to fish species that is habitat specialists.

Invertebrates

Three SASS sampling events are on record for the Rivulets site (X2CROC-RIVUL) on the Crocodile River. These represent one winter and two spring sampling events. A total of 42 SASS taxa have been recorded during these three sampling events, of which 27 taxa in total were recorded during the winter survey and 39 in the two spring surveys. Sensitively rated SASS taxa recorded during all five sampling events included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, Tricorythidae, Macromiidae (Cordulidae), and Philopotamidae. The family Atyidae (Freshwater Shrimps) appears for the first time in the Crocodile River at this site, as do the exotic invasive species *Tarebia granifera* (Quilted melania) from the family Thiaridae. The Quilted melania is present in very high numbers in the Eland River, downstream from the return flow of Sappi Ngodwana' Pulp and Paper Mill irrigated effluent.

Table 20: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22B-00888.

X22B-00888	X2CROC -RIVUL	2012	2017	Change
	Total SASS Score	205	176	
	No. of SASS Families	33	27	
	Average Score Per Taxon	6.2	6.5	
	MIRAI Value	Category B 82.3%	Category C 75.0%	↓
SQ REACH SUMMARY Invertebrate Ecstatus	Category BC 78.1%	Category C 75.0%		

The 2017 SASS5 results (Table 20) indicate deterioration from slightly (BC) to close to largely natural with few modifications most of the time (C) when compared to 2012. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C - 75%) in July 2017. The deterioration is mainly attributed to polluted water from the Elands River entering the Crocodile River further upstream. The Elands River was determined to be one of the fastest deteriorating rivers in Mpumalanga, based on the analysis of long-term chemical water quality data (Griffin et al. 2014). It is clear that the Target Water Quality Range of TDS values in the Elands River far exceeds the 15% Guideline for Aquatic Ecosystems.

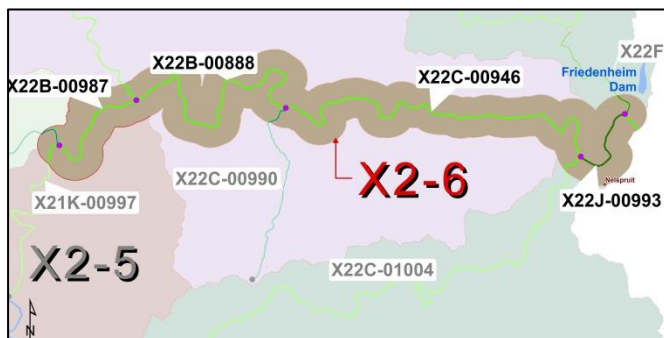
Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified habitat. The Riparian IHI was calculated at 51.28% rating this reach as a Category D indicating a largely modified habitat with a large change or loss of natural habitat, biota and basic ecosystem functions. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (75%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

X22B-00987, X22B-00888, X22C-00946, X22J-00993 (MRU CROC C): CROCODILE RIVER

IUA X2-6 - CROCODILE FROM ELANDS TO NELS



PRIORITY RATINGS

RUs	SQ number	River	PES	REC	PR
IUA X2-6					
MRU Croc C	X22B-00987*	Crocodile	C	B	3WQ 3b
	X22B-00888*	Crocodile	C	B	
	X22C-00946*	Crocodile	C	B	
	X22J-00993*	Crocodile	D	C	
Part of IUA X2-9					
MRU Croc C	X22J-00958*	Crocodile	C	B	3WQ 3b
	X22K-00981*	Crocodile	C	B	

* These SQs form part of EWR C4, which is situated in IUA X2-9, MRU Croc D. Please refer to Section 21.3 for further details.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).	✓
Ensure that turbidity/clarity or TSS levels	A moderate change from present with temporary high sediment	No data

Narrative RQO	Numerical RQO	Notes
stay within Acceptable limits.	loads and turbidity (aquatic ecosystems: driver).	
Ensure that Mn levels are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).	X
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	X Ammonia exceeds the TWQR.

Data collected at the monitoring point 191437: *Crocodile River @ Rivulets @ Road bridge* was used for the assessment for this RU (representative of water quality for SQR X22B-00888). This MRU is downstream of the Nelspruit urban area with its associated urban impacts.

Summarized results for X22B-00888 and X22C-00946: Water quality state for this reach is non-compliant in terms of many parameters.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. Institute more frequent monitoring toxics to check compliance, as only ammonia and Mn could be assessed for present state. Other toxics monitored were at too low a frequency to be of use.
3. Institute turbidity monitoring as it has been flagged as a water quality issue.
4. Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts.

Impacts for SQR

- Invasive plant species in riparian zone
- Presence of exotic snails
- Cultivation and development in riparian zone
- Bank scouring and bank instability resulting in increased siltation and sedimentation
- Domestic waste in stream and riparian zone
- Over abstraction of water for irrigation purposes

See appendix E



Figure 14: Cultivation in riparian zone and removal of riparian vegetation



Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (73.44%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET ?

Discussion:

- Although it appears that the target is met, land use practices and new development in the riparian zone is having a major impact on the instream habitat and biota. If these impacts can be corrected with adequate catchment management the Ecostatus Category of this reach can improve to a BC Category.
- The distribution range of *Chiloglanis bifurcus* (IUCN red data species) is entirely within privately owned land without any formal conservation protection. Land and water use practices need to be carefully managed and probably the best way to effect this would be through conservancy agreements with riparian land owners and Mpumalanga Parks Board.

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2CROC-RIVUL	X22B	X22B-00888	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Elevation (m. a.s.l.)	Geomorphological Zone	
S -25.43013	737	Upper Foothills	
AQUATIC ECOREGION	Longitude	Level II	
	E 30.75744	4.04	
4. North Eastern Highlands			
			
Figure A-17. Upstream view of the Rivulets site, X2CROC-RIVUL, on the Crocodile River (July 2017, G Diedericks).	Figure A-18. Downstream view of the Rivulets site, X2CROC-RIVUL, on the Crocodile River (July 2017, G Diedericks).		

SQ REACH NUMBER X22C-00946

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecotatus	Invertebrate Ecotatus	Instream Ecotatus	Riparian Vegetation Ecotatus	Integrated Ecotatus	TEC	Biomonitoring Year
X22C-00946	X2CROC-STRKS	Crocodile	S-25.44128 E 30.89103	670	18.9	C	BC 78.45%	BC 83.4%	BC 80.93%	C 70%	BC 78.19%	C 70%	2012
							B 82.5%	C 73%	C 77.8%	C 77.5%	C 77.7%		2017

General description

Reach X22C-00946: Visspruit - Gladdespruit

The reach starts at the confluence of the Crocodile River and the Visspruit, flowing for a length of 18.91 km to its downstream boundary which is the confluence with the Gladdespruit. Elevation ranges from 703 m a.s.l. at the upstream boundary to 645 m a.s.l. at the Gladdespruit confluence. The instream habitat in this reach is characterised by bedrock and slow flowing pools, with occasional rapids and riffles. The Visspruit south of the Crocodile River and the Sterkspruit north of the river are the main tributaries to this reach. In 2012 two sites were sampled in this reach, but in 2017 only the X2CROC-STRKS (at Ronde Geluk) were included.

Most of the reach falls within the North Eastern Highlands aquatic ecoregion, but a small section is located in the transitional area between the Northern Escarpment Mountains and the North Eastern Highlands. The vegetation type is described as the Legogote Sour Bushveld comprising of 32% thickets and dense bush. The dominant land-use in the areas adjacent the river is crops, mainly citrus (cultivated orchards 6.2%) (GEOTERRAIMAGE, 2015). There are several planted areas infringing on the riparian zone, and infestation with invasive and exotic weeds is extremely high.

The Crocodile River at the Ronde Geluk site is 20 - 30 m wide, dominated by boulders, with cobble, gravel, sand, silt, and mud. Hydraulic biotopes include riffles, runs, glides, and backwater pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22C-00946 was calculated at 65.21% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

One site (X2CROC-STRKS) was monitored for this SQ reach, however, strong flow conditions as a result of water releases from Kwena dam made sampling of this site challenging. The fish velocity depth classes present were fast deep (very abundant), fast shallow (abundant) and slow shallow (moderately abundant in a side channel). No slow deep habitat was present. The fish cover present was moderate in the form of overhanging vegetation and aquatic macrophytes recorded as abundant. Undercut banks and root wads were moderately abundant, with boulders, rocks and cobbles providing the necessary in-stream cover for especially the flow dependant species.

Table 21: Fish species expected based on the PESEIS Reach Code (X22C-00946) X2CROC-STRKS; is listed, and the numbers of fish species present during the different surveys are indicated.

X22C-00946	Expected Species	X2CROC-STRKS	
		09/2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	-
<i>Enteromius crocodilensis</i>	x	-	-
<i>Enteromius trimaculatus</i>	x	-	1
<i>Labeo molybdinus</i>	x	-	1
<i>Labeobarbus marequensis</i>	x	32	19
<i>Labeobarbus polylepis</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	1	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	-	1
<i>Chiloglanis pretoriae</i>	x	29	14
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	3	3
<i>Pseudocrenilabrus philander</i>	x	7	21
<i>Tilapia sparmanii</i>	x	-	2
Number of species expected	14		
Number of species recorded		5	8
Number of individuals		72	62
Electro-fishing time (minutes)		24	29
Catch/Unit Effort (CPUE)		3.0	2.14

A total of 14 indigenous species of fish are expected to occur in this reach of which eight were collected during the present survey comparing to the five collected during the 2012 survey (Table 21). The rheophilic species *Labeobarbus marequensis* and *Chiloglanis pretoriae* were collected at relative low abundance within the fast shallow habitats, but high flow conditions experienced during this survey could have an influence on the relative low abundance recorded. Of importance is the collection of a single *Chiloglanis bifurcus* collected that has been absent from records for this site for the past 10 years. The low flow conditions due to the 2015/2016 drought period possibly

facilitated the movement patterns of this species outside its normal distribution records. The three cichlid species, *Oreochromis mossambicus*, *Pseudocrenilabrus philander* and *Tilapia sparrmanii* were recorded at relative low densities within this reach indicating favourable flow conditions for limnophilic species. The CPUE for the present survey was calculated at 2.14 (62 individuals; 29 minutes) slightly lower compared to the 2012 survey of 3.0 (72 individuals; 24 minutes) indicating a lower abundance of individuals collected although a higher species diversity is recorded.

A Fish Ecstatus rating of 82.5% was calculated for this reach based on all available information, placing this reach in an Ecological Category B (largely natural with low diversity of species) which is slightly higher compared to the 2012 survey with a (78.45%) Category BC.

Invertebrates

Nine SASS sampling events are on record for the Ronde Geluk site (X2CROC-STRKS) on the Crocodile River. These represent five winter and four spring sampling events. A total of 50 SASS taxa have been recorded during these nine sampling events, of which 42 taxa in total were recorded during the winter surveys and 44 in the four spring surveys. Sensitive rated SASS taxa recorded during all nine sampling events and during all winter surveys included only the family Leptophlebiidae. The families Perlidae, Leptophlebiidae, and Elmidae were recorded during all four spring surveys. Noticeable absence of taxa previously recorded and expected included Tricorythidae, Hydropsychidae >2 sp., and Elmidae. The first records of Porifera: Potamolepidae (freshwater sponges) in the Crocodile River were at the Ronde Geluk site during the 2017 survey.

Table 22: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22C-00946.

X22C-00946	X2CROC -STRKS	2012	2017	Change
	Total SASS Score	204	167	
	No. of SASS Families	30	28	
	Average Score Per Taxon	6.8	6.0	
	MIRAI Value	Category A/B 88.2%	Category C 73.0%	↓
SQ REACH SUMMARY Invertebrate Ecstatus	Category BC 83.4%	Category C 73.0%		

The 2017 SASS5 results (based on MIRAI – Table 22) indicate deterioration from close to largely natural with few modifications most of the time (BC) in 2012 to moderately impaired (C). A combination of severe disturbance of the riparian in the upper catchment (Houtbosloop-Crocodile riparian zones) and polluted water entering from the Elands River could be one of the causes. Anthropogenic disturbances in riverine ecosystems most often manifests itself further downstream (Allan 2004; Anderson 2001; Bruno et al., 2014; Griffin et al. 2014).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified habitat. The Riparian IHI was calculated at 53.88% rating this reach as a Category D indicating a largely modified reach with a large change or loss of natural habitat, biota and basic ecosystem functions. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Invasive plant species
- Severe disturbance in riparian zone
- Presence of exotic snails
- Bank scouring
- Domestic waste in stream and riparian zone
- Pollution from urbanisation
- Pollution impacts from upstream Elands River.

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (77.7%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET





Discussion:

This SQ reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail during target setting. The Integrated Ecostatus of a Category C indicate that a more detailed assessment is required.

Through proper integrated water management the Ecological Category can improve to a BC Category:

- Through proper management of sediment deposition in upper catchment land use practices
 - Urban run-off as well as other urban environmental pollution
 - Improving water quality of Elands River
 - Protecting riparian zone
-

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2CROC-STRKS	X22C	X22C-00946	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Elevation (m. a.s.l.)	Geomorphological Zone	
S -25.44128	670	Upper Foothills	
		Level II	
AQUATIC ECOREGION			
	4. North Eastern Highlands		4.04
			
Figure A-19. Upstream view of the Ronde Geluk site, X2CROC-STRKS, on the Crocodile River (July 2017, G Diedericks).	Figure A-20. Downstream view of the Ronde Geluk site, X2CROC-STRKS, on the Crocodile River (July 2017, G Diedericks).		

SQ REACH NUMBER X22J-00958

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecotatus	Invertebrate Ecotatus	Instream Ecotatus	Riparian Vegetation Ecotatus	Integrated Ecotatus	TEC	Biomonitoring Year
X22J-00958	X2CROC-KAMAG	Crocodile	S-25.45103 E 31.01669	570	14.4	C	B 85.2%	C 67.7%	C 76.45%	C 70%	C 74.84%	C 70%	2012
							BC 81.6%	C 65.3%	C 73.5%	C 77.5%	C 74.3%		2017

General description

Reach X22J-00958: Nelsriver – White River

The reach length of the Crocodile River is 14.44 km, with the upstream boundary starting at the Nelsriver confluence and the downstream boundary at the White River confluence. The main tributary contributing to this reach is the Nelsriver at the upper boundary and the Rietspruit flowing in from the south. Elevation ranges from 602 m a.s.l. at the upstream boundary to 524 m a.s.l. at the White River confluence. The instream habitat in this reach is characterised by bedrock and slow flowing pools, with occasional rapids and riffles.

The reach falls within the North Eastern Highlands aquatic ecoregion, and in the Pretoriuskop Sour Bushveld vegetation type comprising of thickets and dense bush (53.6%), woodlands with open bush (4.2%) and grasslands (9.7%). The river in this reach receives waste water and storm-water from the city of Nelspruit, and the lower parts of the reach are characterised by citrus orchards and tobacco lands (cultivated orchards 11.9%) (GEOTERRAIMAGE, 2015). Exotic weeds are relatively dominant in the riparian vegetation.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22D-00958 was calculated at 77.76% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The reach is situated downstream of Nelspruit and is highly impacted by urbanisation effects which include reduced water quality and quantity. The river habitat diversity consist primarily of slow flowing pools with bedrock and fast shallow instream habitats. At the (X2CROC-KAMAG) site monitored for this reach, two channels provided all fish velocity depth classes with fast deep the most abundant. Moderate overhang vegetation and some undercut banks

and root wads were present as cover and riffles and rapids with boulders, rocks and cobbles provided good substrate cover for fish in the fast habitat types.

Table 23: Fish species expected based on the PESEIS Reach Code (X22J-00958) X2CROC-KAMAG; is listed, and the numbers of fish species present during the different surveys are indicated.

X22J-00958	Expected Species	X2CROC-KAMAG	
		10/2012	07/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	4	1
<i>Petrocephalus wesselsi</i>	x	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	x	-	-
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius eutaenia</i>	x	56	1
<i>Enteromius trimaculatus</i>	x	-	12
<i>Enteromius unitaeniatus</i>	x	8	26
<i>Enteromius viviparus</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	7
<i>Labeo molybdinus</i>	x	-	2
<i>Labeobarbus marequensis</i>	x	22	32
<i>Opsaridium peringueyi</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	38
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	1	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	1	2
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	-	-
<i>Chiloglanis pretoriae</i>	x	17	14
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	3	-
<i>Pseudocrenilabrus philander</i>	x	34	9
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	20		
Number of species recorded		9	11
Number of individuals		146	144
Electro-fishing time (minutes)		34	31
Catch/Unit Effort (CPUE)		4.29	4.65

Eleven indigenous fish species of an expected 20 species were collected at this site, two species more than recorded during the 2012 survey (Table 23). The expected species for this reach can be classified as temperate species associated with Lowveld River reaches namely *Micralestes acutidens*, *Enteromius unitaeniatus*, *Enteromius trimaculatus*, *Chiloglanis pretoriae* and *Labeo cylindricus*. The fish assemblage collected in this reach consisted of eleven species including rheophilic as well as limnophilic species. The absence or low abundance of certain sensitive species such as *Opsaridium peringueyi*, *Enteromius eutaenia* and *Amphilius uranoscopus* is of concern and can be

related to reduced water quality conditions, as well as their intolerance to flow modifications. The catch per unit effort (CPUE) was recorded as 4.65 (144 individuals; 31 minute) remaining consistent with the 2012 survey 4.29 (146 individual; 34 minutes), indicating a relative abundance of fish.

A Fish Ecostatus rating of 81.6% was calculated for this monitoring point based on all available information, placing it in an Ecological Category BC (close to largely natural with few modifications most of the time) lower than the 2012 survey rating of (85.2%) Category B (Largely natural with few modifications).

Invertebrates

Two SASS sampling events are on record for the Kamagugu site (X2CROC-KAMAG) on the Crocodile River. These represent one winter and one spring sampling event. A total of 35 SASS taxa have been recorded during these nine sampling events, of which 26 taxa in total were recorded during the winter survey and 24 in the spring survey. Sensitive rated SASS taxa recorded during both sampling events included Baetidae >2 sp., and Heptageniidae, only the family Leptophlebiidae. High quantities of filamentous algal growth were noted covering substrates in flowing and stagnant waters during the 2017 sampling event.

Table 24: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22J-00958.

X22J-00958	X2CROC –KAMAG	2012	2017	Change
	Total SASS Score	153	131	
	No. of SASS Families	26	24	
	Average Score Per Taxon	5.9	5.5	
	MIRAI Value	Category C 67.7%	Category C 65.3%	→
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 67.7%	Category C 65.3%		

The 2017 SASS5 results (based on MIRAI) (Table 24) were similar to 2012, both years rated as moderately impaired (C).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified with loss and change of natural habitat and biota in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The Riparian IHI was calculated at 81.44% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Excessive algae growth
- Presence of exotic snails
- Invasive plant species
- Disturbance in riparian zone
- Bank scouring
- Domestic waste in stream and riparian zone
- Pollution from urbanisation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (74.3%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET



Discussion:

This SQ reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail during target setting. The Integrated Ecostatus of a Category C indicate that a more detailed assessment is required.

Through proper integrated water management the Ecological Category can improve to a BC Category:

- Through proper management of sediment deposition in upper catchment land use practices
- Urban run-off as well as other urban environmental pollution
- Improving water quality from Waste Water Treatment Plants
- Protecting riparian zone



RIVER		TRIBUTARY OF			
Crocodile		Inkomati			
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH	
X2CROC-KAMAG		X22J		X22J-00958	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)		Geomorphological Zone	
S -25.45103		E 31.01669		Upper Foothills	
AQUATIC Ecoregion		Level I		Level II	
4. North Eastern Highlands				4.04	
					

Figure A-21. Upstream view of the Khamagugu site, X2CROC-KAMAG, on the Crocodile River (July 2017, G Diedericks).

Figure A-22. Downstream view of the Khamagugu site, X2CROC-KAMAG, on the Crocodile River (July 2017, G Diedericks).

SQ REACH NUMBER X22K-01018 (EWR 4)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X22K-01018	X2CROC-N4ROA* EWR 4	Crocodile	S-25.50050 E 31.17869	475	15.2	C	BC 81.95%	C 76.3%	BC 79.53%	C 70%	C 77.44%	C 72.78%	2012
							C 73.2%	C 72.2%	C 72.7%	C 77.5%	C 75.1%		2017

General description

Reach X22K-01018: Blinkwater – Kaap

The reach falls within the area locally known as the Crocodile Gorge. The upper boundary of the reach is below the Blinkwater confluence, and it ends above the Crocodile and Kaap River confluence. The elevation ranges from 478 m.a.s.l. at the upstream boundary to 330 m a.s.l. at the downstream boundary. Instream habitat is characterised by deep slow flowing pools with riffles, glides and rapids over mainly bedrock and large boulders.

The aquatic region has been classified as Lowveld, and the vegetation type as Scrap Forest comprising of thickets and dense bush (74.6%), woodlands and open bush (5.1%) and grasslands (6.2%). Most of the natural vegetation in the gorge is still intact, with roads along the edge of the river, and scattered citrus farms (cultivated fields 11.1%; cultivated orchards 1.3%) at the edges of the reach's boundary (GEOTERRAIMAGE, 2015). Two sites falling within this PESEIS reach were sampled in 2012, and only the X2CROC-N4ROA (EWR 4) site in 2017.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22K-01018 was calculated at 77.76% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

During the 2017 survey the EWR site 4 (X2CROC-N4ROA) was sampled in this reach. Fish velocity depth classes present at the time of the present survey were slow shallow (moderate), fast deep (very abundant) and fast shallow (abundant). The fish cover present for the fast shallow habitats consisted of overhang vegetation (sparse), undercut banks and root wads (moderate) and substrate cover (abundant). In the fast shallow habitat biotope abundant undercut bank and root wads as well as substrate as cover was recorded.

Table 25: Fish species expected based on the PESEIS Reach Code (X22K-01018) X2CROC-N4ROA; is listed, and the numbers of fish species present during the different surveys are indicated.

X22K-01018	Expected Species	X2CROC-N4ROA	
		2012	07/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	2	3
<i>Petrocephalus wesselsi</i>	x	-	1
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	x	-	-
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius annectens</i>	x	-	-
<i>Enteromius eutaenia</i>	x	19	-
<i>Enteromius trimaculatus</i>	x	-	-
<i>Enteromius unitaeniatus</i>	x	5	-
<i>Enteromius viviparus</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	8
<i>Labeo molybdinus</i>	x	1	-
<i>Labeobarbus marequensis</i>	x	16	34
<i>Opsaridium peringueyi</i>	x	14	19
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	2	3
Schilbeidae (Butter catfishes)			
<i>Schilbe intermedius</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	1
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis paratus</i>	x	-	-
<i>Chiloglanis pretoriae</i>	x	23	22
<i>Chiloglanis swierstrae</i>	x	-	-
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	2	-
<i>Pseudocrenilabrus philander</i>	x	8	17
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	24		
Number of species recorded		10	9
Number of individuals		92	108
Electro-fishing time (minutes)		19	54
Catch/Unit Effort (CPUE)		4.84	2.00

The expected fish species were derived from the PES-EIS with a relative high confidence level, but certain migratory species only use these habitats at certain times of their life history stages. The expected species for this reach can be mostly classified as temperate species associated with Lowveld River reaches.

The fish assemblage collected in this reach (Table 25) consisted of nine of an expected 24 species which include both of the snout fishes, *Marcusenius macrolepidotus* and *Petrocephalus wesselsi*, as well as *Opsaridium peringueyi* and *Chiloglanis pretoriae*. These sensitive species are relatively intolerant to flow alterations and modified water

quality. The presence of *Opsaridium peringueyi* is unique as the species is classified as vulnerable (IUCN) and favour shallow, clear, flowing water of perennial rivers frequenting pools below rapids or where water flow over sand and gravel. The range of this species is greatly reduced through habitat changes, dams and water abstraction. Of concern is that none of the expected small barbs species namely *Enteromius annectens*, *Enteromius eutaenia*, *Enteromius trimaculatus*, *Enteromius unitaeniatus* and *Enteromius viviparus* were collected. The flow dependant rheophilic species *Amphilius uranoscopus* and *Chiloglanis pretoriae* were collected in low abundance. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation, loss of instream habitat and deteriorating water quality. The catch per unit effort (CPUE) for this EWR site is calculated at 2.0 (108 individuals; 54 minutes) lower compared to the CPUE of the 2012 survey 4.84 (92 individuals; 19 minutes) indicating a loss of species diversity and abundance.

The Fish Ecostatus rating calculated for this monitoring point based on all available information decreased from a Category B (81.95%) in 2012 to a low Category C (73.2%) indicating a moderately impaired fish assemblage.

Invertebrates

Ten SASS sampling events are on record for the X2CROC-N4ROA site on the Crocodile River. These represent five winter and five spring sampling events. A total of 38 SASS taxa have been recorded during these ten sampling events, of which 38 taxa in total were recorded during winter surveys and 42 in spring surveys. No sensitively rated SASS taxa recorded were recorded during all ten sampling events. Pre-September 1994, the number of SASS taxa recorded ranged from 9 to 19, with the stream community predominantly dominated with tolerant taxa. Taxa diversity (SASS taxa) increased post-July 1994, with number of taxa ranging from 21 to 30 in following surveys. The percentage of SASS taxa rated as sensitive (index score >7) also increased, but are still considered relatively low. Less than 35% of the SASS taxa community was rated as sensitive in the 2012 and 2017 surveys. High quantities of filamentous algal growth were recorded covering substrates in flowing and stagnant waters during the 2017 sampling event.

Table 26: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22K-01018.

X22K-01018	X2CROC -N4ROA	2012	2017	Change
	Total SASS Score	167	170	
	No. of SASS Families	30	28	
	Average Score Per Taxon	5.6	6.1	
	MIRAI Value	Category C 76.3%	Category C 72.2%	↓
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 76.3%	Category C 72.2%		

The 2017 SASS5 results (Table 26) (based on MIRAI) were similar to 2012, with both years rated as moderately impaired (C).

Riparian Vegetation

One site X2CROC-N4ROA (EWR 4) was assessed in this SQ reach.

Marginal Zone: This zone for X2CROC-N4ROA is dominated by grass, shrub and tree species. This include species like *Berula erecta*, *Cynodon dactylon*, *Typha capensis*, *Breonadia salicina*, and *Phragmites mauritanus*. This zone has low woody and high non-woody cover as well as abundance. The species composition resembles the reference state with no or little changes. The water quantity is normal for this time of year and the quality is good. Some exotics were noted consisting mainly of *Eichhornia crassipes* that covered large areas in some places.

Non Marginal Zone: This zone is dominated by grass with some trees and shrubs. Non-grass areas have moderate tree cover with low abundance. The grass dominated areas have a high cover and abundance. The species composition resembles the reference state with no or little changes. The dominant non-woody species include *Imperata cylindrica*, *Setaria megaphylla*, *Thunbergia alata* and *Cynodon dactylon*. Various shrubs and trees are present including, *Combretum erytrophylum*, *Acacia sieberiana*, *Breonadia salicina*, *Ficus sycomorus*, and *Bauhenia galpinii*. Some exotics were noted consisting mainly of *Lantana camara*.

The Level III VEGRAI Assessment range for this site assessed is 77.8% and is consistent with a Category C – moderately modified habitat indicating a loss and change of natural habitat. The Riparian IHI was calculated at 81.44% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat.

Water Quality

IUA X2-9 - CROCODILE FROM NELS TO KAAP INCLUDING BLINKWATER

PRIORITY RATINGS



RUs	SQ number	River	PES	TEC	PR
RU C15	X22K-01042	Mbuzulwane	B	B	2
	X22K-01043	Blinkwater	B	B	
	X22K-01029	Blinkwater	C	C	
MRU Croc D	X22K-01018 EWR C4	Crocodile	C	C	3WQ 3

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data must be less than 0.125 mg/L PO ₄ -P (aquatic ecosystems: driver).	✓
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).	✓
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	✓

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H032Q01.

Summarized results for EWR 4: Water quality at this site has met the RQOs, with the overall integrated state reaching a B category from the C category recorded during the 2010 Reserve study. The TEC for water quality has therefore been met. Note that few toxics data are available.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts, considering the few data points available for a number of parameters.

Impacts for SQR

- Invasive plant species
- Presence of exotic snails
- Excessive algae growth
- Bank scouring

- Domestic waste in stream and riparian zone
- Pollution from urbanisation and Waste Water Treatment Plants
- Removal of indigenous riparian vegetation
- Cultivation and development in riparian zone

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (76.7%)	Category C (72.78%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota



TARGET MET



Discussion:

Although the Ecological Target is met for this EWR site, the Ecological Category can improve to a Category BC:

- Through proper management of land use practices upstream
- Urban run-off as well as urban environmental pollution
- Protecting the riparian zone
- Monitoring of abstraction from river to prevent over-abstraction
- Implementing Ecological flow requirements

RIVER		TRIBUTARY OF			
Crocodile		Inkomati			
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH	
X2CROC-N4ROA		X22K		X22K-01018	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.s.l.)	Geomorphological Zone	
	S -25.50050	E 31.17869	475	Lower Foothills	
AQUATIC ECOREGION		Level I		Level II	
4. North Eastern Highlands				4.04	
					
<p>Figure A-23. Upstream view of the Kanyamazane site, X2CROC-N4ROA, on the Crocodile River (July 2017, G Diedericks).</p>		<p>Figure A-24. Downstream view of the Kanyamazane site, X2CROC-N4ROA, on the Crocodile River (July 2017, G Diedericks).</p>			

SQ REACH NUMBER X24C-01033

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X24C-01033	X2CROC-KAAPM	Crocodile	S-25.53779 E 31.31124	330	7.2	D	C 76.2%	C 73%	C 74.60%	C 70%	C 73.68%	C 70%	2012
							CD 60.9%	C 71.9%	C 66.4%	C 72.5%	C 69.45%		2017

General description

Reach X24C-01033: Kaap – Nsikazi:

The length of this PESEIS reach on the Crocodile River is 7.22 km, with the Kaap River the upstream boundary and the Nsikazi River the downstream boundary. Elevation ranges from 330m.a.s.l. at the upstream boundary to 307 m a.s.l. at the Nsikazi confluence. The Kaap River is the only major tributary contributing to this reach. It is characterised as a low gradient river comprising of large sandy pools with dolerite intrusions where riffles, runs and glides occur over bedrock and boulders.

The aquatic ecoregion was classified as Lowveld, and the vegetation type as Granite Lowveld comprising of 57% thickets and dense bush with 22.2% woodlands and open bush and 4.9% grasslands (GEOTERRAIMAGE, 2015). The main land-use is sugarcane, citrus, subsistence farming, and the Matsulu settlement area. Crops are planted very close to the river in some areas. Only one site X2CROC-KAAPM was sampled within this reach.

Instream Habitat Integrity

The Instream IHI for the SQ reach X24C-01033 was calculated at 78.08% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The site (X2CROC-KAAPM) sampled in this reach is just downstream from the Crocodile Gorge area and the first of the Lowveld biomonitoring sites. At this low gradient river all of the fish velocity depth classes – fast shallow, slow shallow, fast deep and slow deep – were moderately present. Overhang vegetation provided abundant cover for fish in the slow shallow habitat. Bedrock, boulders, rocks and cobbles provided some cover in the fast habitat but the rocks and cobbles were imbedded and covered with thick algae. Sedimentation was evident at this site resulting in a loss of interstitial spaces behind rock further reducing habitat availability.

Table 27: Fish species expected based on the PESEIS Reach Code (X24C-01033) X2CROC-KAAPM; is listed, and the numbers of fish species present during the different surveys are indicated.

X24C-01033	Expected Species	X2CROC-KAAPM	
		2012	07/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	-	3
<i>Petrocephalus wesselsi</i>	x	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	x	-	-
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius annectens</i>	x	-	-
<i>Enteromius afrohamiltoni</i>	x	-	-
<i>Enteromius eutaenia</i>	x	8	7
<i>Enteromius paludinosus</i>	x	-	-
<i>Enteromius radiatus</i>	x	-	-
<i>Enteromius toppini</i>	x	-	-
<i>Enteromius trimaculatus</i>	x	11	-
<i>Enteromius unitaeniatus</i>	x	2	-
<i>Enteromius viviparus</i>	x	-	4
<i>Labeo congoro</i>	x	-	-
<i>Labeo cylindricus</i>	x	6	-
<i>Labeo molybdinus</i>	x	4	-
<i>Labeo rosae</i>	x	-	-
<i>Labeo ruddi</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	-	19
<i>Mesobola brevianalis</i>	x	-	-
<i>Opsaridium peringueyi</i>	x	-	-
Characidae (Characins)			
<i>Brycinus imberi</i>	x	-	-
<i>Hydrocynus vittatus</i>	x	-	-
<i>Micralestes acutidens</i>	x	17	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	4	-
Schilbeidae (Butter catfishes)			
<i>Schilbe intermedius</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis paratus</i>	x	9	-
<i>Chiloglanis pretoriae</i>	x	19	14
<i>Chiloglanis swierstrae</i>	x	-	-
<i>Synodontis zambezensis</i>	x	-	-
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	6	-
<i>Pseudocrenilabrus philander</i>	x	2	3
<i>Tilapia sparmanii</i>	x	-	9
Gobiidae (Gobies)			
<i>Glossogobius giuris</i>	x	-	-
Number of species expected	36		
Number of species recorded		11	7
Number of individuals		111	59
Electro-fishing time (minutes)		34	32
Catch/Unit Effort (CPUE)		3.26	1.84

Most of the Lowveld fish species is expected to occur within this reach and 36 indigenous fish species is expected (Table 27). During this survey only seven indigenous fish species were collected which is less than the number of fish species collected during the 2012 survey. Based on the results only two of the expected nine Barb species were recorded namely *Enteromius eutaenia* and *Enteromius viviparus* at low abundance. This would indicate a loss of the Barb fish assemblage. Of further concern is the loss of the flow dependant species *Amphilius uranoscopus*, *Labeo cylindricus* and *Labeo molybdinus* although these species were recorded in 2012, indicating disrupted flow regimes. Of the three rheophilic Chiloglanis species only *Chiloglanis pretoriae* was recorded at low abundance of 14 individuals while *Chiloglanis paratus* and *Chiloglanis swierstrai* previously collected were absent. Their absence can be related to sedimentation and excessive algae growth over the limited available fish habitat. Few of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation, loss of instream habitat and deteriorating water quality. The CPUE for 2012 was calculated at 3.26 (111 individuals; 34 minutes) declining to a CPUE of 1.84 (59 individuals; 32 minutes) indicating the fish species diversity for this fish assemblage is drastically lower with a decrease in abundance compared to 2012.

A Fish Ecstatus rating of 60.9% was calculated for this monitoring point based on all available information, placing it in an ecological Category CD (close to largely modified most of the time with low diversity and abundance of species). This Fish Ecstatus rating is severely impacted and lower than the C Category (76.2%) recorded during the 2012 survey.

Invertebrates

Eleven SASS sampling events are on record for the X2CROC-KAAPM site on the Crocodile River. These represent one autumn, six winter and four spring sampling events. A total of 53 SASS taxa have been recorded during these 11 sampling events, of which 45 taxa in total were recorded during winter surveys and 38 in spring surveys. Sensitive taxa recorded during all 11 sampling events as well as all winter sampling events included Atyidae, Heptageniidae, and Leptophlebiidae. Sensitive taxa recorded at a high FROC during spring surveys included Perlidae, and Elmidae. The family Tricorythidae was only recorded at an A-abundance for the one autumn sampling event. Extremely high quantities of filamentous algal growth were recorded covering substrates in flowing and stagnant waters during the 2017 sampling event.

Table 28: 2017 SASS5 results for SQ reach X24C-01033.

X24C-01003	X2CROC -KAAPM	2012	2017	Change
	Total SASS Score	Not sampled	182	
	No. of SASS Families		33	
	Average Score Per Taxon		5.5	
	MIRAI Value		Category C 71.9%	↘
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 73% <small>RIVDINT EXTRAPOLATION</small>	Category C 71.9%		

There was limited change in stream conditions (based on SASS) in 2017 (Table 28) between the upstream (X2CROC-N4ROA) and the Kaapmuiden site (X2CROC-KAAPM), with both rated as moderately impaired (C).

Riparian Vegetation

One site (X2CROC-KAAPM) was assessed in this SQ reach.

Marginal Zone: This zone is dominated by open areas grass, shrub and tree species. This include species like *Berula erecta*, *Cynodon dactylon*, *Typha capensis*, *Breonadia salicina*, and *Phragmites mauritianus*. This zone has low woody and non-woody cover as well as low abundance. The species composition does not resemble the reference state due to significant changes that include sand digging and trampling. The water quantity is normal for this time of year and the quality is good. Some exotics were noted consisting mainly of *Eichhornia crassipes* that covered large areas in some places.

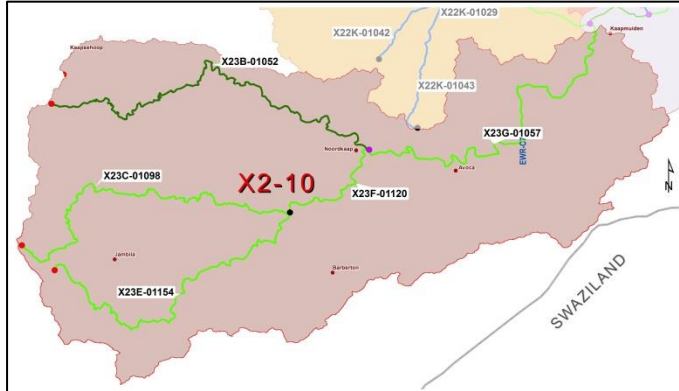
Non Marginal Zone: This zone is dominated by open areas grass, shrub and tree species. This zone has low woody and non-woody cover as well as low abundance. The species composition does not resemble the reference state due to significant changes that include sand digging, trampling, vegetable gardens and other commercial operations on the river banks. The dominant non-woody species include *Imperata cylindrica*, *Setaria megaphylla*, *Thunbergia alata* and *Cynodon dactylon*. Various shrubs and trees are present including, *Diosperos mespeliformis*, *Acacia sieberiana*, *Breonadia salicina*, *Ficus sycomorus*, *Trichilia emetic*, *Syzygium cordatum* and *Bauhenia galpinii*. Various exotics were noted including *Argemone Mexicana*, *Lantana camara* and *Canna indica*.

The Level III VEGRAI Assessment range for this site assessed is 43.7% and is consistent with a Category D – largely modified with a large change or loss of natural habitat. The Riparian IHI was calculated at 81.04% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

X24C-01033: CROCODILE RIVER

IUA X2-11 - CROCODILE: KAAP TO KOMATI



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
MRU Croc D	X24C-01033*	Crocodile	C/D	C/D	3WQ 3b
MRU Croc E	X24H-00880#	Crocodile			3WQ 3
	X24H-00934 EWR C6	Crocodile	C	C	
	X24D-00994 EWR C5	Crocodile	C	C	
	X24E-00982*#	Crocodile			
	X24F-00953*#	Crocodile			

* This SQ forms part of EWR C6, which is situated in IUA X2-10, MRU Croc E. Please refer to Section 23.3 for further details.

Where SQ does not have a EC the EC is different from the EWR site. But because the EWR site has a higher priority rating, the EWR site is the driver for the other sites in this RU.

This SQR falls into the same MRU as EWR C5 and C6. The only monitoring point to possibly use for this reach is X2H078Q01, which is located at the upper end of the reach. Use of this data will however not provide a suitable assessment of the impacts along the length of the reach.

The following water quality recommendations are made:

1. Institute a water quality monitoring point along the lower end of the SQR, or use data from EWR C5 in the downstream SQR to represent this stretch of river.
2. Evaluate biota scores at the biological monitoring point to assess impacts.

Impacts for SQR

- Invasive plant species
- Removal of riparian vegetation
- Presence of exotic snails
- Bank scouring
- Stream bank trampling
- Sand mining in river and riparian zone
- Cultivation in riparian zone
- Domestic waste in stream and riparian zone
- Excessive algae growth

- The river is largely impacted by informal business activities, exotics species, the bridge and road, pathways and trampling.

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (69.45%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET



Discussion:

This SQ reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail during target setting. The Integrated Ecostatus of a Category C indicate that a more detailed assessment is required.

Through proper integrated water management the Ecological Category can improve to a BC Category:

- Through proper management of sediment deposition in upper catchment land use practices
 - Urban run-off as well as other urban environmental pollution
 - Improving water quality from Waste Water Treatment Plants
 - Protecting riparian zone
-

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2CROC-KAAPM		X24C	X24C-01033
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	Geomorphological Zone
Latitude	Longitude	330	Lower Foothills
S -25.53779	E 31.31124		
AQUATIC ECOREGION		Level I	Level II
3. Lowveld			3.07
			

Figure A-25. Upstream view of the Kaapmuiden site, X2CROC-KAAPM; on the Crocodile River (July 2017, G Diedericks).

Figure A-26. Downstream view of the Kaapmuiden site, X2CROC-KAAPM, on the Crocodile River (July 2017, G Diedericks).

SQ REACH NUMBER X24D-00994 (EWR 5)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X24D-00994	X2CROC-MALEL* EWR 5	Crocodile	S-25.48066 E 31.50873	278	22.9	D	BC 78.85%	C 70.1%	C 73.85%	C 70%	C 73.01%	C 73.7%	2012
							BC 78.3%	C 69.9%	C 74.1%	C 72.5%	C 73.3%		2017

General description

Reach X24D-00994: Nsikazi - Matjulu

The PESEIS reach is represented by 22.91 km of the Crocodile River, starting below the Nsikazi confluence (307 m a.s.l.) to where it merges with the Matjulu River (277 m a.s.l.). The Nsikazi River forms the eastern boundary of the Kruger National Park (KNP), and the Crocodile River the southern boundary. Named tributaries from the Kruger National Park in the north contributing to this reach includes the Nsikazi River, Kwamachiyaliwane, Behmansanga, Boomalwynspruit, Kwamhlebeni, Mvovoveni, Mhlumeni, Tinsimbini and Masimbatane. From the south of the reach, major tributaries include the Jan-Tin Creek, Salt Creek and Buffalo Creek. The highly organic and thermally polluted perennial waste water stream from the TSB Sugar-mill also flows into the Crocodile River above the Malelane Bridge into the KNP. Many of the tributaries listed are seasonal, and there are several unnamed ephemeral tributaries.

The instream habitat in this section of the river is dominated with sand and gravel. Only small sections of cobbles, boulders and bedrock are available. Reeds and grasses dominate the marginal vegetation. The area near the broken bridge were characterised by more boulders and bedrock than the rest of the reach. This section of the Crocodile River forms the Kruger National Park border with the northern bank in the KNP and the southern bank impacted by the town of Malelane, low density housing and tourism accommodation as well as irrigated agriculture, mostly sugarcane (18%) and citrus (cultivated orchards 1.6%)(GEOTERRAIMAGE, 2015). The reach falls into the Lowveld aquatic ecoregion, and the vegetation type was classified in as Granite Lowveld comprising of 46% thickets and dense bush, 19.1% woodlands and open bush, with 8.8% grasslands (GEOTERRAIMAGE, 2015). The town of Matsulu is wedged between the Nsikazi and Crocodile rivers, on the south-western boundary of the KNP and west of the Nsikazi River. Matsulu is north of the Crocodile River. The town of Malelane is located close to the southern-eastern boundary of the reach. The land-use in the Kruger National Park is conservation and the southern portions of the reach is characterised by sugarcane, mining, settlements and waste water steam from the TSB sugar-mill flowing through the Malelane Golf Course. Only one site (X2CROC-MALEL) was monitored in this reach.

Instream Habitat Integrity

The Instream IHI for the SQ reach X24D-00994 was calculated at 78.08% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

This EWR site (X2CROC-MALEL) within this river reach falls within the Kruger National Park and the habitat found is typical of the Lowveld reaches and is characterised as a low gradient stream comprising of large sandy pools with isolated riffles and runs. The substrate consists primarily of sand with some rocks and cobbles including aquatic macrophytes. No slow deep habitat was available and a side channel with some backwaters was also present. The fish velocity depth classes present was slow shallow, fast deep and fast shallow, all moderately abundant. Most of the rocky substrate was covered with thick algae.

All the Lowveld associated fish species (36 indigenous species) is expected within this reach which include *Hydrocynus vittatus*, *Glossogobius giuris*, *Chiloglanis swierstrai* and the different Labeo species (*Labeo rosae*; *Labeo ruddi*; *Labeo congoro*). During the 2017 fish assemblage only 12 of the expected 36 indigenous fish species were recorded (Table 29). Of the nine expected *Barbus* species only three were recorded in relative low abundance namely *Enteromius Eutaenia*, *Enteromius trimaculatus* and *Enteromius viviparus* indicating a loss of the *Barbus* fish assemblage. For the rheophilic species only *Chiloglanis paratus* and *Chiloglanis swierstrai* were recorded at extremely low abundance. The instream habitat for these species has been severely reduced due to siltation and excessive algae growth resulting in a loss of available fish habitat. Furthermore, their low abundance would further indicate disrupted flow regimes as a consequence of the 2015/2016 drought period and over-abstraction of water. The absence of *Chiloglanis pretoriae* collected during the 2017 survey, is of concern further attributed to instream habitat alteration. All the limnophilic Cichlid species, *Coptodon rendalli*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander* and *Tilapia sarrmanii* were collected in this reach. The species diversity recorded at this biomonitoring site was higher than during 2012 (12 species recorded in 2017 compared to seven for 2012). During the present survey the CPUE was relatively low calculated at 2.02 (119 individuals; 59 minutes) indicating a low abundance.

Table 29: Fish species expected based on the PESEIS Reach Code (X24D-00994) X2CROC-MALEL; is listed, and the numbers of fish species present during the different surveys are indicated.

X24D-00994	Expected Species	X2CROC-MALEL	
		2012	07/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	X	-	-
<i>Petrocephalus wesselsi</i>	X	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	X	-	-
<i>Anguilla mossambica</i>	X	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius annectens</i>	X	-	-
<i>Enteromius afrohamiltoni</i>	X	-	-
<i>Enteromius eutaenia</i>	X	-	2
<i>Enteromius paludinosus</i>	X	-	-
<i>Enteromius radiatus</i>	X	-	-
<i>Enteromius toppini</i>	X	-	-
<i>Enteromius trimaculatus</i>	X	-	12
<i>Enteromius unitaeniatus</i>	X	-	-
<i>Enteromius viviparus</i>	X	1	27
<i>Labeo congoro</i>	X	-	-
<i>Labeo cylindricus</i>	X	-	-
<i>Labeo molybdinus</i>	X	-	-
<i>Labeo rosae</i>	X	-	-
<i>Labeo ruddi</i>	X	-	-
<i>Labeobarbus marequensis</i>	X	1	20
<i>Mesobola brevianalis</i>	X	-	-
<i>Opsaridium peringueyi</i>	X	-	-
Characidae (Characins)			
<i>Brycinus imberi</i>	X	-	-
<i>Hydrocynus vittatus</i>	X	-	-
<i>Micralestes acutidens</i>	X	-	16
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	X	-	-
Schilbeidae (Butter catfishes)			
<i>Schilbe intermedius</i>	X	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	X	-	2
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis paratus</i>	X	4	5
<i>Chiloglanis pretoriae</i>	X	6	-
<i>Chiloglanis swierstrae</i>	X	5	9
<i>Synodontis zambezensis</i>	X	-	-
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	X	-	1
<i>Oreochromis mossambicus</i>	X	2	16
<i>Pseudocrenilabrus philander</i>	X	2	6
<i>Tilapia sparmanii</i>	X	-	3
Gobiidae (Gobies)			
<i>Glossogobius giuris</i>	X	-	-
Number of species expected	36		
Number of species recorded		7	12
Number of individuals		21	119
Electro-fishing time (minutes)		Not Recorded	59
Catch/Unit Effort (CPUE)		-	2.02

A Fish Ecostatus rating of 78.3% was calculated for this monitoring point based on all available information, placing it in an ecological Category BC (close to largely natural with low diversity and abundance of species) which is consistent with the 2012 results - Category BC (78.85%).

Invertebrates

Eight SASS sampling events are on record for the X2CROC-MALEL site on the Crocodile River. These represent three winter and five spring sampling events. A total of 54 SASS taxa have been recorded during these eight sampling events, of which 36 taxa in total were recorded during winter surveys and 42 in spring surveys. Sensitive taxa recorded during all eight sampling events as well as all winter sampling events included Atyidae, Heptageniidae, and Leptophlebiidae. No sensitive taxa were recorded at a high FROC during all sampling events. Extremely high quantities of filamentous algal growth were recorded covering substrates in flowing and stagnant waters during the 2017 sampling event.

Table 30: Comparison of the 2012 and 2017 SASS5 results for SQ reach X24D-00994.

X24D-00994	X2CROC –MALEL	2012	2017	Change
	Total SASS Score	141	146	
	No. of SASS Families	26	29	
	Average Score Per Taxon	5.4	5.0	
	MIRAI Value	Category C 70.1%	Category C 69.9%	➔
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 70.1%	Category C 69.9%		

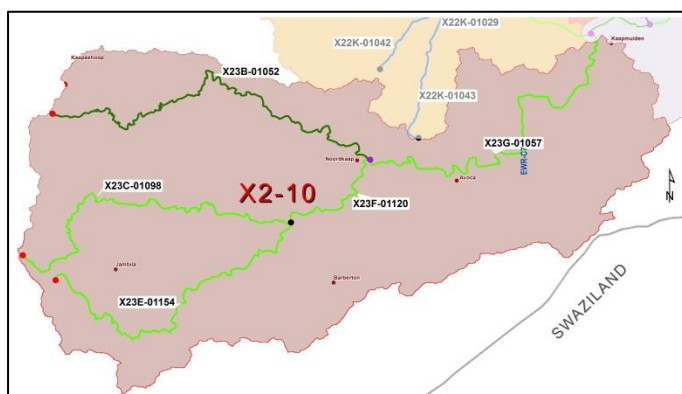
There was limited change in stream conditions (based on SASS) in 2017 (Table 30) between the upstream (X2CROC-KAAPM) and the Malelane site (X2CROC-MALEL), with both rated as moderately impaired (C).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 72.5% and is consistent with a Category C – moderately modified indicating a loss and change of natural habitat. The Riparian IHI was calculated at 81.04% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

IUA X2-11 - CROCODILE: KAAP TO KOMATI



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
MRU Croc D	X24C-01033*	Crocodile	C/D	C/D	3WQ 3b
MRU Croc E	X24H-00880#	Crocodile			3WQ 3
	X24H-00934 EWR C6	Crocodile	C	C	
	X24D-00994 EWR C5	Crocodile	C	C	
	X24E-00982*#	Crocodile			
	X24F-00953*#	Crocodile			

* This SQ forms part of EWR C6, which is situated in IUA X2-10, MRU Croc E. Please refer to Section 23.3 for further details.

Where SQ does not have a EC the EC is different from the EWR site. But because the EWR site has a higher priority rating, the EWR site is the driver for the other sites in this RU.

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data must be less than 0.075 mg/L PO ₄ -P (aquatic ecosystems: driver, EWR C6).
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 70 mS/m (aquatic ecosystems: driver).
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity.
Ensure that temperatures stay within Acceptable limits.	A moderate change to instream temperatures should occur infrequently, i.e. vary by no more than 2°C. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver).
Ensure that toxics are within the CEV limits.	95 th percentile of the data must be within the CEV for toxics or the B category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b) (aquatic ecosystems: driver, EWR C6).

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H017Q01 for EWR C5. Data from DWS gauge X2H017Q01 should be used for the present state evaluation of SQ X24F-00958 (Crocodile River), while data from X2H048Q01 was used for **EWR C5**.

Summarized results for EWR 5: Water quality at this site has met the RQOs and the TEC for water quality. Note that few toxics data were available for evaluation.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data must be less than 0.075 mg/L PO ₄ -P (aquatic ecosystems: driver, EWR C6).	✓
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 70 mS/m (aquatic ecosystems: driver).	✓
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity.	No data
Ensure that temperatures stay within	A moderate change to instream temperatures should occur	No data. See

Narrative RQO	Numerical RQO	Notes
Acceptable limits.	infrequently, i.e. vary by no more than 2°C. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver).	biotic responses
Ensure that toxics are within the CEV limits.	95 th percentile of the data must be within the CEV for toxics or the B category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b) (aquatic ecosystems: driver, EWR C6).	✓

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts for turbidity and temperature.
Data are not available to evaluate these impacts other than on a qualitative basis.
2. Limited toxics data were available.

Impacts for SQR

- Presence of exotic snails
- Bank scouring
- High sand deposition
- Excessive algae growth
- Pollution from urbanisation and Waste Water Treatment Plants

See appendix E

Integrated Ecstatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (73.78%)	Category C (73.7%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota.


TARGET MET



Discussion:

Although the Ecological Target is met for this EWR site, the Ecological Category can improve to a Category B:

- Through proper management of land use practices upstream
- Urban run-off as well as urban environmental pollution
- Protecting the riparian zone
- Monitoring of abstraction from river to prevent over-abstraction
- Implementing Ecological flow requirements

RIVER		TRIBUTARY OF			
Crocodile		Inkomati			
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH	
X2CROC-MALEL		X24D		X24D-00994	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Latitude	Longitude	Elevation (m. a.s.l.)	Geomorphological Zone
		S -25.48066	E 31.50873	278	Lower Foothills
AQUATIC ECOREGION		Level I		Level II	
		3. Lowveld		3.07	
					
<p>Figure A-27. Upstream view of the Malelane site, X2CROC-MALEL, on the Crocodile River (July 2017, G Diedericks).</p>			<p>Figure A-28. Downstream view of the Malelane site, X2CROC-MALEL, on the Crocodile River (July 2017, G Diedericks).</p>		

SQ REACH NUMBER X24F-00953

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X24F-00953	X2CROC-MARO2	Crocodile	S-25.38159 E 31.74561	209	31.0	D	C 73.2%	C 75.8%	C 74.69%	C 70%	C 73.66%	C 70%	2012
							C 76.9%	C 66%	C 71.5%	C 72.5%	C 71.7%		2017

General description

Reach X24F-00953: Nsikazi - Matjulu

This PESEIS reach represents 31 km of the Crocodile River, with the Mlambeni confluence (249 m a.s.l.) the upstream boundary and the Mbyamiti River (200 m a.s.l.) the downstream boundary. The Crocodile River forms the southern boundary of the KNP. The major tributaries include the Mlambeni, Mhlalathi, Lwakahle and Hlongo seasonal streams flowing from the KNP. A large weir falls within this reach, named the Van Graan Dam.

The upper reaches of this reach are inundated by the Van Graan Dam, and were therefore not included in the assessment. The instream habitat in this section of the river is characterised by larger areas of bedrock compared to the upstream reaches. Another weir, the Maroala Weir, is located approximately 2 km downstream of the Van Graan Dam.

The entire reach falls within the Lowveld aquatic ecoregion, and the Granite Lowveld vegetation type comprising of thicket and dense bush (36%), woodlands and open bush (30.2%) and grasslands (19.8%). Apart from irrigated agriculture, Marloth Park is also located on this reach. The main land-uses include conservation, sugarcane (cultivated cane 5%), and citrus (cultivated orchards 5%) (GEOTERRAIMAGE, 2015). The Maroela site (X2CROC-MARO2) was the only site sampled within this reach.

Instream Habitat Integrity

The Instream IHI for the SQ reach X24F-00953 was calculated at 78.08% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

One site (X2CROC-MAR02) was monitored for this reach. The habitat sampled was just downstream from a bridge with no fast deep habitat present. Most of the fish velocity depth classes sampled was shallow, with both slow

Table 31: Fish species expected based on the PESEIS Reach Code (X24F-00953) X2CROC-MAR02; is listed, and the numbers of fish species present during the survey is indicated.

X24F-00953	Expected Species	X2CROC-MAR02	
		2012	08/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	X	-	-
<i>Petrocephalus wesselsi</i>	X	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	X	-	-
<i>Anguilla mossambica</i>	X	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius annectens</i>	X	-	-
<i>Enteromius afrohamiltoni</i>	X	-	-
<i>Enteromius eutaenia</i>	X	-	-
<i>Enteromius paludinosus</i>	X	-	-
<i>Enteromius radiatus</i>	X	1	-
<i>Enteromius toppini</i>	X	-	-
<i>Enteromius trimaculatus</i>	X	1	8
<i>Enteromius unitaeniatus</i>	X	-	-
<i>Enteromius viviparus</i>	X	-	-
<i>Labeo congoro</i>	X	-	-
<i>Labeo cylindricus</i>	X	4	-
<i>Labeo molybdinus</i>	X	2	1
<i>Labeo rosae</i>	X	-	-
<i>Labeo ruddi</i>	X	-	-
<i>Labeobarbus marequensis</i>	X	21	32
<i>Mesobola brevianalis</i>	X	-	-
<i>Opsaridium peringueyi</i>	X	-	-
Characidae (Characins)			
<i>Brycinus imberi</i>	X	-	-
<i>Hydrocynus vittatus</i>	X	4	1
<i>Micralestes acutidens</i>	X	3	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	X	-	-
Schilbeidae (Butter catfishes)			
<i>Schilbe intermedius</i>	X	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	X	1	6
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis paratus</i>	X	4	4
<i>Chiloglanis pretoriae</i>	X	-	-
<i>Chiloglanis swierstrae</i>	X	3	2
<i>Synodontis zambezensis</i>	X	-	-
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	X	-	26
<i>Oreochromis mossambicus</i>	X	2	59
<i>Pseudocrenilabrus philander</i>	X	9	4
<i>Tilapia sparrmanii</i>	X	-	-

X24F-00953	Expected Species	X2CROC-MAR02	
		2012	08/2017
Gobiidae (Gobies)			
<i>Glossogobius giuris</i>	x	-	-
Number of species expected	36		
Number of species recorded		12	11
Number of individuals		55	143
Electro-fishing time (minutes)		Not Recorded	43
Catch/Unit Effort (CPUE)			3.30

shallow and fast shallow moderately present. The rocky substrate in the fast shallow habitat was covered with algae and the slow habitat was silted up with very fine silt. Cover for fish was very sparse with no undercut banks and root wads.

The fish assemblage collected in this reach consisted of eleven of an expected 36 indigenous fish species (Table 31). The abundant species was the limnophilic *Oreochromis mossambicus* and *Coptodon rendalli*. Abundant rheophilic species include *Labeobarbus marequensis*. The absence of the flow dependant *Chiloglanis pretoriae* and the low abundance of *Chiloglanis paratus* and *Chiloglanis swierstrai* is of concern, indicating that the instream habitat for these species has been severely altered as a result of excessive algae growth, sedimentation and disrupted flow regimes. Of the nine expected Barbus species only one *Enteromius trimaculatus* was collected at relative low abundance therefore indicating a loss of the Barbus assemblage. Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation, loss of instream habitat due to sedimentation and excessive algae growth. The catch per unit effort (CPUE) was recorded as 3.30 (143 individuals: 43 minutes) indicating a relative abundance of fish.

A Fish Ecstatus rating of 76.9% was calculated for this monitoring point based on all available information, placing it in an ecological Category C (moderately impaired with low diversity and abundance of species) comparing favourably to the 2012 results Category C (73.2%).

Invertebrates

Eight SASS sampling events are on record for the X2CROC-MAROE and X2CROC-MAR02 site on the Crocodile River. These represent four winter and four spring sampling events. A total of 47 SASS taxa have been recorded during these eight sampling events, of which 44 taxa in total were recorded during winter surveys and 38 in spring surveys. Sensitively rated SASS taxa frequently (>87%) recorded during winter samples included Atyidae, and Leptophlebiidae. Spring families frequently recorded included Elmidae, and Leptophlebiidae. Extremely high quantities of filamentous algal growth were recorded covering substrates in flowing and stagnant waters during the 2017 sampling event.

Table 32: Comparison of the 2012 and 2017 SASS5 results for SQ reach X24F-00953.

X24F-00953	X2CROC -MAROE	2012	2017	Change
	Total SASS Score	159	132	
	No. of SASS Families	26	28	
	Average Score Per Taxon	6.1	4.7	
	MIRAI Value	Category C 75.8%	Category C 66.0%	↓
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 75.8%	Category C 66.0%		

There was limited change in stream conditions (based on SASS) in 2017 (Table 32) between the upstream Malelane site (X2CROC-MALEL) and the Maroela site (X2CROC-MAROE), both rated as moderately impaired (C).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 72.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 81.04% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Presence of exotic snails
- Bank scouring
- High sand deposition
- Excessive algae growth
- Reduced water quality

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (71.7%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET





Discussion:

This SQ reach is not an EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail during target setting. The Integrated Ecostatus of a Category C indicate that a more detailed assessment is required.

Through proper integrated water management the Ecological Category can improve to a B Category:

- Through proper management of sediment deposition in upper catchment land use practices
 - Improving water quality from Waste Water Treatment Plants
-

RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2CROC-MARO2		X24F	X24F-00953
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	Geomorphological Zone
Latitude	Longitude	209	Lower Foothills
S -25.38159	E 31.74561		
AQUATIC ECOREGION		Level I	Level II
3. Lowveld			3.07
			
<p>Figure A-29. Upstream view of the Maroela site, X2CROC-MARO2, on the Crocodile River (July 2017, G Diedericks).</p>		<p>Figure A-30. Downstream view of the Maroela site, X2CROC-MARO2, on the Crocodile River (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X24H-00880

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X24H-00880	X2CROC-MYAMB	Crocodile	S-25.31625 E 31.74811	196	28.6	D	C 74.8%	C 65.4%	C 68.53%	C 70%	C 68.87%	C 70%	2012
							C 76%	C 72.3%	C 74.2%	C 70%	C 73.3%		2017

General description

Reach X24H-00880: Mbyamiti - Vurhami

This PESEIS reach of the Crocodile River includes the river from the Mbyamiti confluence (200 m a.s.l.) to the Vurhami confluence (155 m a.s.l.), and the reach length is listed as 29 km. As the Crocodile River forms the southern boundary of the KNP this reach falls entirely within the conservation area. Major tributaries contributing from the KNP include the Bume, Soswanini and Mangilana, and the Kumoyana from the south (agricultural lands).

The instream habitat in this section of the river is dominated with sand and gravel. Only small sections of cobbles, boulders and bedrock are available. Reeds and grass dominate the marginal vegetation. The southern banks of the Crocodile River within this reach is dominated by irrigated agriculture (mostly sugarcane). A weir is located approximately 300 m downstream from a bridge over the Crocodile River, causing pushback and deposition.

The entire reach falls within the Lowveld aquatic ecoregion, and the Granite Lowveld vegetation type comprising of thickets and dense bush (23.6%), woodlands and open bush (53.4%) and grasslands (3%). The main land-uses include conservation, sugar-cane (cultivated cane fields 7.5%), and citrus (cultivated orchards 6%) (GEOTERRAIMAGE, 2015). Large portions of the agricultural crops are established within the riparian buffer. The Mbyamiti site (X2CROC-MYAMB) was the only site sampled within this reach.

Instream Habitat Integrity

The Instream IHI for the SQ reach X24H-00880 was calculated at 78.08% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

Only one site (X2CROC-MYAMB) was surveyed in this reach. The habitat sampled is typical of the Lowveld reaches with long stretches of runs over substrate consisting primarily of sand with very few riffles, some rocks, cobbles and pebbles. Slow deep habitat was sparsely available with deep undercut banks and huge root wads. Slow shallow habitat was less than 15 cm deep, but abundantly present. The fast shallow habitat were recorded very shallow with very little cover for fish in the form of rocks, cobble and pebbles. Furthermore, most of the fish habitat was covered with a layer of filamentous algae further reducing available fish habitat. Aquatic macrophytes was sparse in the shallow habitat types providing some cover for fish. Excessive sedimentation was, however, recorded further reducing interstitial spaces between rocks and pebbles in the available fish habitat.

Nine indigenous fish species of an expected 36 species were collected at this site (Table 33). The three limnophilic species *Oreochromis mossambicus*, *Coptodon rendalli* and *Pseudocrenilabrus philander* was recorded in relative abundance forming the majority of the fish assemblage. For the rheophilic fish assemblage only *Labeobarbus marequensis*, *Chiloglanis paratus* and *Chiloglanis swierstrai* were collected. In total 14 *Chiloglanis swierstrai* were recorded which can be related to their preference for fast shallow sandy runs. Only two of the expected nine Barb species, *Enteromius toppini* and *Enteromius viviparus* were recorded. Of concern is the absence of the five Labeo species within this reach that can be related to the absence of fast deep instream habitats.

Cherax quadricarinatus (Freshwater crayfish) the NEMBA alien and invasive species was recorded at this site. The presence of these alien species is of great concern because they are omnivorous and ferocious feeders and may outcompete indigenous crustaceans and other aquatic invertebrates. It is known that they do have an effect on the breeding of fish (De Moor, 2002). They may also spread previously unknown parasites (Du Preez & Smit, 2013). According to the NEMBA Alien and Invasive species classification *C. quadricarinatus* is categorized as a category 1b species and a management plan to control this species is needed.

Few of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation, loss of instream habitat due to sedimentation and excessive algae growth. The species diversity within this reach was low (9 species recorded) with a relative low abundance with a CPUE of 2.10 (101 individuals; 48 minutes).

Table 33: Fish species expected based on the PESEIS Reach Code (X24H-00880) X2CROC-MYAMB; is listed, and the numbers of fish species present during the different surveys are indicated.

X24H-00880	Expected Species	X2CROC-MYAMB	
		2012	08/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	X	-	-
<i>Petrocephalus wesselsi</i>	X	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	X	-	-
<i>Anguilla mossambica</i>	X	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius annectens</i>	X	-	-
<i>Enteromius afrohamiltoni</i>	X	-	-
<i>Enteromius eutaenia</i>	X	-	-
<i>Enteromius paludinosus</i>	X	-	-
<i>Enteromius radiatus</i>	X	-	-
<i>Enteromius toppini</i>	X	-	-
<i>Enteromius trimaculatus</i>	X	-	2
<i>Enteromius unitaeniatus</i>	X	-	-
<i>Enteromius viviparus</i>	X	68	7
<i>Labeo congoro</i>	X	-	-
<i>Labeo cylindricus</i>	X	-	-
<i>Labeo molybdinus</i>	X	-	-
<i>Labeo rosae</i>	X	-	-
<i>Labeo ruddi</i>	X	-	-
<i>Labeobarbus marequensis</i>	X	28	16
<i>Mesobola brevianalis</i>	X	-	-
<i>Opsaridium peringueyi</i>	X	-	-
Characidae (Characins)			
<i>Brycinus imberi</i>	X	-	-
<i>Hydrocynus vittatus</i>	X	-	-
<i>Micralestes acutidens</i>	X	11	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	X	-	-
Schilbeidae (Butter catfishes)			
<i>Schilbe intermedius</i>	X	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	X	-	3
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis paratus</i>	X	4	3
<i>Chiloglanis pretoriae</i>	X	-	-
<i>Chiloglanis swierstrae</i>	X	-	14
<i>Synodontis zambezensis</i>	X	-	-
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	X	-	13
<i>Oreochromis mossambicus</i>	X	18	38
<i>Pseudocrenilabrus philander</i>	X	5	5
<i>Tilapia sparmanii</i>	X	-	-
Gobiidae (Gobies)			
<i>Glossogobius giuris</i>	X	1	-
Number of species expected	36		
Number of species recorded		7	9
Number of individuals		135	101
Electro-fishing time (minutes)		Not recorded	48
Catch/Unit Effort (CPUE)			2.10

A Fish Ecostatus rating of 76.0% was calculated for this monitoring point based on all available information, placing it in an ecological Category C (moderately impaired with low diversity and abundance of species). These results correlate and are fairly similar to 2012 results of low species diversity and abundance.

Invertebrates

Five SASS sampling events are on record for the X2CROC-MYAMB site on the Crocodile River. These represent one autumn, three winter, and one spring sampling event. A total of 37 SASS taxa have been recorded during these five sampling events, of which 18 were recorded for one autumn survey, 34 taxa in total were recorded during winter surveys and 19 during one spring survey. Sensitively rated SASS taxa frequently (>87%) recorded during all sampling events included only Leptophlebiidae. Extremely high quantities of filamentous algal growth attracted high numbers of Egyptian Geese (*Alopochen aegyptiaca*), when the site was visited in 2017.

Table 34: 2017 SASS5 results for SQ reach X24H-00880.

X24H-00880	X2CROC -MYAMB	2012	2017	Change
	Total SASS Score	Not sampled	160	
	No. of SASS Families		29	
	Average Score Per Taxon		5.5	
	MIRAI Value		Category C 72.3%	Not applicable
SQ REACH SUMMARY Invertebrate Ecostatus		Category C 72.3%		

There was limited change in stream conditions (based on SASS – Table 34) in 2017 between the upstream Maroela site (X2CROC-MARO2) and the Mbyamiti site (X2CROC-MYAMB), both rated as moderately impaired (C).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 70% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 81.04% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (70%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Presence of invasive crayfish
- Presence of exotic snails
- Bank scouring
- Excessive algae growth

- High sand deposition
- Flow regulation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (73.3%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred

TARGET MET ?

Discussion:

This SQ reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail during target setting. The Integrated Ecostatus of a Category C indicate that a more detailed assessment is required.

Through proper integrated water management the Ecological Category can improve to a B Category:

- Through proper management of sediment deposition in upper catchment land use practices
- Improving water quality
- Management of river regulation and flow regime

Urgent research is required into the impact of the alien and invasive *Cherax quadricarinatus* and a management plan for the control of this species needs to be developed and implemented by the responsible authority.



RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2CROC-MYAMB		X24H	X24H-00880
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	Geomorphological Zone
Latitude	Longitude	196	Lower Foothills
S -25.31625	E 31.74811		
AQUATIC Ecoregion		Level I	Level II
3. Lowveld		Level I	3.07
			

Figure A-31. Upstream view of the Mbyamiti site, X2CROC-MYAMB, on the Crocodile River (July 2017, G Diedericks).

Figure A-32. Downstream view of the Mbyamiti site, X2CROC-MYAMB, on the Crocodile River (July 2017, G Diedericks).

SQ REACH NUMBER X24H-00934 (EWR 6)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X24H-00934	X2CROC-NKONG* EWR 6	Crocodile	S-25.39113 E 31.97425	129	21.0	D	C 72.9%	C 62.2%	C 65.77%	C 70%	C 66.74%	C 73.11%	2012
							CD 61.0%	C 70.3%	C 65.65%	C 82.5%	C 67.83%		2017

General description

Reach X24H-00934: Vurhami - Komati

The upstream boundary of this PESEIS reach on the Crocodile River is the Vurhami confluence (155 m a.s.l.) and ends where the Crocodile merge with the Komati River (118 m a.s.l.). The main seasonal tributaries contributing to this reach originates in the KNP. These include the Makambue, Shidzumbalala, Dzuweni, Wescott, Mpanamana and Nwangela streams.

The instream habitat in this section of the river is dominated with sand and gravel. However, there are substantial areas that are bedrock dominated. Reeds and grass dominate the marginal vegetation. The southern banks are dominated with irrigated agriculture (mostly sugarcane). The main land use practices include 3.1% cultivated orchards and 14.7 % cultivated commercial cane fields (GEOTERRAIMAGE, 2015). The town of Komatipoort is located at the lower section of the reach close to the confluence with the Komati River.

The reach falls within two aquatic ecoregions, with the upstream portion classified as Lowveld and the lower part of the reach against the Lebombo Mountains categorised as the Lebombo Upland ecoregion. Vegetation type is also represented by two types, the Lowveld in the upper portions and the Tshokwane-Hlane Basalt Lowveld bordering the Lebombo Mountains. Vegetation comprise of 30% thickets and dense bush, 46.2% woodlands and open bush and 3.4% grasslands (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The Instream IHI for the SQ reach X24H-00934 was calculated at 78.08% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

This EWR site is downstream of the Crocodile Bridge within the Kruger National Park. It is the last biomonitoring site before the confluence of the Crocodile River with the Komati River where after it becomes the Inkomati River, entering Mozambique downstream of the town of Komatipoort. The habitat surveyed has a relatively high habitat diversity comprising of pools, riffles and runs. This habitat is typical of the Lowveld reaches with the substrate consisting primarily of sand and bedrock with isolated boulders. The fish velocity depth classes recorded were fast deep (sparse), fast shallow (moderate), slow deep (sparse) and slow shallow (abundant). The fish cover present was some overhanging vegetation and aquatic macrophytes only present in the shallow habitat. Undercut banks and root wads were moderately abundant in the fast shallow habitat. Substrate as cover was very sparse with mostly sandy runs. All Lowveld fish species is expected to occur in this reach and consist of 36 indigenous fish species.

Table 35: Fish species expected based on the PESEIS Reach Code (X24H-00934) X2CROC-NKONG; is listed, and the numbers of fish species present during the different surveys are indicated.

X24H-00934	Expected Species	X2CROC-NKONG	
		2012	08/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	X	-	-
<i>Petrocephalus wesselsi</i>	X	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla marmorata</i>	X	-	-
<i>Anguilla mossambica</i>	X	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius annectens</i>	X	-	-
<i>Enteromius afrohamiltoni</i>	X	-	-
<i>Enteromius eutaenia</i>	X	-	-
<i>Enteromius paludinosus</i>	X	-	-
<i>Enteromius radiatus</i>	X	-	-
<i>Enteromius toppini</i>	X	-	-
<i>Enteromius trimaculatus</i>	X	1	8
<i>Enteromius unitaeniatus</i>	X	-	-
<i>Enteromius viviparus</i>	X	76	-
<i>Labeo congoro</i>	X	-	-
<i>Labeo cylindricus</i>	X	8	-
<i>Labeo molybdinus</i>	X	-	2
<i>Labeo rosae</i>	X	-	-
<i>Labeo ruddi</i>	X	-	-
<i>Labeobarbus marequensis</i>	X	2	12
<i>Mesobola brevianalis</i>	X	-	-
<i>Opsaridium peringueyi</i>	X	-	-
Characidae (Characins)			
<i>Brycinus imberi</i>	X	-	-
<i>Hydrocynus vittatus</i>	X	-	5
<i>Micralestes acutidens</i>	X	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	X	-	-
Schilbeidae (Butter catfishes)			

X24H-00934	Expected Species	X2CROC-NKONG	
		2012	08/2017
<i>Schilbe intermedius</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	2
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis paratus</i>	x	15	-
<i>Chiloglanis pretoriae</i>	x	-	-
<i>Chiloglanis swierstrae</i>	x	7	31
<i>Synodontis zambezensis</i>	x	-	-
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	13
<i>Oreochromis mossambicus</i>	x	-	58
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparmanii</i>	x	-	-
Gobiidae (Gobies)			
<i>Glossogobius giuris</i>	x	-	-
Number of species expected	36		
Number of species recorded		6	8
Number of individuals		109	131
Electro-fishing time (minutes)		Not Recorded	40
Catch/Unit Effort (CPUE)			3.27

The fish assemblage (Table 35) at this reach consisted of only eight species of an expected 36 indigenous fish species. In addition to this low species diversity, the abundance is also relatively low. The status of the fish assemblage for this site is of concern as only one of the nine *Barbus* species, *Enteromius trimaculatus* (8 individuals), were collected. The flow sensitive species assemblage comprised of only three species namely, *Labeobarbus marequensis*, *Labeo molybdinus* and *Chiloglanis swierstrai*. The low species diversity and low abundance of these rheophilics indicate severe flow regulation and disruption, as well as reduced available fish habitat. No *Chiloglanis paratus* were recorded which should occur in high abundance at this site. The limnophilic Cichlidae species were represented in relative abundance by two species, *Coptodon rendalli* and *Oreochromis mossambicus*. Only eight of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of all species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has been altered as a result of disrupted flow regime, loss of instream habitat due to sedimentation and excessive algae growth. The CPUE for this site was calculated at 3.27 (131 individuals; 40 minutes) primarily dominated by the limnophilic Cichlidae assemblage.

A Fish Ecstatus rating of 61% was calculated for this monitoring point based on all available information, placing it in an ecological Category CD (close to largely modified with low diversity of species). This site cannot be compared to the 2012 data as different biomonitoring sites on this reach were monitored.

Invertebrates

Eleven SASS sampling events are on record for the X2CROC-NKONG site on the Crocodile River. These represent one autumn, five winter, and five spring sampling events. A total of 37 SASS taxa have been recorded during these 11 sampling events, of which 20 were recorded for one autumn survey, 43 taxa in total were recorded during winter surveys and 36 during one spring survey. Sensitive rated SASS taxa frequently (>87%) recorded during all sampling events included only Atyidae. Sand dominated, riffles and mostly dominated with bedrock and high quantities of filamentous algal growth.

Table 36: Comparison of the 2012 and 2017 SASS5 results for SQ reach X24H-00934.

X24H-00934	X2CROC -NKONG	2012	2017	Change
	Total SASS Score	78	136	
	No. of SASS Families	19	27	
	Average Score Per Taxon	4.1	5.0	
	MIRAI Value	Category C 62.2%	Category C 70.3%	↗
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 62.2%	Category C 70.3%		

There was limited change in stream conditions (based on SASS) in 2017 (Table 36) between the upstream Mbyamiti site (X2CROC-MYAMB) and the Nkongoma site (X2CROC-NKONG), both rated as moderately impaired (C).

Riparian Vegetation

The EWR 6 site X2CROC-NKONG was assessed in this SQ reach.

Marginal Zone: Both banks in this zone were dominated by open areas consisting mostly of sandbanks and bedrock followed by reed beds. This include species like *Berula erecta* and *Phragmites mauritianus*. This zone has low woody and non-woody cover as well as low abundance. The species composition resembles the reference state and very limited changes are expected. The water quantity is normal for this time of year and the quality is good. Some exotics were noted consisting mainly of *Eichhornia crassipes* that was present in some areas that may impact on the species composition in the longer term.

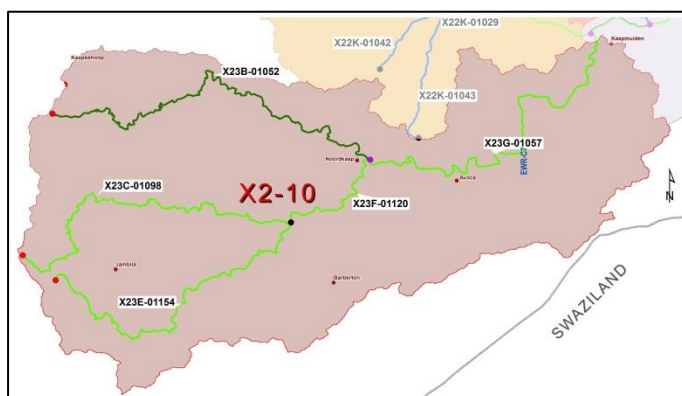
Non Marginal Zone: The left bank inside the KNP is dominated by open rocky areas and grass areas followed by shrub and tree species. This zone has low woody cover and abundance and a moderate non-woody cover and abundance. The species composition resembles the reference state and very limited changes are expected. The right bank outside of the KNP is overgrazed and dominated by open areas with some grass, shrub and tree species. This zone has low woody cover and abundance and a low non-woody cover and abundance. The species composition however resembles the reference state and very limited changes are expected in the short term. The dominant non-woody species include *Imperata cylindrica*, *Setaria megaphylla*, *Thunbergia alata* and *Cynodon*

dactylon. Various shrubs and trees are present including, *Diosperos mespeliformis*, *Acacia sieberiana*, *Breonadia salicina*, *Ficus sycomorus*, *Trichilia emetic*, *Syzygium cordatum* and *Bauhenia galpinii*. Some exotics were noted consisting mainly of *Lantana camara*,

The Level III VEGRAI Assessment range for this EWR site assessed is 81.9% and is consistent with a Category BC – close to largely natural with few modifications most of the time. The Riparian IHI was calculated at 81.04% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Water Quality

IUA X2-11 - CROCODILE: KAAP TO KOMATI



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
MRU Croc D	X24C-01033*	Crocodile	C/D	C/D	3WQ 3b
MRU Croc E	X24H-00880#	Crocodile			3WQ 3
	X24H-00934 EWR C6	Crocodile	C	C	
	X24D-00994 EWR C5	Crocodile	C	C	
	X24E-00982*#	Crocodile			
	X24F-00953*#	Crocodile			

* This SQ forms part of EWR C6, which is situated in IUA X2-10, MRU Croc E. Please refer to Section 23.3 for further details.

Where SQ does not have a EC the EC is different from the EWR site. But because the EWR site has a higher priority rating, the EWR site is the driver for the other sites in this RU.

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data must be less than 0.075 mg/L PO ₄ -P (aquatic ecosystems: driver, EWR C6).
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 70 mS/m (aquatic ecosystems: driver).
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity.
Ensure that temperatures stay within Acceptable limits.	A moderate change to instream temperatures should occur infrequently, i.e. vary by no more than 2°C. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver).
Ensure that toxics are within the CEV limits.	95 th percentile of the data must be within the CEV for toxics or the B category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b) (aquatic ecosystems: driver, EWR C6).

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H016Q01 for EWR C6.

Summarized results for EWR 6: Water quality at this site has met the RQOs, other than a slight elevation of salts over the RQO and the TEC for water quality has been met. Note that few toxics data were available for evaluation.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data must be less than 0.075 mg/L PO ₄ -P (aquatic ecosystems: driver, EWR C6).	✓
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 70 mS/m (aquatic ecosystems: driver).	Levels have increased to 80 mS/m
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity.	
Ensure that temperatures stay within Acceptable limits.	A moderate change to instream temperatures should occur infrequently, i.e. vary by no more than 2°C. Highly temperature sensitive species will occur in lower abundances (aquatic ecosystems: driver).	
Ensure that toxics are within the CEV limits.	95 th percentile of the data must be within the CEV for toxics or the B category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b) (aquatic ecosystems: driver, EWR C6).	✓

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts for turbidity and temperature. Data are not available to evaluate these impacts other than on a qualitative basis.
2. Electrical conductivity levels have increased beyond the RQO (based on WMS data from 2000 to 2017) requiring an investigation into the source of elevated salts.
3. Limited toxics data were available.

Impacts for SQR

- Presence of exotic snails
- High sand deposition
- Excessive algae growth
- Flow regulation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (67.83%)	Category C (73.11%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET NOT MET



Possible reasons:

- Low Fish Ecostatus Category CD
- High sedimentation loads resulting in loss of available habitat to fish
- Reduced water quality
- Implementing and adjusting Ecological Flow Requirements

Dam regulation, over-abstraction and upstream land use (towns, rural settlements, industries, and agriculture) are the major impacts on this reach. If these factors are corrected with adequate catchment management the Ecostatus of this reach can improve to a Category B.



RIVER		TRIBUTARY OF	
Crocodile		Inkomati	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2CROC-NKONG		X24H	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Geomorphological Zone	
Latitude	Longitude	Lower Foothills	
S -25.39113	E 31.97425	Level II	
AQUATIC ECOREGION		Level II	
12. Lebombo Uplands		12.01	
			

Figure A-33. Upstream view of the Nkongoma site, X2CROC-NKONG, on the Crocodile River (July 2017, G Diedericks).

Figure A-34 Downstream view of the Nkongoma site, X2CROC-NKONG, on the Crocodile River (July 2017, G Diedericks).

DISCUSSION CROCODILE RIVER MAINSTEM

Fish

In general fish diversity will increase longitudinally with an increase in stream size (Schlosser, 1987; Beecher *et al.*, 1988). This is also the case with the Crocodile River mainstem where only four indigenous fish species are expected to occur in the headwaters, of which two were collected during the survey. Within these upper reaches the trout industry and the release of this NEMBA predatory alien and invasive species impact on the indigenous fish species through predation, disease and habitat competition. Fish species numbers increase to a maximum of 36 expected indigenous fish species in the lower Lowveld reaches of the river. A total of 45 indigenous reference fish species is expected to occur in the Crocodile River catchment of which 25 species was recorded during this survey. This is a decline of four species compared to the 2012 survey. It must, however, be mentioned that during the 2012 survey 24 mainstem biomonitoring sites were sampled compared to the 17 mainstem sites during the present survey.

Fish species collected in relative high abundance were the limnophylic small barb species, *Enteromius anoplus*, which was recorded in the headwaters, the rheophilic, *Chiloglanis pretoriae*, *Enteromius crocodilensis* and *Labeobarbus marequensis* were collected in relative abundance in the lower reaches. The IUCN endangered red data species *Chiloglanis bifurcus* was recorded during the recent survey at one site during the 2012 survey. For the recent survey it was recorded at five sites with a relative density in relation to other associated fish species of 1.08% - 2.63% and a CPUE of 0.02 – 0.08 individuals caught per minute. These low values compares well with what was found by Kleynhans (1984), (2.8% with CPUE of 0.18), indicating that this species is naturally found at low population densities. Twelve small barb species are expected to occur in the Crocodile River of which only seven were recorded during the survey (*Enteromius anoplus*, *E. crocodilensis*, *E. eutaenia*, *E. neefi*, *E. trimaculatus*, *E. unitaeniatus* and *E. viviparus*). The intolerant rheophilic *Opsaridium peringueyi* recorded at a single site (X2CROC-N4ROA). All four of the cichlids expected to occur were recorded during the survey with *Pseudocrenilabrus philander* the most prominent. Based on the Instream Habitat Integrity (IHI) results the surrounding land use practices result in excessive sedimentation and siltation impacting on the available instream habitat for fish.

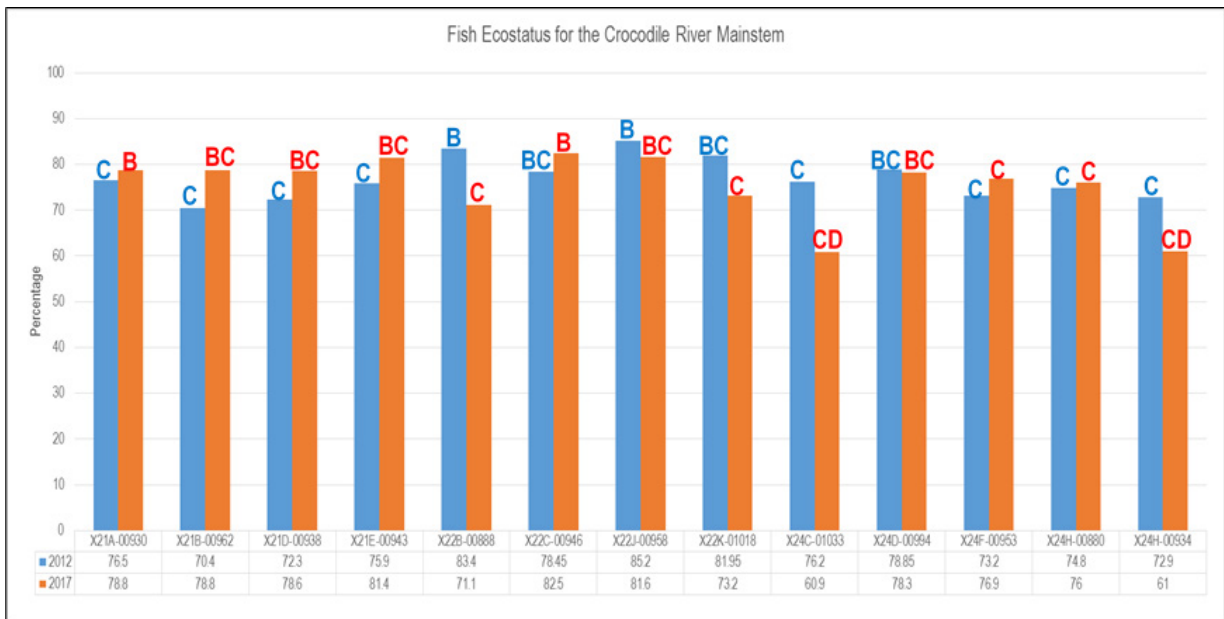


Figure 15: Summary of the Fish Ecostatus for the Crocodile River mainstem for biomonitoring in 2012 and 2017 as calculated on the RIVDINT model.

Figure 15 summarise the Fish Ecostatus categories for the 13 SQ reaches (17 biomonitoring sites) on the Crocodile River mainstem. Of concern is the decline of the Fish Ecostatus at the SQ reach X22B-00888 (X2CROC-RIVUL) where the fish Ecostatus decreased from a Category B (83.4%) to a low Category C (71.1%). This site is severely impacted by irresponsible land use management with removal of riparian vegetation and cultivation of crops in the riparian zone (see Figure 14) resulting in excessive siltation and sedimentation decreasing available instream fish habitat to sensitive habitat specialist species. The other SQ reaches of concern are X22K-1018 (X2CROC-N4ROA – EWR4); X24C-01033 (X2CROC-KAAPM) and X24H-00934 (X2CROC-NGONG – EWR 6) where the fish Ecostatus decreased significantly as a result of the combined effect of reduced water quality, flow regulation and the effect of upstream urbanisation and industrial return flows having an impact on the fish assemblage for these reaches. Figure 15 indicate that the overall Fish Ecostatus percentage for 2017 is 75.3% placing the mainstem in a category C. This indicates a moderately impaired fish assemblage remaining consistent with the 2012 results of 76.9% a Category C. The present category C (75.3%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

Invertebrates

Table 37: A summary of MIRAI results for sites sampled on the Crocodile River in 2012 and 2017, the number of available data on record for the different sampling, and a summary of results for the PESEIS Reaches, indicating change between the 2012 and 2017 results with arrows. Change are indicated with arrows, e.g. = improvement, = slight improvement, = similar conditions, = slight deterioration, and = deterioration.

SITE CODE	2012	2017	SAMPLING EVENTS					REACH CODE	YEAR			
			Au	Wi	Sp	Su	ALL		2012	2017	CHANGE	
X2CROC-VERLO	86.1	87.8		2	3							
X2CROC-VALYS	86.1	91.1		1	2			X21A-00930	86.1	89.5		
X2CROC-DONKE	86.4	87.7		1	2							
X2CROC-GOEDE	86.4	83.9		1	6	5			X21B-00962	86.4	85.8	
X2CROC-DOORN		86.3		1	1				X21D-00938		86.3	
X2CROC-RIETV	71.9	84.0		1	2							
X2CROC-POPLA	71.9	83.3		1	2	2			X21E-00943	71.9	80.9	
X2CROC-MONTR	71.9	75.3		1	6	5						
X2CROC-RIVUL	82.3	75.0		1	2				X22B-00888	82.3	75.0	
X2CROC-STRKS	88.2	73.0		5	4				X22C-00946	88.2	73.0	
X2CROC-KAMAG	67.7	65.3		1	1				X22J-00958	67.7	65.3	
X2CROC-N4ROA	76.3	72.2		5	4				X22K-01018	76.3	72.2	
X2CROC-KAAPM		71.9		1	6	4			X24C-01003		71.9	
X2CROC-MALEL	70.1	69.9		3	5				X24D-00994	70.1	69.9	
X2CROC-MARO2	75.8	66.0		4	4				X24F-00953	75.8	66.0	
X2CROC-MYAMB	65.4	72.3		1	3	1			X24H-00880	65.4	72.3	
X2CROC-NKONG	62.2	70.3		1	5	5			X24H-00934	62.2	70.3	

SASS data from the Crocodile River sites was analysed for a total of 111 sampling events carried out at the 17 sampling sites (listed in Table 37), spanning over a period of 24 years (1993 to 2017). Most of the sampling (48% and 47%) was carried out during the winter (Wi) and spring (Sp) surveys respectively, and 5% during autumn (Table 37). Winter to spring are generally considered to represent the low flow season, and summer to autumn the high flow season.

Based on available macro-invertebrate data, conditions in the Crocodile River in 2017 was categorized as follows:

- natural to largely natural (A/B) in its headwaters (Verloren Valei and Valyspruit);
- largely natural (B) above and below Kwena Dam (Donkerhoek to Doornhoek);
- slightly deteriorating to largely natural and moderately modified (BC) from Rietvlei to above Montrose Falls, and;
- deteriorates to moderately modified (C) from below the Elands River confluence to the lowest sampling point in the Kruger National Park.

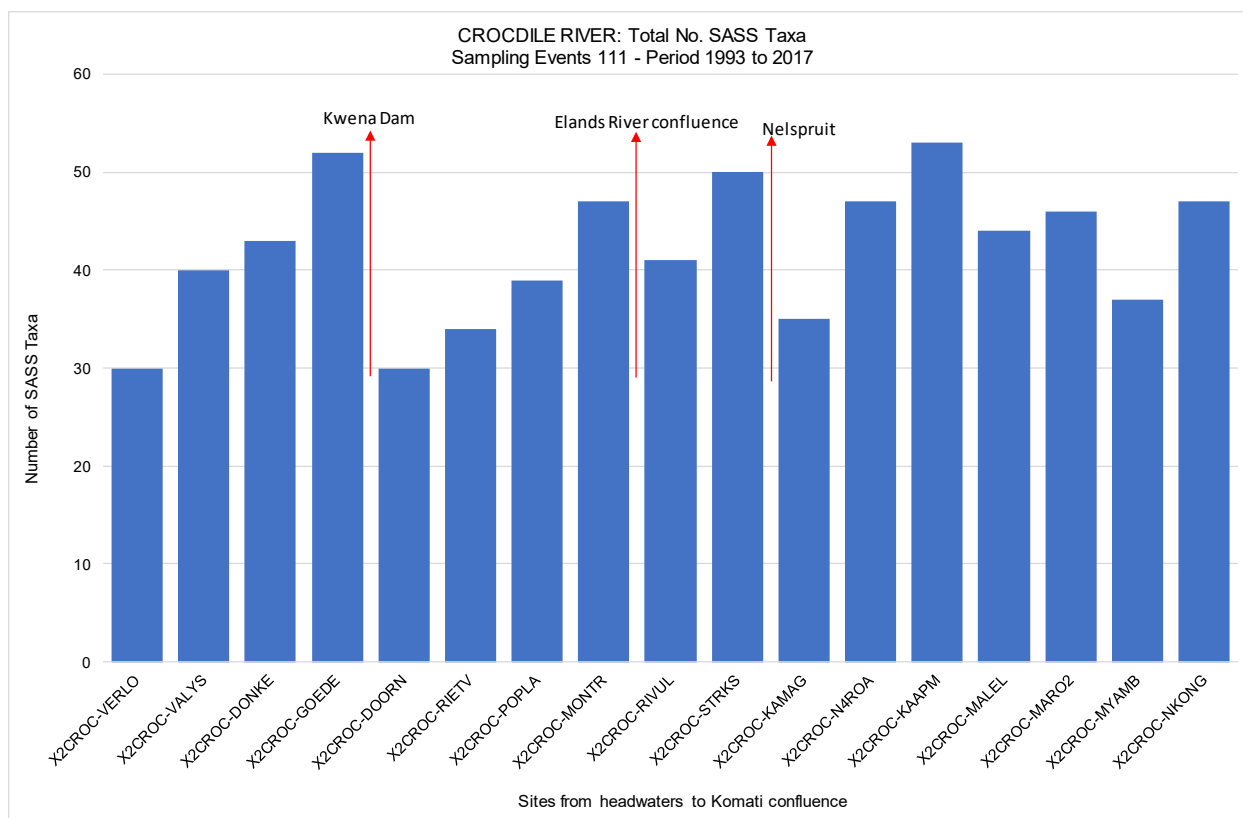


Figure 16: SASS taxa diversity recorded at each site during different surveys ranging from 1993 to 2017. Sites are listed from headwaters (left) towards the Komati confluence (right). The number of sampling events per site and seasonal distribution are listed in Table 37 above. The location of Kwena Dam, the Elands River confluence, and Nelspruit-Kanyamazane town between sampling locations are indicated as red arrows.

Taxa diversity is low in the headwaters, increasing in a downstream direction to the Goedehoop site, located upstream from Kwena Dam. The number of SASS taxa increase in a downstream direction from Kwena Dam to Montrose Falls. There is slight decrease downstream from the Elands-Crocodile confluence, and then increase in sites above Nelspruit. Below Nelspruit taxa diversity decrease, and then steadily increases up to the Kaapmuiden site (Figure 16).

The family *Athyidae* (*Cardinia nilotica* – Freshwater shrimp) first appears at the Rivulets (X2CROC-RIVUL) site, and are then frequently recorded in a downstream direction. They are regarded as filter feeders, generally increasing as their food source (suspended material) increase.

The family *Tricorythidae* (Stout crawlers), has a high frequency of occurrence (FROC) from the headwaters to the Rivulets site, after which the families' FROC steadily decrease in a downstream direction. Increases in electrical conductivity values have been recorded. Records of the sensitive SASS rated *Prosopistomatidae* (Water specs) exists for sites from Valyspruit (X2CROC-VALYS) to Kaapmuiden (X2CROC-KAAPM), with the percentage FROC decreasing in a downstream direction. Zokufa et al. (2001) found in a study on the effect of effluent from the Ngodwana Pulp and Paper Mill on *Tricorythidae* under controlled conditions, negative responses to selected concentrations of the effluent high in sulphate salts. The authors stated that “high

electrical conductivity has been found to be a major contributor to” Tricorythidae: *Tricorythus tinctus* “mortality with sulphate having a synergistic and calcium an antagonistic effect”.

The exotic *Physa acuta* (Sewage snail) starts appearing at a high FROC from the Kamagugu site (downstream from Nelspruit) downwards, indicating increased organic inputs.

Filamentous algal growth increased considerably from the Kamagugu site (X2CROC-KAMAG) in a downstream direction, with high sand deposition from Mbyamiti (X2CROC-MBYAM) towards Nkongoma (X2CROC-NKONG).

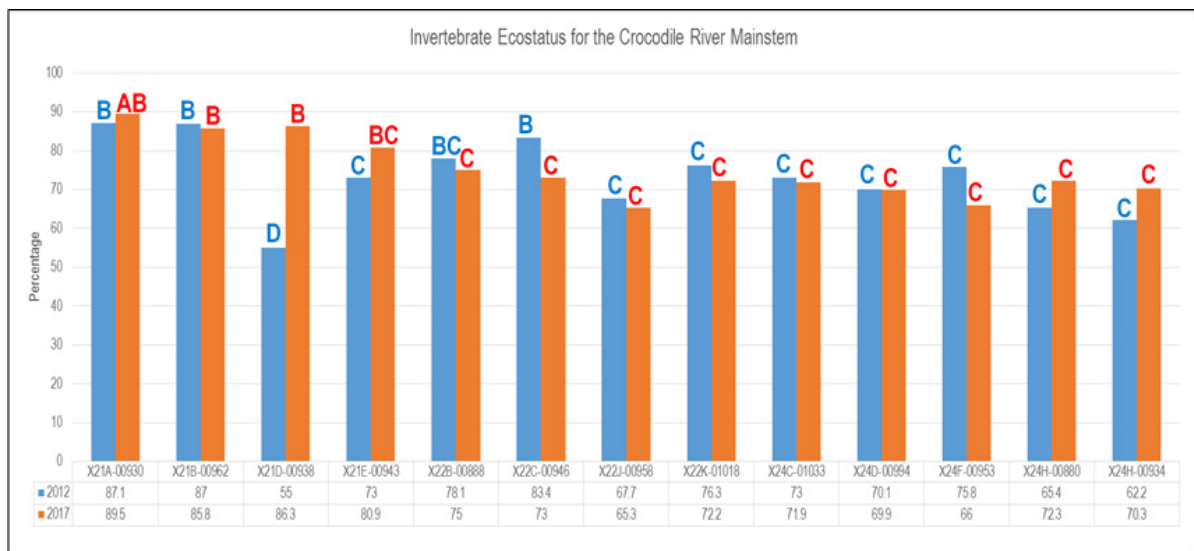


Figure 17: Graphical comparison of the Invertebrate Ecstatus of the main Crocodile River in 2012 and 2017.

When comparing the Crocodile Rivers’ Invertebrate Ecstatus between 2012 and 2017 (Figure 17), conditions improved in the upper reaches, deteriorating from PESEIS reach X21E-00943 (below Montrose Falls) in a downstream direction. Several expected sensitive taxa are absent, with decreased taxa diversity.

When comparing aquatic invertebrate results between the 2012 and 2017 survey, overall conditions deteriorated. Although the aquatic inverts indicated improved conditions at some sites, the Crocodile River downstream from Nelspruit and Elands River from Waterval Boven onwards deteriorated considerably. High algal growth further affects instream habitat conditions in the Crocodile River downstream from Nelspruit.

Water Quality

An analysis of the present state for water quality (as at March 2018, using data generally available until late 2017), and evaluation against water quality RQOs gazetted in December 2016, showed a maintenance of water quality state, with a small improvement noted for the lower stretches (i.e. EWR C4, C5 and C6).

Conditions downstream of the Elands River confluence to the Nels River confluence has shown some deterioration, probably linked to the input from the lower Elands River where water quality has deteriorated over the past few years, as well as urban impact from the greater Nelspruit urban area.

Hydrology status

The present Ecstatus study was conducted during the 2016-17 hydrological year (October-September). Whilst that year had average hydrological conditions it followed the severe El Nino induced drought of 2014-16 and it is therefore likely that traces of this drought would still be felt in both the biotic response and abiotic parameters. It's important to note therefore that an interim drought arrangement was agreed by the CROCOC for August to November 2016 for minimum flows at Tenbosch set as $0.6 \text{ m}^3 \cdot \text{s}^{-1}$. This was largely achieved although there were instances where the flows dropped considerably below this for several hours or more. The following charts depict the hydrological status of the Crocodile River during the reporting period, and commences with the most downstream gauge. It is quite clear from Figure 8 that flows were markedly different at the lowest end of the catchment comparing the study period with the previous hydrological year. Here represented as annualised flow duration curves demonstrate that during 2016-17 flows were 90% compliant with the ecological reserve, although during 2015-16 at the height of the drought there was 70% non-compliance with the ecological reserve. One must be cognisant of the fact that flows are typically compliant with EWR requirements even during dry times up to the Riverside Weir (X2H036 – the next weir upstream from Tenbosch) in order to meet the large irrigation requirements between the two weirs. Furthermore, whilst there was high non-compliance with the ecological reserve during the drought, in fact the river performed significantly better than during previous major droughts.

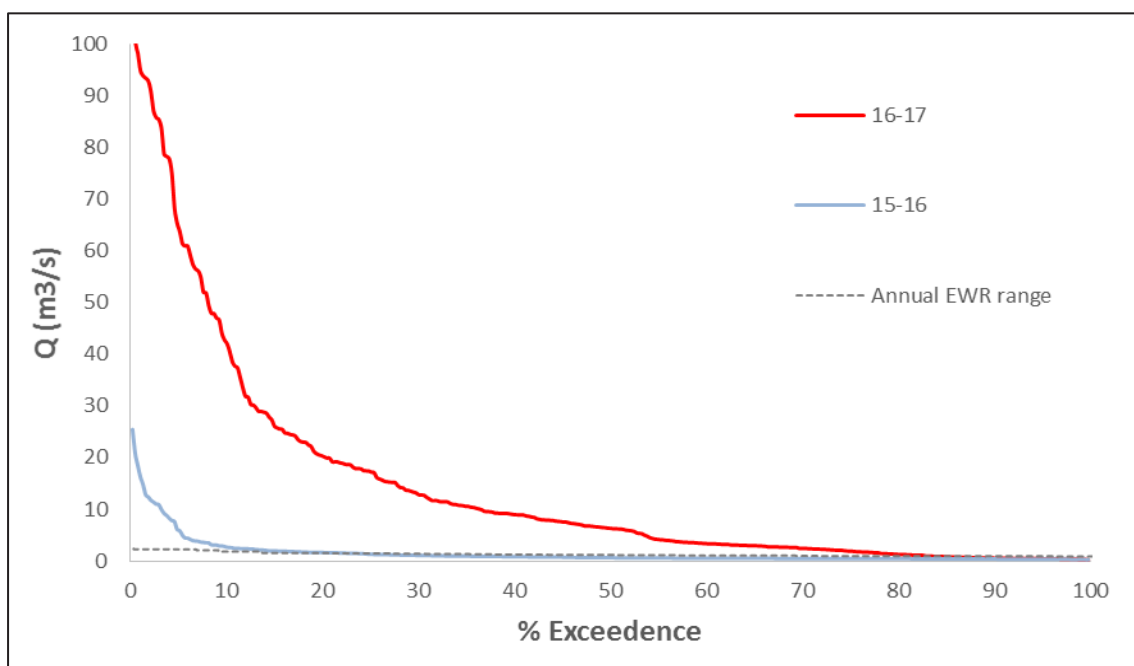


Figure 18: Flow duration curve for Compliance with the ecological reserve at EWR 6 (Tenbosch, X2H016) during the reporting and previous hydrological years

This pattern is similarly reflected throughout the catchment. Moving upstream to the Riverside gauge (Figure) one notes that the 2016-17 flows were typically in the normal to above normal range throughout, whilst flows during the drought were very low according to the hydrological record. Similarly in the main tributary, the Kaap River (Figure 20) had normal flows during the survey period and effectively ceased flowing during the drought. Flows further upstream on the main stem in the Crocodile River at Karino (Figure) during 2016-17 were typically from normal to above normal, and similarly this was observed in the upstream tributary in the Elands (Figure 22), in both cases flows during the drought were very low as compared to the hydrological record.

Meanwhile, outflows from the Kwena Dam (Figure23) were in the above normal to very high range during the drought of 2015-16, as discussed this was to supply the needs of bulk users, EWR and International flows targets downstream. Releases during 2016-17 were however below normal in order to recover storage following the drought. However outflows did begin to increase once again from June 2017 onwards, coinciding with warm late winter and early spring conditions. These outflows are therefore represent reversed seasonality in the upper reaches of the river and must be considered when interpreting the river ecostatus data for upstream sites between Kwena and Montrose.

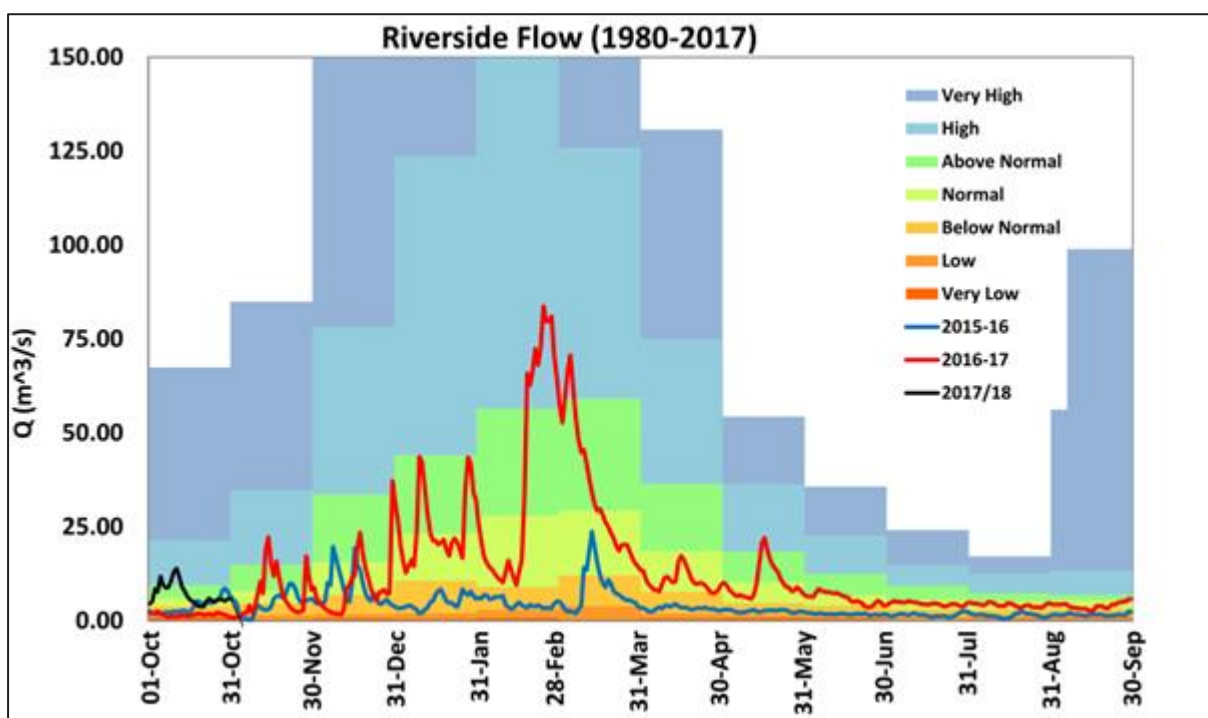


Figure 19: Observed flows at Riverside (X2H046) during the reporting period against the previous hydrological year and historical range of flows (Courtesy: Siphon Magagula, IUCMA)

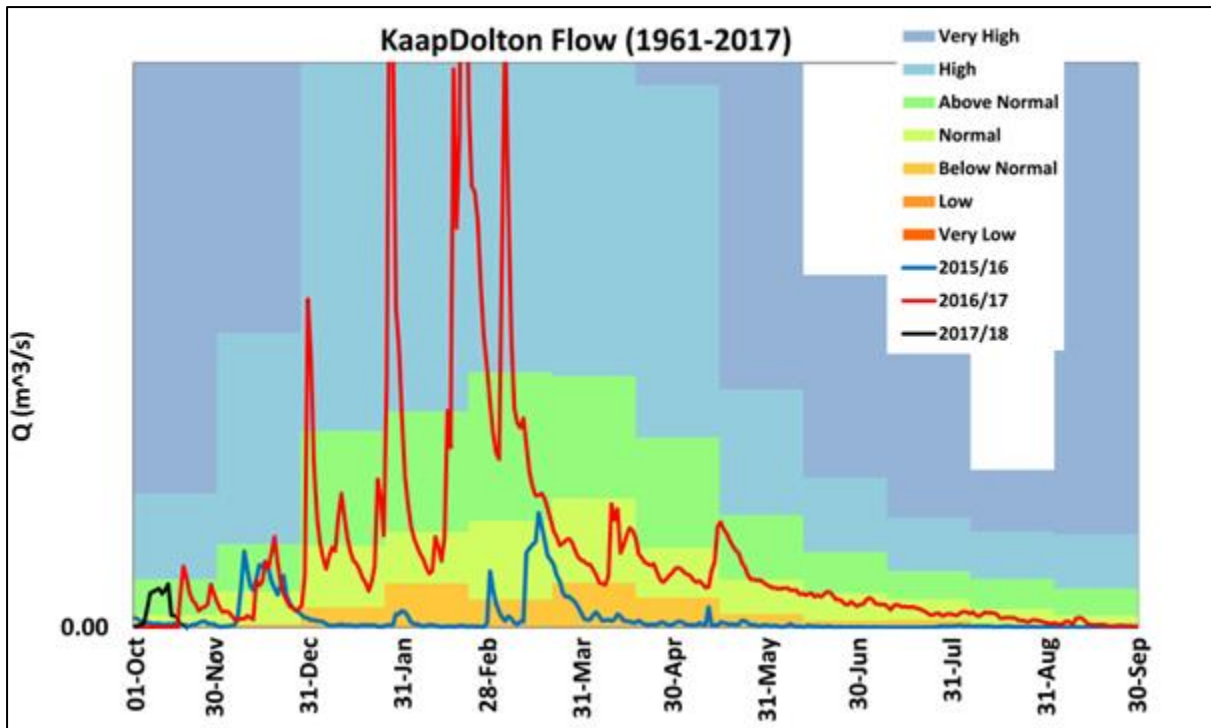


Figure 20: Observed flows at Dalton (X2H022) during the reporting period against the previous hydrological year and historical range of flows (Courtesy: Siphon Magagula, IUCMA)

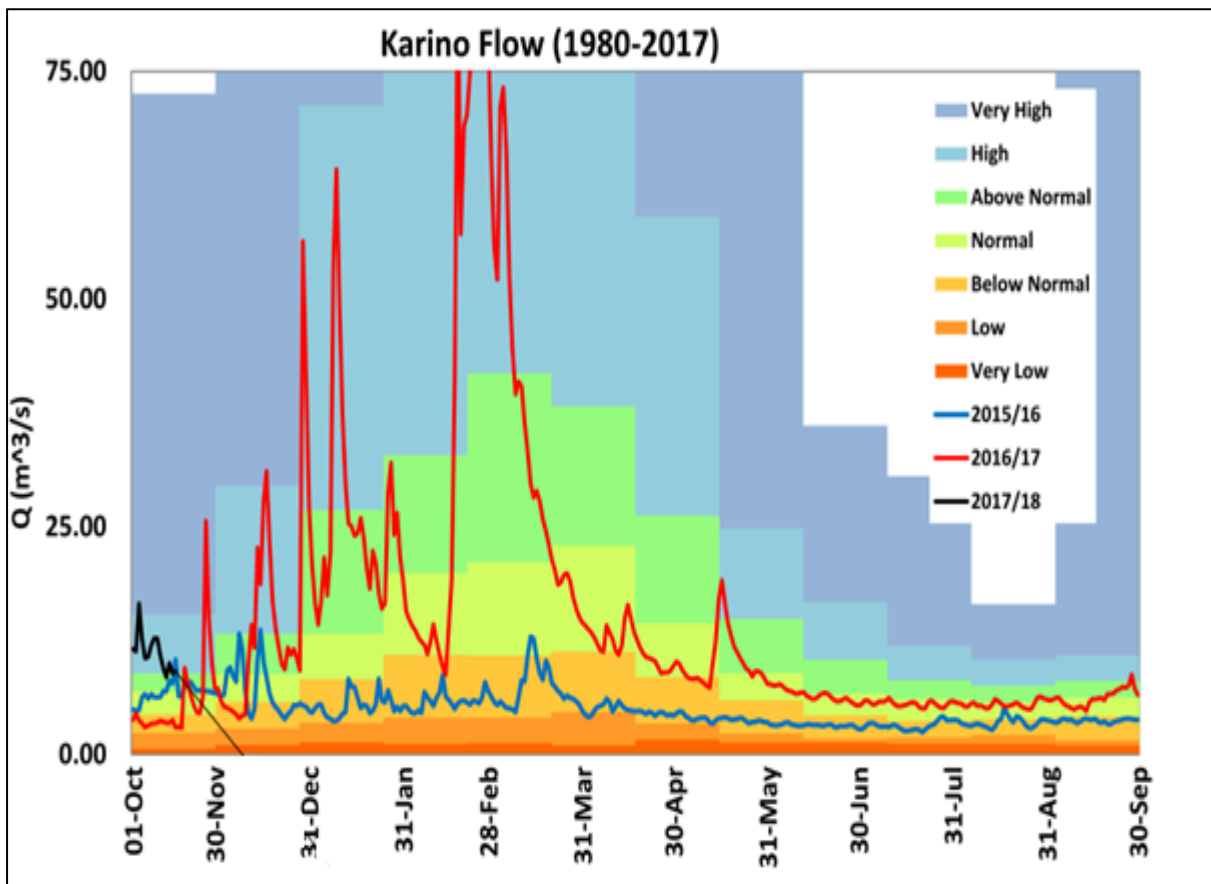


Figure 21: Observed flows at Karino (X2H006) during the reporting period against the previous hydrological year and historical range of flows (Courtesy: Siphon Magagula, IUCMA)

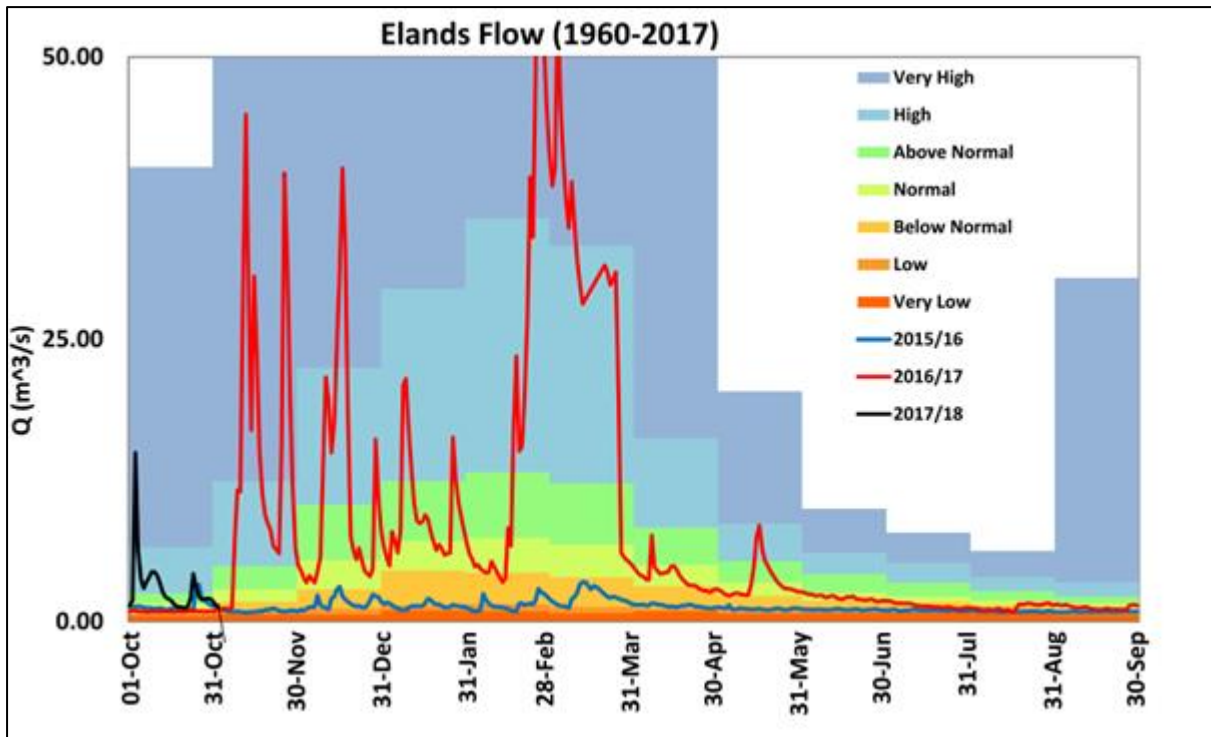


Figure 22: Observed flows at Elands Lindenau (X2H015) during the reporting period against the previous hydrological year and historical range of flows (Courtesy: Siphon Magagula, IUCMA)

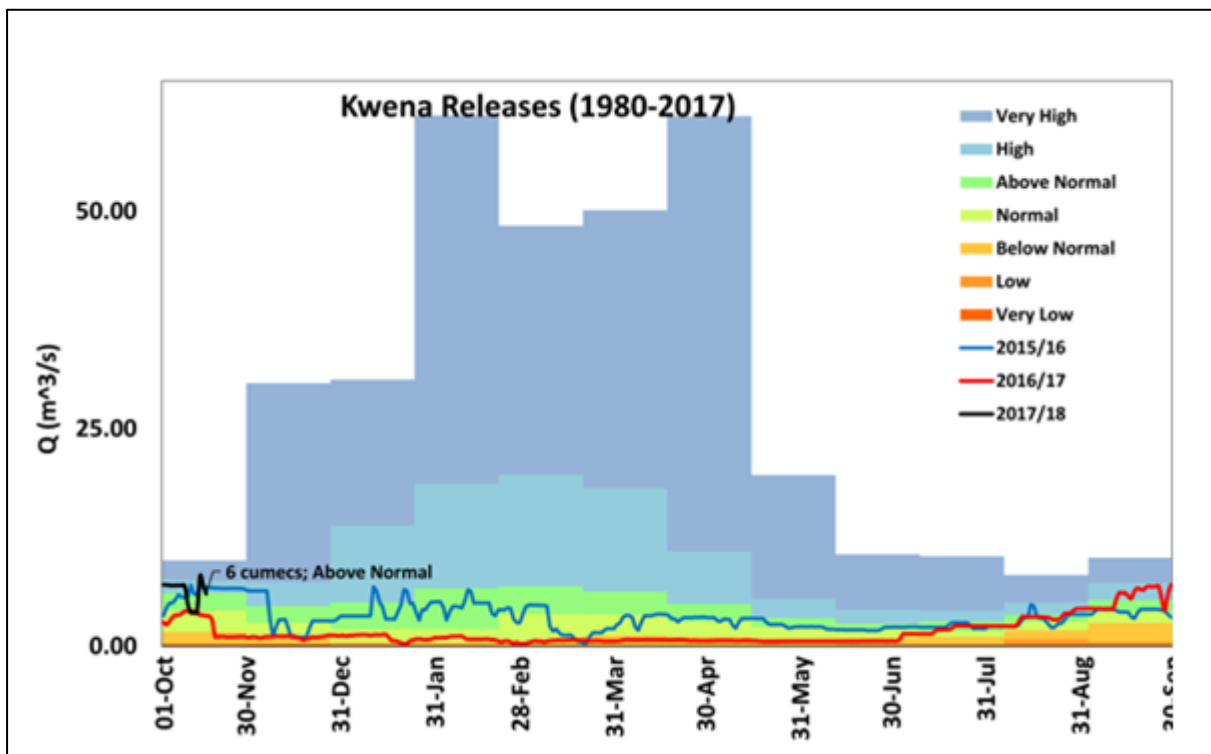


Figure 23: Releases from the Kwena Dam (X2H070) during the reporting period against the previous hydrological year and historical range of outflows (Courtesy: Siphon Magagula, IUCMA)

Instream - and Integrated Ecstatus rating and Target Ecological Category of the Crocodile River Mainstem

The Instream Ecstatus rating is derived from the Fish Ecstatus, Invertebrate Ecstatus and Instream Habitat Integrity assessment. From Figure 24 it is evident that the Instream Ecstatus fluctuates throughout the mainstem ranging from a category C (65.65%) to a category B (84.15%) with a mean of 75.28% category C. This remains consistent with the Instream Ecstatus for 2012 surveys at (74.76% Category C). The Integrated Ecstatus is derived from the Fish Ecstatus, Invertebrate Ecstatus and the Riparian Vegetation Ecstatus calculated on the RIVDINT (River Data Integration) model. The Integrated Ecstatus for the mainstem (Figure 25) also remained consistent throughout the 2012 (74.76%) and 2017 (75.28%) monitoring with a category C indicating a moderately impaired habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

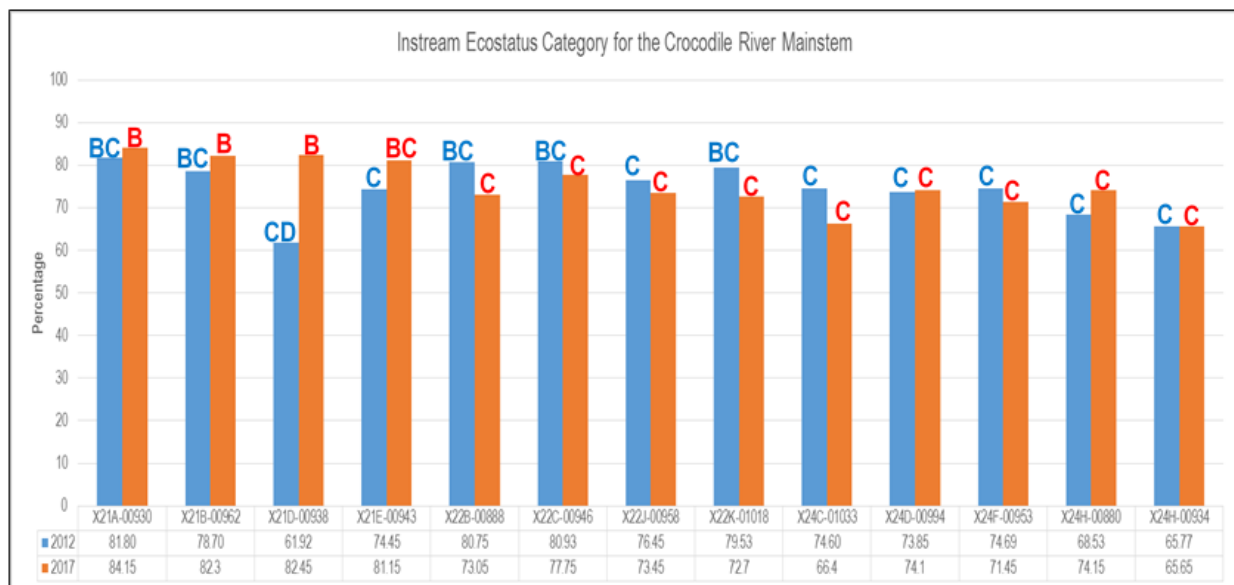


Figure 24: Comparison of the Instream Ecstatus of the main Crocodile River in 2012 and 2017.

When comparing the Integrated Ecstatus with the Target Ecological Category within the various SQ reaches and EWR sites as per gazetted RQO's, it is evident that the set targets are met for all the reaches except for X21A-00930; X21B-00962; X21E-00943 and X24H-00934. Factors contributing to this can be related to inefficient catchment management in the upper reaches of the river negatively affecting instream habitat and reduced water quality standards. Whereas flow regulation and over-abstraction as well as the combined effect of reduced water quality contribute to targets not met in the lower reaches of the Crocodile River mainstem.

Integrated Ecosystem and Target Ecological Category for the Crocodile River Mainstem

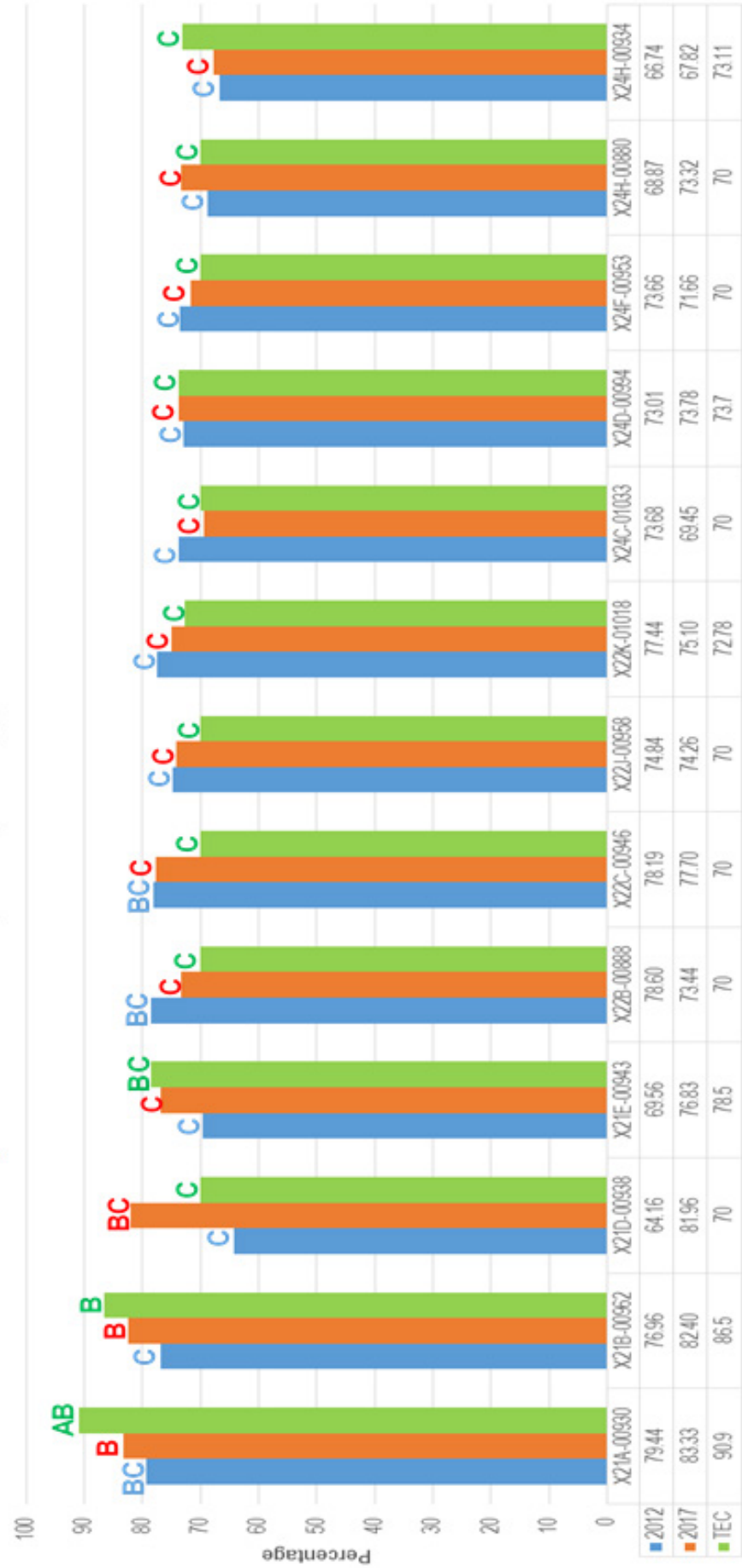


Figure 25: Comparison of the Integrated Ecosystem and Target Ecological Category for the main Crocodile River in 2012 and 2017.

Crocodile River Tributaries

Ten biomonitoring sites were monitored representing 9 SQ-reaches on smaller tributaries of the Crocodile River: Lunsklip River, Alexanderspruit, Buffelskloofspruit, Houtbosloop, Visspruit, Gladdespruit, Nelsriver and White River. The biomonitoring site on the Kareekraalspruit although assessed is not on Reach. This site has been compiled in the RIVDINT model and can therefore be used in future biomonitoring.

NOT ON REACH X2KARE-GOLFC

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Biomonitoring Year
Not on reach	X2KARE-GOLFC	Kareekraal spruit	S-25.44106 E 30.21203	1 606	8.35	C	BC 78.8%	C 76.7%	C 77.75%	C 75%	C 77.2%	2017

General description

Not on Reach X21A – Kareespruit

The source of the Kareekraalspruit is at an elevation of 2,160 m a.s.l., flowing in a general south-south easterly direction towards the Crocodile River, merging downstream from a waterfall at an elevation of 1,387 m a.s.l. The stream length from source to the confluence is 12.6 km, with the entire catchment located in the Eastern Bankenveld (9.02) aquatic ecoregion. The upper portion of the catchment falls within Lydenburg Montane Grassland (Gm 18) vegetation type, and in the Lydenburg Thornveld (Gm 21) downstream from the waterfall. Numerous small farm dams stocked with exotic and invasive trout and bass are typical of this reach, and the river runs through an irrigated golf estate. The Golf Estate site on the Kareekraalspruit (X2KARE-GOLFB) was sampled on the stream, residence to an endangered fish species, *Enteromius cf motebensis*, yet undescribed.



Figure 26: Kareekraalspruit from DJI drone indicating hydraulic biotopes.

The Kareekraalspruit at the sampling site is 1 to 2 m wide, dominated by cobble, gravel, boulders, and mud-silt (Figure 20). Hydraulic biotopes include cascades, riffles, runs, pools, and glides.

Instream Habitat Integrity

The Instream IHI for the X2KAREEKRAALSPRUIT was calculated at 80.36% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

This site (X2KARE-GOLFB) is a headwater stream situated within Highlands Golf Estate. Fish velocity depth classes present was slow deep (sparse), slow shallow (moderate) and fast shallow (abundant). Cover was moderately present as overhanging vegetation with undercut banks and large rocks offered good substrate cover for fish.

Table 38: Fish species expected based on the PESEIS Reach Code (Not on reach) X2KARE-GOLFB; is listed, and the numbers of fish species present during the survey is indicated.

Not on a reach Kareekraalspruit	Expected Species	X2KARE-GOLFB	
		09/2012	07/2017
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius neefi</i>	x	-	-
<i>Enteromius cf motebensis</i>	x	-	42
Cichlidae (Cichlids)			
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparmanii</i>	x	-	-
Number of species expected	4		
Number of species recorded		Not sampled	1
Number of individuals			42
Electro-fishing time (minutes)			12
Catch/Unit Effort (CPUE)			3.5

Four indigenous species of fish are expected to occur in this reach of which only one, *Enteromius cf motebensis*, was collected during the present survey (Table 38). This species is one of the chubby head group of small barbs (*Enteromius anoplus*, *E. gurneyi*, *E. motebensis* and *E. amatolicus*) (Skelton, 2001), which are morphologically very close and difficult to identify and there is a need to do further genetic studies on this group of minnows, especially on this isolated population. *Enteromius cf motebensis* seems to be fairly resilient to water quality issues, but is reliant on certain habitats, in particular deep runs and shallow pools with good instream and overhanging cover. The catch per unit effort (CPUE) calculated was 3.5 (42 individuals; 12 minutes) indicating a high abundance for a headwater stream of this magnitude.

A mean Fish Ecostatus rating of 78.8% was calculated for the SQR based on all available information, placing this reach in an Ecological Category BC (close to largely natural with few modifications most of the time with a low diversity of fish).

Invertebrates

Six SASS sampling events are on record for the Kareekraalspruit. The sampling represents one autumn, four winters, and one spring sampling event. A total of 43 SASS taxa have been recorded during these six sampling events, of which 36 taxa in total were recorded during winter surveys. The sensitive rated SASS taxa Leptophlebiidae, Tricorythidae, and Aeshnidae were recorded during all six sampling events.

Taxa diversity increased since monitoring was initiated in 1993, from 15 SASS taxa in October 1996 to 31 in July 2017. Increased diversity could be linked to enrichment (increased food), but also due to slight changes in sampling methods: SASS4 combined all biotopes in one sample and one identification tray, while SASS5 splits biotopes into three samples and trays.

Table 39: 2017 SASS5 results for SQ reach X2KARE-GOLF.

Not on reach	X2KARE-GOLFB	2012	2017	Change
	Total SASS Score	Not sampled	189	
	No. of SASS Families		31	
	Average Score Per Taxon		6.1	
	MIRAI Value		Category C 76.7%	
SQ REACH SUMMARY Invertebrate Ecostatus			Category C 76.7%	Not applicable

Algal growth on substrates was visible during the 2017 survey, but the seasonal characteristics of the stream is not fully known, and could therefore also be largely natural. Conditions in the Kareekraalspruit in 2017 at the sampling point (Table 39), based on MIRAI, and were rated as moderately impaired (Category C – 77%).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 75.32% rating this reach as a Category C indicating a moderately modified riparian. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (75%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- High quantities of siltation and sedimentation in pools
- Invasive plant species
- Bank instability and scouring
- Alien and invasive fish species (trout and bass)

See appendix E

Integrated Ecostatus Category

The Integrated Ecostatus Category for this reach was consistent with a Category C (77.2%) suggesting a moderately modified habitat. The loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. There is no TEC available for this SQ Reach as it is not on an allocated reach, however it is recommended that the TEC for this reach is set at a Category B (85%).



INTEGRATED ECOSTATUS	TARGET ECOSTATUS (RECOMMENDED)
Category C (77.2%)	Category B (85%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural ecosystem most of the time

TARGET NOT MET



Possible reasons:

- Sedimentation and siltation reducing available fish habitat
- Presence of alien and invasive fish species

RIVER		TRIBUTARY OF	
Kareekraalspruit		Crocodile	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2KARE-GOLFC	X21A	Not on Reach	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Elevation (m. a.s.l.)	Geomorphological Zone	
S -25.44106	1 606	Mountain stream	
		Level I	Level II
9.Eastern Bankenveld			9.02
			
<p>Figure A-35. Upstream view of the Kareekraalspruit on the Highlands Golf Estate (July 2017, G Diedericks).</p>		<p>Figure A-36. Downstream view of the Kareekraalspruit on the Highlands Golf Estate (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X21B-00898

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21B-00898	X2LUNS-VERLO	Lunsklip	S-25.31040 E 30.14557	2 075	11.0	D	B 85.5%	B 83%	B 84.25%	C 70%	BC 81.40%	CD 60%	2012
							BC 80.9%	BC 81.9%	BC 81.4%	C 77.5%	BC 80.62%		2017

General description

The Lunsklip River originates on the Verloren Valei Nature Reserve in the Steenkampsberg mountains at an elevation of 2,240 m a.s.l., flowing eastwards towards its confluence with the Crocodile River upstream from the Kwena Dam. The river was divided into two reaches, with the upper reach including the origin of the river to where it merges with a tributary below the R540 national road between Dullstroom and Lydenburg (Mashishing). The reach below this to where it merges with the Crocodile River is the next reach. Both reaches are characterised by many farm dams and weirs, stocked mainly with exotic rainbow trout (*Oncorhynchus mykiss*).

Reach X21B-00898: Source – Gembokspruit confluence

The PESEIS reach length is 11 km, originating at 2,240 m a.s.l., flowing towards its downstream boundary with the Gembokspruit at 1,849 m a.s.l. The headwaters of the river are in very good condition, after which the stream is frequently dammed for the purpose of maintaining exotic fish populations. Several small tributaries contribute to the reach, which are also dammed for exotic fish breeding. The entire reach falls within the Eastern Bankenveld (9.02) aquatic ecoregion, and the Lydenburg Montane Grassland (Gm 18) vegetation type (grassland 87.3%; wetlands 1.7%). Land-use is mainly trout fishing, but there are a few commercial pine plantations (5.2%) and small-scale live-stock farming (GEOTERRAIMAGE, 2015).

The Lunsklip River at the Verloren Valei site is 1 - 3 m wide, dominated by cobble, boulders, gravel, silt, mud, and sand. Hydraulic biotopes include rapids, riffles, runs, glides, and pools (Figure 27).



Figure 27: Drone photograph of the biotopes indicating instream fish habitat in the X21B-00898 SQ reach.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21B-00898 was calculated at 82.2% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. Flow regime has been slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The X2LUNS-VERLO site was sampled on Verloren Valei Nature Reserve (MTPA) on this relative long reach. This is one of the highest SQ reaches of the Crocodile River Catchment. Riffles and runs provided both slow shallow and fast shallow habitat with moderate substrate cover provided by cobbles and pebbles in the riffles. Sedimentation was prominent in especially the slow shallow habitat. Cover for the fish was also moderate to abundant present as overhanging vegetation and undercut banks. No aquatic macrophytes were present.

Table 40: Fish species expected based on the PESEIS Reach Code (X21B-00898) X2LUNS-VERLO; is listed, and the numbers of fish species present during the different surveys are indicated.

X21B-00898	Expected Species	X2LUNS-VERLO	
		09/2012	07/2017
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	11	5
Cichlidae (Cichlids)			
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	2		
Number of species recorded		1	1
Number of individuals		11	5
Electro-fishing time (minutes)		12	17
Catch/Unit Effort (CPUE)		0.92	0.29

Only one of the two indigenous species of fish expected to occur in this reach was collected (Table 40). The small barb species, *Enteromius anoplus*, was recorded in low abundance and the cichlids species (*Tilapia sparrmanii*) expected to occur, were not recorded. During the 2012 and the 2017 surveys the catch per unit effort

(CPUE) recorded very low at 0.92 and 0.29 respectively. This low abundance of fish can be related to the presence of the alien and invasive Rainbow trout (*Oncorhynchus mykiss*) further downstream in this reach.


A FRAI score of 82.5% was determined placing the reach in an Ecological Category B (largely natural with few modifications) comparing favourably with the 2012 survey of a Category B (85.5%)

Invertebrates

At the Verloren Valei site on the Lunsklip River (X2LUNS-VERLO), twelve SASS sampling events each are on record, carried out from June 1993 to July 2017. These represent one autumn, six winters, and five spring sampling events.

A total of 42 SASS taxa have been recorded during these twelve sampling events, of which 31 taxa in total were recorded during winter surveys and 36 in spring. Even though the stream is very close to pristine, sensitively taxa is limited, and taxa diversity is naturally low. Sensitive SASS taxa recorded during most (FROC > 90%) sampling events included Leptophlebiidae, and Aeshnidae in spring, and none in winter. Tolerant taxa were dominant during most of the surveys, with low taxa diversity (9 – 26).

Table 41: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21B-00898.

X21B-00898	X2LUNS-VERLO	2012	2017	Change
	Total SASS Score	146	154	
	No. of SASS Families	26	25	
	Average Score Per Taxon	5.6	6.2	
	MIRAI Value	Category B 83.0%	Category BC 81.9%	
SQ REACH SUMMARY Invertebrate Ecostatus	Category B 83.0%	Category BC 81.9%		

The PESEIS reach, X21B-00898, was categorised as slightly impaired (83%) in 2012, and as slightly to moderately impaired (82%) in 2017 (Table 41). Conditions for both years are similar, with onsite sediment inputs from a hoed tracer belt, considered the main source of impairment.

Impacts for SQR

- Removal of riparian vegetation
- Presence of alien and invasive fish species
- Numerous instream dams and weirs
- Thermal pollution due to numerous dams in the catchment
- Reduced water quality

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category BC (81.26%)	Category CD
Largely natural most of the time with few modifications	This system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category.



TARGET MET ?

Discussion:

Although it would appear that the target is met, this is not a EWR site and the TEC is derived from a PES-EIS desktop assessment (DWA, 2014b) indicating the Ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail. The Integrated Ecostatus of a Category BC would indicate that a more detailed assessment is required.

It is recommended that the TEC for this reach be adapted to reflect a Category B.

The main impact on this reach is the alien and invasive Trout Industry, creating numerous dams and weirs impacting on the natural flow regime and reduced water quality. This NEMBA species also impacts on the indigenous fish species. For more impact see National Trout Risk Assessment by the Environmental Programs: Directorate of the Department of Environmental Affairs, South Africa (May, 2014).

RIVER		TRIBUTARY OF	
Lunsklip		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2LUNS-VERLO		X21B	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	
S -25.31040		2 075	
E 30.14557		Upper Foothills	
AQUATIC ECOREGION		Geomorphological Zone	
Level I		Level II	
Eastern Bankenveld		9.02	
			
<p>Figure A-37. Upstream view of the Verloren Valei site on the Lunsklip, X2LUNS-VERLO (July 2017, G Diedericks).</p>		<p>Figure A-38. Downstream view of the Verloren Valei site on the Lunsklip, X2LUNS-VERLO (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X21B-00925

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21B-00925	X2LUNS-UITWA	Lunsklip	S-25.39339 E 30.30177	1 227	21.5	C	C 76.8%	B 83%	BC 79.90%	D 50%	C 73.92%	C 70%	2012
							C 77.5%	BC 78.4%	C 77.9%	C 75%	C 77.4%		2017

General description

Reach X21B-00925: Gemsbokspruit – Crocodile

The PESEIS reach length is 21.5 km, starting upstream below the Gemsbokspruit tributary (1,849 m a.s.l.) flowing through impoundments and weirs towards the Steenkampsberg. The Lunsklip plummets down a waterfall towards the point where it merges with the Crocodile River at an elevation of 1,198 m a.s.l.

The reach falls within the Eastern Bankenveld (9.02) aquatic ecoregion, and in the Lydenburg Montane Grassland (Gm 18) vegetation type above the Steenkampsberg and Lydenburg Thornveld (Gm 21) below the waterfall. Vegetation comprise of 1.45% wetlands, 10.1% thickets and dense bush, 5.5% woodlands and open bush and 68% grasslands (GEOTERRAIMAGE, 2015). Land-use includes mainly trout farms, a few commercial pine plantations (7.1% commercial plantations), small-scale live-stock farming, and irrigated crops (cultivated fields 5.5%) in the portion of the reach close to the Kwena Dam (GEOTERRAIMAGE, 2015).

The Lunsklip River at the Uitwaak site is 4 – 10 m wide, dominated by cobble, boulders, gravel, silt, and mud. Hydraulic biotopes include rapids, riffles, runs, glides, and pools. The rocks are covered in algal-moss growths, with prolific growth of submerged aquatic plants (*Lagarosiphon major* – Oxygen Weed) in slower flowing portions.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21B-00925 was calculated at 69.12% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified with a loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The site (X2LUNS-UITWA) is downstream from a trout hatchery and was the only site sampled for this reach. All the fish velocity depth classes were present with fast deep, slow deep and slow shallow sparse and fast shallow in abundance. The most prominent cover for fish was the substrate which was covered by algae-moss growth

with some overhanging vegetation and undercut banks also present. Aquatic macrophytes were only present in the slow deep habitat.

Table 42: Fish species expected based on the PESEIS Reach Code (X21B-00925) X2LUNS-UITWA; is listed, and the numbers of fish species present during the different surveys are indicated.

X21B-00925	Expected Species	X2LUNS-UITWA	
		2012	07/2017
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	-
<i>Enteromius neefi</i>	x	13	72
Amphiliidae (Mountain Catfishes)			
<i>Amphilius natalensis</i>	x	-	-
<i>Amphilius uranoscopus</i>	x	1	7
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	3	4
Cichlidae (Cichlids)			
<i>Pseudocrenilabrus philander</i>	x	-	3
<i>Tilapia sparrmanii</i>	x	-	1
Number of species expected	7		
Number of species recorded		3	5
Number of individuals		17	87
Electro-fishing time (minutes)		31	35
Catch/Unit Effort (CPUE)		0.55	2.49

A total of seven indigenous species of fish are expected to occur in this reach of which five were collected during the present survey and three species during the 2012 survey (Table 42). The most abundant fish species collected was *Enteromius neefi* that is a hardy species with a preference for slow shallow habitats and aquatic macrophytes, moderately intolerant to changes in flow regime (3.4) and modified water quality (3.4). The two cichlid species, *Pseudocrenilabrus philander* and *Tilapia sparrmanii*, were only recorded during the present survey. The rheophilic species *Chiloglanis pretoriae* and *Amphilius uranoscopus* were collected at relatively low abundance. Their low abundance can be related to their sensitivity preferring fast shallow habitat with high intolerance to flow modifications (4.8) and intolerance to reduced water quality (4.8).

Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most rheophilic species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of reduced water quality and flow regulation due to upstream aquaculture farming (trout) and land use practices. The CPUE calculated was very low during the 2012 survey at 0.55 (17 individuals; 31 minute) but higher for the present survey at 2.49 (87 individuals; 35 minutes). The large number of *Enteromius neefi* (72) collected creating a skewed representation of the CPUE.

A mean Fish Ecstatus rating of 77.5% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low diversity of species and low abundance) similar to the 2012 results.

Invertebrates

Seven SASS sampling events are on record for the Uitwaak site (X2LUNS-UITWA) on the Lunsklip River, carried out since October 1996. These represent one autumn, four winters, and two spring sampling events. A total of 45 SASS taxa have been recorded during these seven sampling events, of which 41 was recorded during the four winter, and 29 during the two spring surveys. Sensitively rated SASS taxa recorded during most (>90%) sampling events (high frequency of occurrence) included Heptageniidae, Leptophlebiidae, and Tricorythidae.

Table 43: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21B-00925.

X21B-00925	X2LUNS-UITWA	2012	2017	Change
	Total SASS Score	122	185	
	No. of SASS Families	19	27	
	Average Score Per Taxon	6.4	6.9	
	MIRAI Value	Category B 83.0%	Category BC 78.4%	↓
SQ REACH SUMMARY Invertebrate Ecstatus	Category B 83.0%	Category BC 78.4%		

Based on the 2017 SASS5 results, MIRAI indicates a slight deterioration in conditions compared to 2012 (Table 43). In 2012, conditions based on MIRAI was categorised as slightly impaired (83%), and as slightly to moderately impaired (78%) in 2017. Water quality problems (nutrients) manifest in aquatic plant growth, which affect the instream community.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified with a loss and change in natural habitat. The Riparian IHI was calculated at 79.44% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (75%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Stream bank trampling
- Bank instability
- Invasive plant species
- Alien and invasive fish species
- Commercial trees planted in riparian zone
- Domestic waste in stream and riparian zone
- Poor road drainage
- Aquaculture Facility impacting on water quality and flow regulation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (77.4%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota.

TARGET MET





Discussion:

This is not a EWR site and the TEC is derived from a PES-EIS desktop assessment (DWA, 2014b) indicating the Ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail. The Integrated Ecostatus of a Category C would indicate that a more detailed assessment is required.

It is recommended that the TEC for this reach be adapted to reflect a Category B.

The main impact on this reach is the alien and invasive Aquaculture Facility, impacting on the natural flow regime and reduced water quality of this reach. This NEMBA species also impacts on the indigenous fish species. For more impact see National Trout Risk Assessment by the Environmental Programs: Directorate of the Department of Environmental Affairs, South Africa = (May, 2014).

RIVER		TRIBUTARY OF	
Lunsklip		Crocodile	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2LUNS-UITWA	X21B	X21B-00925	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Longitude	Elevation (m. a.s.l.)	Geomorphological Zone
S -25.39339	E 30.30177	1 227	Upper Foothills
AQUATIC ECOREGION	Level I	Level II	
9. Eastern Bankenveld		9.04	
			
Figure A-39. Upstream view of the Uitwaak site, X2LUNS-UITWA, on the Lunsklip River (July 2017, G Diedericks).	Figure A-40. Downstream view of the Uitwaak site, X2LUNS-UITWA, on the Lunsklip River (July 2017, G Diedericks).		

SQ REACH NUMBER X21C-00859

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21C-00859	X2ALEX-RIETF	Alex-se-Loop	S-25.26896 E 30.40847	1 267	6.9	C	C 70.7%	BC 80.6%	C 75.65%	C 70%	C 74.52%	C 70%	2012
							C 70.2%	C 75.2%	C 72.7%	BC 80%	C 74.16%		2017

General description

Reach X21C-00859: Alex-se-Loop

The entire Alex-se-Loop is marked as one PESEIS reach, with a total length of 36.9 km. The reach originates on the Tree Falls Trout Farm and Hatchery at an elevation of 2,000 m a.s.l., and flows through the hatchery's commercial pine trees and numerous weirs stocked with exotic trout. The river then flows through Komatiland Forest's Uitsoek plantation before entering agricultural lands, again with numerous trout dams. The agricultural lands were established in the riparian zone of the river, negatively affecting its ecological functions. The Alex-se-Loop flows directly into the Kwena Dam.

The sampling site, X2ALEX-RIETF, is located a few kilometres upstream from the Kwena Dam, on the farm Rietfontein. The portion of the reach extends into the dam, but where it flows into the dam the elevation is 1190 m a.s.l. The entire catchment falls within in the Eastern Bankenveld (9.02) aquatic ecoregion. The upper portion of reach's' vegetation type is classified as Lydenburg Montane Grassland (Gm 18) and lower portions towards the dam as Lydenburg Thornveld (Gm 21). Land cover comprise of thickets dense bush (13%), woodlands and open bush (20%) and grasslands (37.7%) with 9% cultivated fields and 14.5% pine plantations (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The Instream IHI for the SQ reach X21C-00859 was calculated at 81.16% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The habitat at this site (X2ALEX-RIETF) where biomonitoring was conducted remained consistent with the previous survey. The fish velocity depth classes present were fast shallow (abundant) and both the slow shallow and slow deep habitats moderately abundant with no fast deep habitat present. The fish cover present was mainly overhanging vegetation and root wads with some cover provided by stones, cobbles and pebbles in the shallow riffles. No aquatic macrophytes were present. Leafy detritus and dead tree branches in the slow deep habitat provided some habitat for fish. The habitat availability is impaired due to bank instability, increased siltation and sedimentation and the damming of certain sections.

Table 44: Fish species expected based on the PESEIS Reach Code (X21C-00859) X2ALEX-RIETF; is listed, and the numbers of fish species present during the different surveys are indicated.

X21C-00859	Expected Species	X2ALEX-RIETF	
		09/2012	07/2017
Kneriidae (Knerias)			
<i>Kneria (auriculata) sp. nova.</i>	x	27	43
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	4	-
<i>Enteromius neefi</i>	x	16	23
Amphiliidae (Mountain Catfishes)			
<i>Amphilius natalensis</i>	x	-	-
<i>Amphilius uranoscopus</i>	x	12	5
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	-	-
Cichlidae (Cichlids)			
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	6		
Number of species recorded		4	3
Number of individuals		59	71
Electro-fishing time (minutes)		18	22
Catch/Unit Effort (CPUE)		3.28	3.23

A total of six indigenous species of fish are expected to occur in this reach of which three were collected during the present survey (Table 44). The most abundant fish species during the recent survey was the endangered IUCN red data *Kneria (auriculata) sp. Nov.* 'South Africa' recorded at relative abundance. *Kneria sp. nov.* 'South Africa' occurs only in the headwaters of a few tributaries of the Crocodile River, Inkomati River system. After the completion of the Kwená Dam (formerly Braam Raubenheimer Dam) in 1984 some of the tributaries and Crocodile River mainstem were inundated where previously *Kneria sp. nov.* 'South Africa' were recorded (Kleynhans 1982; 1984). This species is restricted in its distribution and shows a preference for pools with a rocky bottom in cool, clear water of slow flowing streams (Kleynhans, 1988). The mean flow velocity of water entering these pools were 0.12 m/sec⁻¹ with a mean width of 2.4m and a mean depth of 0.7m (Kleynhans, 1988). The substrate consist of stones and pebbles which are usually covered with "aufwuchs" (algae and diatoms). *Kneria sp. nov.* 'South Africa' is a listed fish species of conservation concern and listed into the MBSP (Mpumalanga Biodiversity Sector Plan) and labeled as critically endangered and incorporated in the MBSP as fish support areas (Lotter *et al.* 2014). Based on this species' conservation importance regular surveys is

conducted to determine the status and present data indicate a continuous decline in the extent of occurrence and population size (Roux, 2016; Roux & Hoffmann, 2017b).

The two other species collected was the limnophilic species *Enteromius neefi* and the rheophilic species *Amphilius uranoscopus*. The CPUE calculated for this site 3.23 (71 individuals; 22 minute) remained consistent with 2012 survey results.

A Fish Ecstatus rating of 70.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low diversity of species), similar to the 2012 surveys.

Invertebrates

Two SASS sampling events are on record for the Rietfontein site (X2ALEX-RIETF) on the Alex-se-Loop. A total of 30 SASS taxa have been recorded during the two sampling events, of which 25 were recorded during the winter survey, and 28 taxa during the spring survey. Sensitive rated SASS taxa recorded during both sampling events included Baetidae >2 sp., Leptophlebiidae, Tricorythidae, Chlorocyphidae, Aeshnidae, Psephenidae, and Dixidae.

Table 45: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21X-00859.

X21C-00859	X2ALEX-RIETF	2012	2017	Change
	Total SASS Score	173	155	
	No. of SASS Families	28	25	
	Average Score Per Taxon	6.2	6.2	
	MIRAI Value	Category BC 80.6%	Category C 75.2%	↓
SQ REACH SUMMARY Invertebrate Ecstatus	Category BC 80.6%	Category C 75.2%		

The 2017 SASS5 results (Table 45), based on MIRAI, indicates deterioration in the Alex-se-Loop compared to 2012, which was rated as slightly to moderately impaired (81%) in 2012 and moderately impaired (75%) in 2017. The deterioration is attributed to changes in water chemistry and abstraction.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 80% and is consistent with a Category BC – close to largely natural with few modifications most of the time. The Riparian IHI was calculated at 86.92% rating this reach as a Category B indicating a largely natural reach with few modifications. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach is close to largely natural with a few modifications most of the time.

Impacts for SQR

- Stream bank trampling
- Siltation in pools
- Invasive plant species
- Alien and invasive fish species
- Bank scouring
- Stream crossing creates upstream impoundment
- Stream crossing physical barrier during low flow conditions
- Poor road drainage

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (74.16%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota.	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged

TARGET MET



Discussion:

This is not a EWR site and the TEC is derived from a PES-EIS desktop assessment (DWA, 2014b) indicating the Ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail. The Integrated Ecostatus of a Category C would indicate that a more detailed assessment is required.

It is recommended that the TEC for this reach be adapted to reflect a Category B due to the presence of *Kneria sp. nov.* 'South Africa'.

The distribution range of *Kneria sp. nov.* 'South Africa' is entirely within privately owned land where the prime land use activity is agriculture. None of the distribution localities falls within protected areas. Surveys are needed urgently to assess the current status for this species. Areas suitable for conservation actions and possible sanctuary areas need to be identified. Possibly some streams need to have alien species removed to allow *Kneria sp. nov.* 'South Africa' to either recover or for restocking with *Kneria sp. nov.* 'South Africa' from adjacent stream populations. Use of water resources by riparian land users' needs to be carefully controlled.

RIVER		TRIBUTARY OF	
Alex-se-loop		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2ALEX-RIETF		X21C	X21C-00859
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	Geomorphological Zone
S -25.26896		1 267	Upper Foothills
AQUATIC ECOREGION		Level I	Level II
9. Eastern Bankenveld			9.02

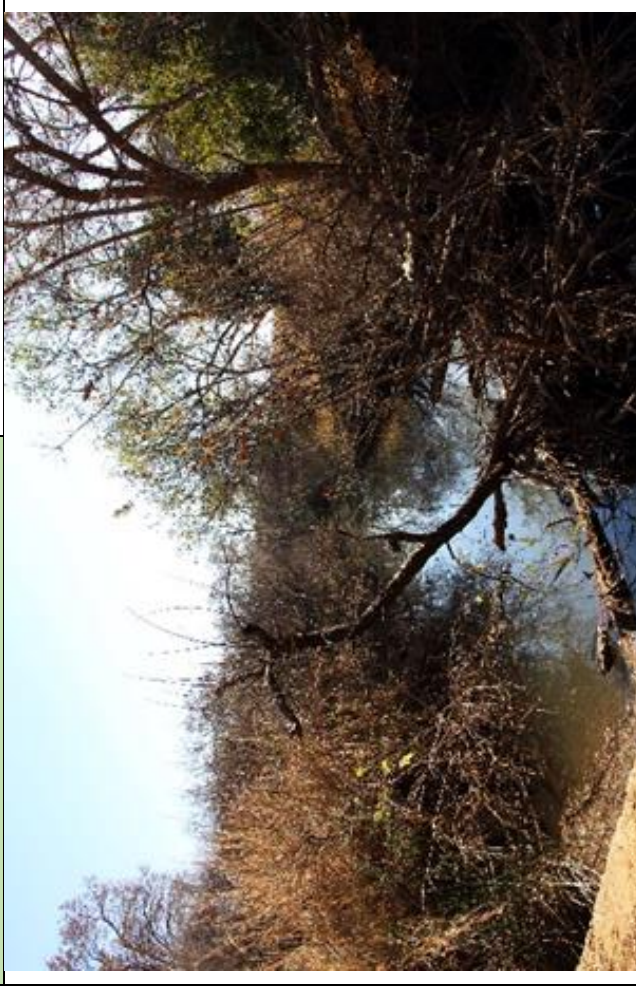


Figure A-41. Upstream view of the Rietfontein site, X2ALEX-RIETF, on Alex-se-Loop (July 2017, G Diedericks).



Figure A-42. Downstream view of the Rietfontein site, X2ALEX-RIETF, on Alex-se-Loop (July 2017, G Diedericks).

SQ REACH NUMBER X21D-00957

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21D-00957	X2BUFF-SOMER	Buffelskloof spruit	S-25.43802 E 30.44810	1 168	27.1	C	C 74.6%	C 76.4%	C 76.40%	C 70%	C 75.12%	BC 80%	2012
							B 85.7%	B 86.3%	B 86%	B 82.5%	B 85.3%		2017

General description

Reach X21D-00957: Southern Buffelskloofspruit

The Buffelskloof South originates north from where the Cluvia Pass road meets the N4 on Schoemanskloof (between Lydenburg and Machadodorp). The elevation is 1,720 m a.s.l., and the river flows through Sappi's commercial pine plantations in a north-easterly direction towards the Crocodile River.

The PESEIS reach length is listed as 27.1 km. The elevation where the Buffelskloof South enters the Crocodile River, downstream from Kwena Dam, is 1,028 m a.s.l. The upper portion of the reach falls within the Eastern Bankenveld (9.02) aquatic ecoregion, from where it flows into the Northern Escarpment Mountains (10.03) ecoregion. The vegetation types are similar, with Lydenburg Montane Grassland (Gm 18) in the upper reaches and Legogote Sour Bushveld (SVI 9) in the lower portion of the reach. Land cover comprise of 26.8% thickets and dense bush with 11.5% woodland open bush and 30.8% grasslands (GEOTERRAIMAGE, 2015). The reach is characterised by commercial forestry (commercial plantations 23.1%) in its origin, numerous dams in its upper reaches, with agricultural crops (in most cases right up to the edge of the stream) in the riparian zone and adjacent floodplains.

The southern Buffelskloofspruit site at In-da-Busche is 2 - 6 m wide, dominated by large cobble, gravel, boulders, sand, silt, and mud. Hydraulic biotopes include riffles, runs, glides, and shallow pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21D-00957 was calculated at 57.49% rating this SQ reach as a D category indicating that the instream habitat integrity is largely modified. A large loss of natural habitat, biota and ecosystem functions has occurred. (RIVDINT model Crocodile River System, 2017).

Fish

The (X2BUFF-SOMER) site was sampled on this reach with no deep habitat present. Both slow shallow and fast shallow habitat were abundantly present. There was more cover for the fish present in the slow shallow habitat

where overhanging vegetation and undercut banks were moderately present. Aquatic macrophytes were sparsely present as cover. Rocks, cobbles and pebbles offered good substrate cover for fish in the riffles and runs.

Table 46: Fish species expected based on the PESEIS Reach Code (X21D-00957) X2BUFF-SOMER; is listed, and the numbers of fish species present during the different surveys are indicated.

X21D-00957	Expected Species	X2BUFF-SOMER	
		09/2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	X	-	-
Kneriidae (Knerias)			
<i>Kneria auriculata</i>	X	61	75
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	16	20
<i>Enteromius crocodilensis</i>	x	-	-
<i>Enteromius neefi</i>	x	21	269
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	5	20
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	-	-
<i>Chiloglanis pretoriae</i>	x	-	37
Cichlidae (Cichlids)			
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparmanii</i>	x	-	3
Number of species expected	10		
Number of species recorded		4	6
Number of individuals		103	424
Electro-fishing time (minutes)		21	45
Catch/Unit Effort (CPUE)		4.9	9.42

Of the 10 expected indigenous fish species, six species were recorded (Table 46) which included *Kneria* sp. Nov. 'South Africa' (Roux & Hoffman, 2017), *Enteromius anoplus*, *Enteromius neefi*, *Amphilius uranoscopus*, *Chiloglanis pretoriae* and *Tilapia sparmanii*. All these species were collected in relative high abundance that included all age classes (juveniles, sub-adults, adults) indicating that successful breeding is taking place at present. The presence of the rheophilic *Amphilius uranoscopus* and *Chiloglanis pretoriae* in relative high abundance indicate that stream flow is not disrupted and that instream habitat in certain areas is sufficient for these sensitive species. The presence of illegal weirs is obstructing migrational routes in this reach preventing recolonisation of absent species. Land use practices further contribute to high siltation and sedimentation loads recorded within this reach. The catch per unit effort (CPUE) was high and calculated at 9.42 (424 individuals: 45 minutes) with *Enteromius neefi* (269 individuals), contributed to the high CPUE. The CPUE effort for the 2012 survey was much lower at 4.90 (103 individuals; 21 minutes).

A Fish Ecstatus rating of 85.7% was calculated for this monitoring point based on all available information, placing it in an Ecological Category B (close to largely natural most of the time) which is an improvement from the 2012 survey results - Category C (74.6%).

Invertebrates

Three SASS sampling events are on record for the Buffelskloofspruit site (X2BUFF-SOMER). These represent two winters, and one spring sampling event. A total of 43 SASS taxa have been recorded during these three sampling events, with tolerant taxa mostly dominant. Sensitively rated SASS taxa recorded during all three sampling events included Baetidae >2 sp., Leptophlebiidae, Tricorythidae, Chlorocyphidae, and Aeshnidae.

Table 47: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21D-00957

X21D-00957	X2BUFF-SOMER	2012	2017	Change
	Total SASS Score	149	191	
	No. of SASS Families	26	30	
	Average Score Per Taxon	5.7	6.4	
	MIRAI Value	Category C 74.6%	Category B 86.3%	↑
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 74.6%	Category B 86.3%		

The 2017 SASS5 results indicate improvement based on MIRAI (Table 47), with conditions rated as moderately impaired (75%) in September 2012 to slightly impaired (86%) in July 2017.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 74.84% rating this reach as a Category C indicating a moderately modified habitat with a loss and change of natural habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Impacts for SQR

- Siltation and sedimentation due to land use practices
- Over-abstraction of water
- Invasive plant species
- Cultivation in riparian zone: agricultural activities on land upstream from the site within riparian zone (reduced filtering capacity) (Figure 28 & 29) upstream and crops are irrigated (abstraction and return flow)

See appendix E



Figure 28: Removal of riparian vegetation in the Houtbosloop River riparian zone near the confluence with the Crocodile River.



Figure 29: Houtbosloop River riparian zone with cultivation in the riparian zone.

Integrated Ecostatus Category and Target Ecological Category (TEC)



INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category B (85.3%)	Category BC
Largely natural with few modifications	Close to largely natural most of the time

TARGET MET



Discussion:

Although target is met, but due to the presence of *Kneria* sp. nov. 'South Africa' the Target Ecological Category should be managed at a Category B

RIVER		TRIBUTARY OF	
Buffelskloofspruit		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2BUFF-SOMER		X21D	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude		X21D-00957	
Longitude		Geomorphological Zone	
E 30.44810		Upper Foothills	
AQUATIC ECOREGION		Level II	
10. Northern Escarpment Mountains		10.2	
			
<p>Figure A-43. Upstream view of the Buffelskloofspruit site, X2BUFF-SOMER (July 2017, G Diedericks).</p>		<p>Figure A-44. Downstream view of the Buffelskloofspruit site, X2BUFF-SOMER (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X22A-00913

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X22A-00913	X2HOUT-SUDWA	Houtbosloop	S-25.38747 E 30.71042	804	28.3	C	C 69.4%	B 86.8%	BC 79.34%	C 70%	C 77.30%	B 85%	2012
							C 77%	C 77.8%	C 77.4%	BC 80%	C 77.9%		2017

General description

Reach X22A-00913: Houtbosloop from Blyfstaanspruit

This PESEIS reach of the Houtbosloop starts at the Blyfstaanspruit-Houtbosloop confluence (1,107 m a.s.l.), flowing in a south-westerly direction towards the confluence of the Houtbosloop (744 m a.s.l.) with the Crocodile River. The entire Houtbosloop catchment falls within the Northern Escarpment Mountains (10.01) aquatic ecoregion, with the Lydenburg Montane Grassland (Gm 18) in the headwaters, and the Legogote Sour Bushveld (SVI 9) the dominant downstream vegetation type. Land cover comprise of thickets and dense bush (25.4%), woodlands open bush (9.3%) and grasslands (4%) (GEOTERRAIMAGE, 2015)

The catchment is dominated by commercial forestry (plantations 52.8%) in the upper reaches, with tourism, livestock, crops, and an old mine further downstream (GEOTERRAIMAGE, 2015). Large fires in the forestry area (Blyfstaanspruit) in 2012 resulted in extreme levels of siltation within the catchment, which is improving over time.

The Houtbosloop at Marekele is 8 to 12 m wide, dominated by gravel, cobble, large boulders, sand, silt, and mud. The stream banks are scoured, with invasive plants prolific. Hydraulic biotopes include riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22A-00913 was calculated at 78.08% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

One site (X2HOUT-SUDWA) was sampled on this reach. For this reach the habitat remains consistent with the 2012 habitat descriptions with only shallow habitat present consisting of moderately abundant slow shallow and fast shallow very abundant. Cover was moderately present as overhanging vegetation with undercut banks with

some rocks, cobbles and pebbles. The instream biotopes sampled was riffles and runs were present with sedimentation still evident although not as abundant as during the 2012 survey.

Table 48: Fish species expected based on the PESEIS Reach Code (X22A-00913) X2HOUT-SUDWA; is listed, and the numbers of fish species present during the different surveys are indicated.

X22A-00913	Expected Species	X2HOUT-SUDWA	
		2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	-
<i>Enteromius crocodilensis</i>	x	7	11
<i>Enteromius neefi</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	-	14
<i>Labeobarbus polylepis</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	-	1
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	-	3
<i>Chiloglanis pretoriae</i>	x	11	19
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparmanii</i>	x	-	-
Number of species expected	14		
Number of species recorded		2	5
Number of individuals		18	48
Electro-fishing time (minutes)		31	26
Catch/Unit Effort (CPUE)		0.58	1.85


Of the expected 14 indigenous fish species, five fish species were recorded (Table 48) which include *Enteromius crocodilensis*, *Labeobarbus marequensis*, *Amphilius uranoscopus*, *Chiloglanis bifurcus* and *Chiloglanis pretoriae*. The fish assemblage therefore indicate that all species collected were rheophilic species that is stream dependant. Although collected their abundance is relatively low, particularly *Amphilius uranoscopus* of which only one individual was collected. *Amphilius uranoscopus* has a preference for fast deep and fast shallow (4.6) biotopes with an intolerance to no flow conditions (4.8). This species has a preference for a very high substrate cover (5) and is intolerant to reduced water quality (4.8). Based on the preferences of this habitat specialist, the excessive siltation and sedimentation remains a major impact on this species. This would further be true for *Chiloglanis bifurcus* and *Chiloglanis pretoriae*. The presence of the endangered IUCN red data species *Chiloglanis bifurcus* indicate the importance of this tributary as a refuge stream for this species, and should therefore be realised and receive special conservation measures. The CPUE for the present survey (1.85) (48 individuals; 26 minutes) was slightly higher than the effort for the 2012 survey (0.58) (18 individuals; 31 minutes).

An improved Fish Ecstatus rating of 77.0% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a few modifications).

Invertebrates

Two SASS sampling events are on record for the Marekele site (X2HOUT-SUDWA) on the Houtbosloop. These represent one winter, and one spring sampling event. A total of 50 SASS taxa have been recorded during the two sampling events, with the highest taxa diversity in winter and the most sensitive taxa during the spring survey. Sensitively rated SASS taxa recorded during both sampling events included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, Tricorythidae, Chlorocyphidae, Aeshnidae, and Philopotamidae.

Table 49: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22A-00913.

X22A-00913	X2HOUT-SUDWA	2012	2017	Change
	Total SASS Score	177	200	
	No. of SASS Families	23	28	
	Average Score Per Taxon	7.7	7.1	
	MIRAI Value	Category C 67.1%	Category BC 77.8%	
	SQ REACH SUMMARY Invertebrate Ecstatus	Category C 67.1%	Category BC 77.8%	

The 2017 SASS5 results indicate slight improvement when compared to 2012 (Table 49). Conditions in the PESEIS reach based on MIRAI were rated as slightly impaired (67%) in September 2012, and as moderately impaired (78%) in July 2017. Most of the taxa associated with marginal vegetation was absent in the 2012 sample, with evidence of stream bank scouring. In 2018 marginal vegetation established on portions of the scoured stream banks, and most expected taxa associated with the vegetation biotope were present.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified habitat with a loss of natural habitat. The Riparian IHI was calculated at 59.07% rating this reach as a Category CD indicating a close to largely modified habitat most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach is close to largely natural with a few modifications most of the time.

Impacts for SQR

- Siltation and sedimentation
- Invasive plant species
- Bank scouring
- Domestic waste in stream and riparian zone

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)



INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (77.9%)	Category B
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural with few modifications

TARGET NOT MET



Possible reasons:

- Forestry related activities cause high sedimentation loads, resulting in loss of available instream habitat to fish and macroinvertebrates.

RIVER		TRIBUTARY OF	
Houtbosloop		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2HOUT-SUDWA		X22A	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	
Latitude	Longitude	804	
S -25.38747	E 30.71042	Upper Foothills	
AQUATIC ECOREGION		Level II	
10. Northern Escarpment Mountains		Level I	
		10.1	
			
<p>Figure A-45. Upstream view of the Houtbosloop site, X2HOUT-SUDWA at Marekele (July 2017, G Diedericks).</p>		<p>Figure A-46. Downstream view of the Houtbosloop site, X2HOUT-SUDWA at Marekele (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X22C-00990

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X22C-00990	X2VISS-ALKMA	Visspruit	S-25.45834 E 30.81643	742	10.0	C	C 71.2%	C 71.8%	C 71.50%	C 70%	C 71.20%	BC 80%	2012
							C 74.5%	B 83.2%	BC 78.9%	B 85%	BC 80.1%		2017

General description

Reach X22C-00990: Visspruit

The source of the Visspruit is at an elevation of 1,800 m a.s.l., draining predominantly commercial forestry on highly erodible soils in a north-north easterly direction towards the Crocodile River. The Visspruit enters the Crocodile River at an elevation of 703 m a.s.l. A very small portion of the upper catchment falls within the Northern Escarpment Mountains (10.02) aquatic ecoregion, and the bulk within the North Eastern Highlands (4.04). A small portion of the upper catchment falls within the Northern Escarpment Quartzite Sourveld (Gm 23), and the largest portion in the Legogote Sour Bushveld (SVI 9). The Land cover comprise of 2.5% wetlands, 45.1% thickets and dense bush, 3.4% woodlands open bush and 9.6% grasslands.

The instream habitat is dominated by sandy runs on boulder-bedrock, mainly attributed to excessive erosion and sedimentation from the upper portion of the catchment. The riparian vegetation is dominated by dense stands of alien plant species such as *Lantana camara* and bramble (*Rubus* spp.). Commercial forestry (plantations 10.6%) dominates the land-use in the upper reaches, with tropical fruit irrigation (8.1% cultivated fields; 14.1% cultivated orchards) and livestock farming dominating the lower reach (GEOTERRAIMAGE, 2015).

The Visspruit at the Alkmaar sampling point is 1 to 6 m wide, dominated by sand, bedrock, cobble, boulders, gravel, silt, and mud. Large pool areas with high quantities of deposited leaf litter dominate the area directly upstream from the sampling point. Hydraulic biotopes include riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22C-00990 was calculated at 80.88% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The fish velocity depth classes for this site (X2VISS-ALKMA) were fast shallow (abundant), slow shallow (moderately abundant) and slow deep (moderately abundant). No fast deep habitat was present. The fish cover present was some overhanging vegetation with undercut banks which was moderately abundant. A few rocks and cobbles provided some substrate cover for the rheophilic fish species.

Table 50: Fish species expected based on the PESEIS Reach Code (X22C-00990) X2VISS-ALKMA; is listed, and the numbers of fish species present during the different surveys are indicated.

X22A-00990	Expected Species	X2VISS-ALKMA	
		2012	07/2017
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	3	5
<i>Enteromius neefi</i>	x	-	2
<i>Enteromius trimaculatus</i>	x	1	4
<i>Labeobarbus marequensis</i>	x	1	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	-	-
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	-	2
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	11		
Number of species recorded		3	4
Number of individuals		5	13
Electro-fishing time (minutes)		39	19
Catch/Unit Effort (CPUE)		0.13	0.68

A total of 11 indigenous species of fish are expected to occur in this reach of which only four were collected (Table 50). The fish assemblage indicate a loss of all habitat specialists and rheophilic species. This can be attributed to loss of available instream habitat through excessive siltation and sedimentation. The species collected included *Enteromius anoplus*, *Enteromius neefi*, *Enteromius trimaculatus* and *Pseudocrenilabrus philander*. All the recorded species are hardy limnophilic species tolerant to reduced water quality and changes in flow conditions. Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of loss of instream habitat due to sedimentation and siltation. The CPUE for the present survey was calculated at 0.68 (13 individuals; 19 minutes) compared to the CPUE of 0.13 (5 individuals; 39 minutes) for the 2012 survey indicating low species diversity with low abundance.

A Fish Ecostatus rating of 74.5% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species) which is consistent with the 2012 survey results (Fish Ecostatus of 71.2% and an Ecological Category C).

Invertebrates

Two SASS sampling events are on record for the Visspruit site (X2VISS-ALKMA), representing one spring and one winter survey. A total of 49 SASS taxa have been recorded during the two sampling events, of which 30 taxa in total were recorded during the winter survey and 25 in the spring survey. Most sensitive taxa were recorded during the spring survey. Sensitively rated SASS taxa recorded during both sampling events included Atyidae, Perlidae, Baetidae >2 sp., Leptophlebiidae, Macromiidae, Philopotamidae, Elmidae, and Athericidae.

Table 51: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22C-00990.

X22C-00990	X2VISS-ALKMA	2012	2017	Change
	Total SASS Score	178	202	
	No. of SASS Families	25	30	
	Average Score Per Taxon	7.1	6.7	
	MIRAI Value	Category C 71.8%	Category B 83.2%	↑
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 71.8%	Category B 83.2%		

Despite the higher ASPT recorded in 2012 when compared to 2017, interpretation based on the MIRAI assessment is based on stream community composition in terms of preferences for flow, habitat and water quality. SASS scores also do not incorporate abundances, which means that for example that one Heptageniidae at an impaired site dominated by Chironomidae counts the same as a site with a high abundance of Heptageniidae and a low abundance of Chironomidae. That is why community composition is assessed rather than just the SASS scores.

The 2017 SASS5 results indicate improved conditions when compared to 2012 (Table 51). Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C - 72%) in September 2012, improving to slightly impaired (83%) in July 2017.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 82% rating this reach as a Category B indicating a largely natural reach with few modifications. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (85%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Impacts for SQR

- Sedimentation and siltation
- Invasive plant species
- Bank instability and scouring
- Stream crossing creates upstream impoundment
- Domestic waste in stream and riparian zone
- Poor road drainage network



See appendix E

Integrated Ecstatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category BC (80.1%)	Category BC
Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C Category	Close to largely natural most of the time with few modifications.

TARGET MET



RIVER		TRIBUTARY OF	
Visspuit		Crocodile	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2VISS-ALKMA	X22C	X22C-00990	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Elevation (m. a.s.l.)	Geomorphological Zone	
S -25.45834	742	Upper Foothills	
Longitude		Level II	
E 30.81643		4.04	
AQUATIC ECOREGION		Level I	
4.North Eastern Highlands			
			
<p>Figure A-47. Upstream view of the Visspuit site, X2VISS-ALKMA (July 2017, G Diedericks).</p>		<p>Figure A-48. Downstream view of the Visspuit site, X2VISS-ALKMA (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X22C-01004

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X22C-01004	X2GLAD-HERMA	Gladdespruit	S-25.52147 E 30.87853	899	36.7	C	D 54.6%	C 69.8%	C 63.29%	C 70%	C 64.75%	BC 80%	2012
							CD 59.4%	CD 59.8%	CD 59.6%	C 77.5%	C 63.18%		2017

General description

Reach X22C-01004: Gladdespruit

The Gladdespruit originates at the small town of Kaapsehoop, at an elevation of 1,675 m a.s.l., flowing in a general east-north easterly direction towards the Crocodile River, merging upstream from Nelspruit (Mbombela) at an elevation of 645 m a.s.l.

Based on available maps, the entire catchment falls within the North Eastern Highlands (4.04) aquatic ecoregion, and Legogote Sour Bushveld vegetation type. Land cover comprise of thickets and dense bush (19.3), woodlands open bush (2.3%) and grasslands (8%). Commercial forestry (64.9% plantations) dominates the upper catchment, with mining, agricultural irrigated crops, and livestock the rest (GEOTERRAIMAGE, 2015). At the site, X2GLAD-HERMA, the instream habitat is dominated by sand with bedrock embedded linked to excessive sediment input and deposition. Massive forestry fires in 2009 contributed to sedimentation. The riparian vegetation is dominated by dense stands of alien plant species such as *Lantana camara* and *Ruvus* spp.

The Gladdespruit at the Hermansbrug sampling point is 1 to 4 m wide, dominated mostly by sand. Hydraulic biotopes include shallow runs and glides over sand.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22C-01004 was calculated at 83.76% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. Flow regime has been slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The combination of cold water species from the higher altitudes of this reach and the more temperate species from the lower part of this reach, result in a high number of expected species. The two fish velocity depth classes at the site (X2GLAD-HERMA) representing this reach were slow shallow moderately abundant and fast shallow

abundant. Very little cover was present with some small undercut banks and root wads. The fast shallow habitat was very shallow with only some cobbles and gravel providing little substrate cover for fish. Most of the available fish habitat was covered with excessive siltation resulting in severely reduced instream fish habitat.

Table 52: Fish species expected based on the PESEIS Reach Code (X22C-01004) X2GLAD-HERMA; is listed, and the numbers of fish species present during the different surveys are indicated.

X22C-01004	Expected Species	X2GLAD-HERMA	
		2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	15
<i>Enteromius crocodilensis</i>	x	51	41
<i>Enteromius trimaculatus</i>	x	-	11
<i>Labeobarbus marequensis</i>	x	-	-
<i>Labeobarbus polylepis</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis bifurcus</i>	x	-	-
<i>Chiloglanis pretoriae</i>	x	-	2
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparrmanii</i>	x	-	-
Number of species expected	14		
Number of species recorded		1	4
Number of individuals		51	69
Electro-fishing time (minutes)		24	18
Catch/Unit Effort (CPUE)		2.13	3.83

In total four indigenous fish species of a reference expected 14 species was collected (Table 52). All three of the expected small barb species (limnophilic species) were recorded, *Enteromius anoplus*, *Enteromius crocodilensis* and *Enteromius trimaculatus* at relative abundance. The habitat specialists and rheophilic species were absent apart from *Chiloglanis pretoriae* at extreme low abundance (2 individuals). Their absence can be related to loss of available fish habitat as a result of excessive siltation filling interstitial spaces between rocks and cobble. Few of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of all species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of loss of instream habitat due to sedimentation and the presence of alien and invasive fish species (trout). The catch per unit effort (CPUE) was slightly higher at 3.83 (69 individuals; 18 minutes) compared to the 2012 survey CPUE of 2.13 (51 individuals: 24 minutes) indicating low diversity of species and low abundance.

A Fish Ecostatus rating of 59.4% was calculated for this reach based on all available information, placing this reach in an Ecological Category CD (close to largely modified most of the time with low diversity of species) which is a slight improvement to results for the 2012 survey (Fish Ecostatus of 54.6% and an Ecological Category D).

Invertebrates

Two SASS sampling events are on record for the Gladdespruit at the Hermansbrug site (X2GLAD-HERMA), representing one winter and one spring event. A total of 29 SASS taxa have been recorded during the two sampling events, of which 19 were recorded during winter, and 22 in spring surveys. Sensitive rated SASS taxa recorded during both sampling events included Baetidae >2 sp., Chlorocyphidae, and Athericidae.

Table 53: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22C-01004.

X22C-01004	X2GLAD-HERMA	2012	2017	Change
	Total SASS Score	147	118	
	No. of SASS Families	22	19	
	Average Score Per Taxon	6.7	6.2	
	MIRAI Value	Category C 69.8%	Category CD 59.8%	↓
SQ REACH SUMMARY Invertebrate Ecostatus	Category C 69.8%	Category CD 59.8%		

Stream conditions based on MIRAI, deteriorated in 2017 when compared to 2012 (Table 53). In 2012, conditions were rated as moderately impaired (70%), deteriorating to largely to moderately impaired (60%) in 2017. Several taxa expected were absent, and habitat destruction through sedimentation is the main cause for deterioration.

Riparian Vegetation

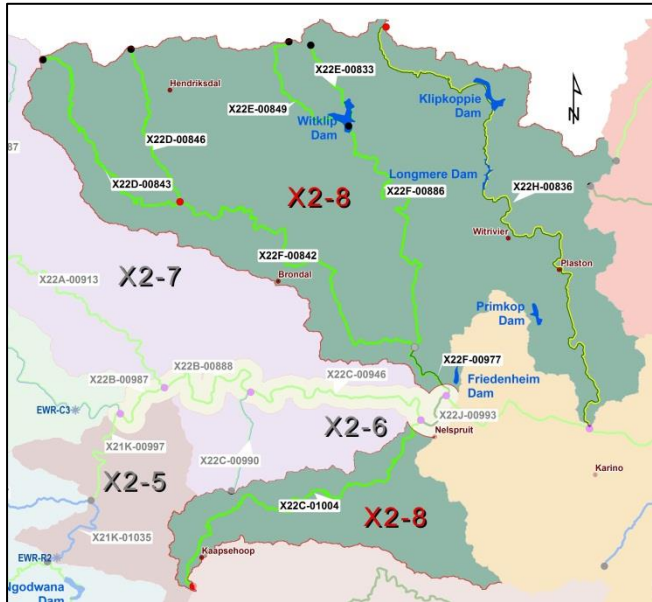
The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 53.89% rating this reach as a Category D indicating a largely modified reach with a large loss and change of natural habitat, biota and basic ecosystems functions. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

X22C-01004: GLADDESPRUIT (RU C12)

Gladdespruit falls with IUA X2-8, which contains two High Priority water quality SQR.

IUA X2-8 - NELS, WIT, GLADDESPRUIT



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
RU C12	X22C-01004	Gladdespruit	B/C*	B/C	3WQ 2
RU C13	X22D-00843	Nels	C	C	2
	X22D-00846		C	C	
	X22E-00849	Sand	C	C	
	X22E-00833	Kruisfonteinspruit	C	C	
	X22F-00842	Nels	C	C	
	X22F-00886	Sand	C	C	
RU C14	X22F-00977	Nels	C/D	C/D	2
	X22H-00836	Wit	D/E	D	

*Representative of the top section of the River

Narrative RQO	Numerical RQO	Notes
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).	No data
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	X Ammonia exceeds the TWQR
Ensure that Mn levels are within Ideal limits or A categories.	95 th percentile of the data must be less than 0.080 mg/L Mn (aquatic ecosystems: driver).	X

Data collected at the monitoring point 1-9826: *Gladdespruit Pappa's Quarry* was used for the assessment.

Summarized results: Water quality state for this reach is non-compliant in terms of a number of parameters. Pappa's Quarry at the confluence of the Gladdespruit and Crocodile River is a source of increased Mn concentrations in both systems.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. Institute more frequent monitoring of toxics to check compliance, as only ammonia and Mn could be assessed for present state. Other toxics monitored were at too low a frequency to be of use.
3. Mn levels were substantially above the RQO, requiring further evaluation of license conditions from effluent discharge points, particularly diffuse effluent loads emanating from the Pappa's Quarry area.

4. Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts.

Impacts for SQR

- Stream bank trampling
- Sedimentation and siltation
- Invasive plant species
- Alien and invasive fish species
- Bank instability and scouring
- Stream crossing creates upstream impoundment
- Stream crossing physical barrier during low flow conditions
- Poor road drainage network

See appendix E

Integrated Ecstatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (68.9%)	Category BC
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural most of the time with few modifications.

TARGET NOT MET





Possible reasons:

Low Fish Ecstatus and low Macro-Invertebrate ratings

Low riparian IHI ratings

Poorly managed forestry related activities results in siltation and sedimentation drastically reducing instream available habitat.

RIVER		TRIBUTARY OF	
Gladdespruit		Crocodile	
SITE NUMBER		REACH	
X2GLAD-HERMA		X22C-01004	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Geomorphological Zone	
Latitude	Longitude	Upper Foothills	
S -25.52147	E 30.87853	Level II	
AQUATIC ECOREGION		Level II	
4. North Eastern Highlands		4.04	
			
<p>Figure A-49. Upstream view of the Gladdespruit site, X2GLAD-HERMA (July 2017, G Diedericks).</p>		<p>Figure A-50. Downstream view of the Gladdespruit site, X2GLAD-HERMA (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X22F-00977

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecotatus	Invertebrate Ecotatus	Instream Ecotatus	Riparian Vegetation Ecotatus	Integrated Ecotatus	TEC	Biomonitoring Year
X22F-00977	X2NELS-R40RO	Nelsriver	S-25.42728 E 30.96444	645	6.7	D	C 75.3%	C 70%	C 72.12%	C 70%	C 71.53%	CD 60%	2012
							C 74.3%	C 76.4%	C 75.4%	C 75%	C 75.3%		2017

General description

Reach X22F-00977: Nels-Sand confluence - Crocodile

The catchment originates in commercial forestry areas, with two main rivers namely the Sand and Nels contributing the system. The upper boundary of the PESEIS reach is the confluence of the Nels and Sand rivers at an elevation of 732 m a.s.l, to the Nelsriver confluence with the Crocodile River at 600 m a.s.l.

The upper portion of the catchment falls within the Northern Escarpment Mountains (10.01) aquatic ecoregion, and the lower portion in the North Eastern Highlands (4.04). The PESEIS reach falls within the Legogote Sour Bushveld (SVI 9), with the catchment further upstream made up with Lydenburg Montane Grassland (Gm 18), and Northern Escarpment Dolomite Grassland (Gm 22). The riparian vegetation is dominated by dense stands of alien plant species.

Commercial forestry (pines plantations) dominates the upper catchment, with agricultural irrigated crops (cultivated fields 7.4%; cultivated orchards 10.7%), saw mills, and livestock dominating the rest. (GEOTERRAIMAGE, 2015). At the site, X2NELSR-R40BR, the instream habitat is dominated by bedrock with sand and limited cobble areas.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22F-0977 was calculated at 84.6% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. Flow regime has been slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

This relatively long reach consist of a small to medium size tributary of the Crocodile River, upstream west of the town of Nelspruit. The (X2NELS-R40RO) site was sampled with the habitat for fish mostly in the form of fast habitat with both deep and shallow habitat in abundance. Both the slow shallow and deep shallow habitat was sparsely present. Rapids and riffles provided fast deep and shallow habitat in abundance with substrate

providing cover through bedrock, boulders and rocks. Cover for the fish was also moderately present as overhanging vegetation at only the fast habitat with sparse undercut banks and root wads.

Table 54: Fish species expected based on the PESEIS Reach Code (X22F-00977) X2NELS-R40RO; is listed, and the numbers of fish species present during the survey is indicated.

X22C-00977	Expected Species	X2NELS-R40RO	
		2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	-
<i>Enteromius crocodilensis</i>	x	-	6
<i>Enteromius eutaenia</i>	x	-	-
<i>Enteromius trimaculatus</i>	x	-	-
<i>Enteromius unitaeniatus</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	-
<i>Labeo molybdinus</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	3
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	-	7
Cichlidae (Cichlids)			
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	-	14
<i>Tilapia sparrmanii</i>	x	-	26
Number of species expected	16		
Number of species recorded		Not Sampled	5
Number of individuals			56
Electro-fishing time (minutes)			26
Catch/Unit Effort (CPUE)			2.15

Five indigenous fish species of an expected 16 species were collected at this site (Table 54). The fish assemblage consisted primarily of the tolerant limnophilic species *Pseudocrenilabrus philander* and *Tilapia sparrmanii* contributing to the majority fish collected. Only one of the five small barb species, *Enteromius crocodilensis*, was recorded with *Enteromius anoplus*, *E. eutaenia*, *E. trimaculatus* and *E. unitaeniatus* absent. Of the flow dependant habitat specialists (rheophilics) only *Chiloglanis pretoriae* was collected in low abundance which can be ascribed to loss of available fish habitat as a result of sedimentation and siltation. The presence of the alien and invasive species (trout) in the upper reaches can also be related to low species diversity and abundance. The catch per unit effort (CPUE) was calculated at 2.15 (56 individuals; 26 minutes) which indicates a low abundance of fish found.

A Fish Ecostatus rating of 74.3% was calculated for this monitoring point based on all available information, placing it in an Ecological Category C (moderately impaired with a low diversity and abundance of fish).

Invertebrates

Four SASS sampling events are on record for the Nelsriver at the R40 Bridge site (X2NELS-R40BR), representing one autumn, two winters, and one spring event. A total of 39 SASS taxa have been recorded during the four sampling events, of which the highest diversity (33) was encountered during the July 2017 survey. Even though sensitive taxa were present, no sensitively rated SASS taxa were recorded during all four sampling events.

Table 55: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22F-00977.

X22F-00977	X2NELS-R40RO	2012	2017	Change
	Total SASS Score	Not sampled	189	
	No. of SASS Families		30	
	Average Score Per Taxon		6.3	
	MIRAI Value		Category C 76.4%	
SQ REACH SUMMARY Invertebrate Ecostatus			Category C 76.4%	Not applicable

Stream conditions, based on MIRAI, were rated as moderately impaired (76%) in 2017 (Table 55). Several taxa expected were absent, with the bedrock dominated habitat most likely one of the main reasons for low scores.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 72.7% rating this reach as a Category C indicating a moderately modified habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (75%) indicating that the riparian vegetation for this SQ reach moderately modified.

Impacts for SQR

- Invasive plant species
- Alien and invasive fish species in upper reaches
- Numerous dams and weirs
- Large scale agricultural developments in catchment
- Siltation and sedimentation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (75.3%)	Category CD
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	The system is in a close to moderately modified condition most of the time.



TARGET MET



Discussion:

This is not a EWR site and the TEC is derived from a PES-EIS desktop assessment (DWA, 2014b) indicating the Ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail. The Integrated Ecostatus of a Category CD would indicate that a more detailed assessment is required.

It is recommended that the TEC for this reach be adapted to reflect a Category BC through integrated catchment management.

RIVER		TRIBUTARY OF	
Nelsriver		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2NELS-R40RO		X22F	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude	Longitude	X22F-00977	
S -25.42728	E 30.96444	Geomorphological Zone	
AQUATIC ECOREGION		Upper Foothills	
4. North Eastern Highlands		Level II	
Level I		4.04	
			
<p>Figure A-51. Upstream view of the Nelsriver site, X2NELS-R40BR (July 2017, G Diedericks).</p>		<p>Figure A-52. Downstream view of the Nelsriver site, X2NELS-R40BR (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X22H-00836

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X22H-00836	X2WITR-VALLE	White River	S-25.40214 E 31.06811	671	59.2	E	C 63.5%	C 77.7%	C 70.60%	E 30%	C 62.48%	D 50%	2012
							D 56.4%	C 67%	CD 61.7%	C 62.5%	CD 61.86%		2017

General description

Reach X22H-00836: White River

The stream originates in commercial forestry areas at an elevation of 1,240 m a.s.l, flowing in a south-south easterly direction through several large dams towards the Crocodile River. There are six relatively large dams on the White River, namely the Kruisfontein, Klipkopjes, Longmeer, Diees, Manchester-Noordwyk, and Primkop. Longmere is the oldest (1940) and deepest dam, Klipkopjes the shallowest with the largest surface area (2.34 km²) and Diees the youngest (1986) and smallest (0.03 km²). Within this reach most of the river habitats have been altered to lentic conditions due to the numerous dams and weirs. The natural flow regime is greatly reduced to the impact and flow regulation from these dams. The catchment is relatively small, 307 km², dominated by commercial forestry (plantations 46%) in its upper reaches and intensive irrigated crop farming (cultivated fields 8% cultivated orchards 56%), with The White River town and town sprawl making up the rest. The PESEIS reach boundary is the source of the White River and the lower boundary the confluence with the Crocodile River at an elevation of 524 m a.s.l.

The upper and lower portions (based on the maps) of the catchment fall within the North Eastern Highlands (4.04), and the middle portion in the Lowveld (3.07) aquatic ecoregions. Based on the vegetation maps, the upper portion of White River falls within the Northern Escarpment Quartzite Sourveld (Gm 23), and the lower portion in the Legogote Sour Bushveld (SVI 9). Land cover comprise of 17.9% thickets and dense bush, 3.1% wetlands and 5.4% grasslands (GEOTERRAIMAGE, 2015).

The White River at the sampling point was <1 to 6 m wide, with no flow, and dominated mostly by bedrock and silt. Hydraulic biotopes include shallow and deep (>0.5 m) pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X22H-00836 was calculated at 55.82% rating this SQ reach as a D category indicating that the instream habitat integrity is largely modified with a large loss of natural habitat, biota and ecosystem functions. (RIVDINT model Crocodile River System, 2017).

Fish

At the (X2WITR-VALLE) site the instream habitat was represented by only shallow pools and deep pools with an absence of any instream flow. Therefore the biotopes present consisted mainly of slow shallow and slow deep with isolated small sections of fast shallow. Cover was very poor consisting primarily of silt and some aquatic macrophytes. These poor habitat parameters is a clear indication of over-abstraction of water and disrupted flow regimes.

Table 56: Fish species expected based on the PESEIS Reach Code (X22H-00836) X2WITR-VALLE; is listed, and the numbers of fish species present during the different surveys are indicated.

X22C-00836	Expected Species	X2WITR-VALLE	
		2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	X	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius eutaenia</i>	x	-	-
<i>Enteromius trimaculatus</i>	x	-	-
<i>Enteromius unitaeniatus</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	-
<i>Labeo molybdinus</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	4	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	-	-
Centrarchidae (Basses and sunfishes)			
<i>Micropterus salmoides</i>		12	1
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	7	7
<i>Tilapia sparrmanii</i>	x	15	16
Number of species expected	14		
Number of species recorded		3 + 12	2 + 1
Number of individuals		38	24
Electro-fishing time (minutes)		34	19
Catch/Unit Effort (CPUE)		1.12	1.26

Of the expected 14 indigenous fish species as derived from the PES-EIS MTPA data base, only two indigenous fish species were recorded (Table 56). The fish assemblage primarily consisted of limnophilic Cichlidae species namely *Pseudocrenilabrus philander* and *Tilapia sparrmanii*. These species have a preference for slow shallow habitats (4.3) and is tolerant to no flow conditions (0), preferring aquatic macrophytes as cover (3.6). They are furthermore tolerant to reduced water quality (0). No rheophilic or habitat sensitive species was recorded as a result of the poor instream habitat and altered habitats. This is a results of disrupted instream flow due to dam regulation. The presence of the predatory alien and invasive *Micropterus salmoides* further contribute to the low


species diversity and low abundance recorded. The catch per unit effort (CPUE) calculated was 1.26 (24 individuals; 19 minutes) indicating a low species diversity and abundance of fish.

A Fish Ecstatus rating of 56.4% was calculated for this monitoring point based on all available information, placing it in an Ecological Category D (largely modified with a low diversity and abundance of species).

Invertebrates

Two SASS sampling events are on record for the White River at this sampling point, X2WITR-VALLE, representing one winter, and one spring event. A total of 40 SASS taxa have been recorded during the two sampling events, of which 30 were recorded during the 2012 spring survey and 28 during the July 2017 survey.

Table 57: Comparison of the 2012 and 2017 SASS5 results for SQ reach X22H-00836.

X22H-00836	X2WITR-VALLE	2012	2017	Change
	Total SASS Score	168	133	
	No. of SASS Families	30	28	
	Average Score Per Taxon	5.6	4.8	
	MIRAI Value	Category C 74.9%	Category C 67.0%	
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 74.9%	Category C 67.0%		

Due to the lack of flow, tolerant taxa dominated in the July 2017 survey. Stream conditions, based on MIRAI, were rated as moderately impaired in 2012 and 2017 (71% and 67%)(Table 57). The large number of dams on the systems, and high water demand in the catchment results in no surface flow at the beginning of the low flow (winter) season, when all other rivers are still flowing. Several taxa expected were absent, all linked to the lack of flow.

Riparian Vegetation

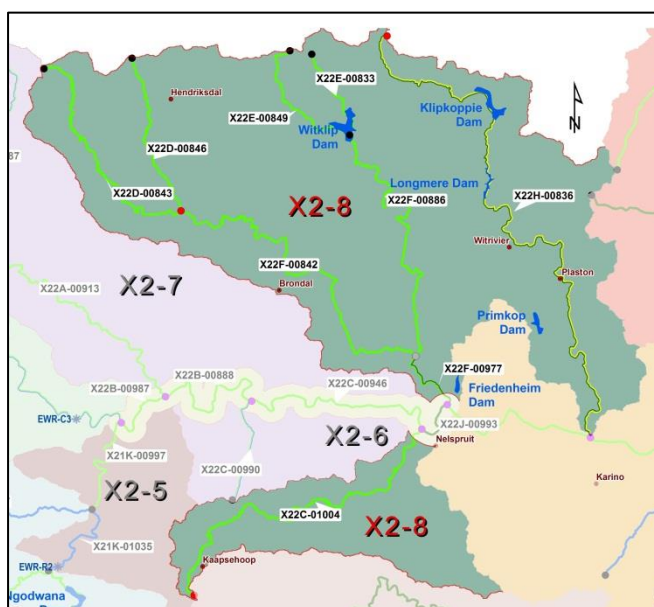
The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 62.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 66.48% rating this reach as a Category C indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (62.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

X22H-00836 (RU C14): WIT RIVIER

IUA X2-8 - NELS, WIT, GLADDESPRUIT

PRIORITY RATINGS



RUs	SQ number	River	PES	TEC	PR
RU C12	X22C-01004	Gladdespruit	B/C*	B/C	3WQ 2
RU C13	X22D-00843	Nels	C	C	2
	X22D-00846		C	C	
	X22E-00849	Sand	C	C	
	X22E-00833	Kruisfonteinspruit	C	C	
	X22F-00842	Nels	C	C	
	X22F-00886	Sand	C	C	
RU C14	X22H-00836	Wit	D/E	D	3WQ 2

*Representative of the top section of the River

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data must be less than 0.125 mg/L PO ₄ -P (aquatic ecosystems: driver).	✓
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).	✓
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	X Mn and NH ₃ -N levels exceeded the TWQR

Data collected at the monitoring point 192544: Longmere Dam @ down stream (Wit River) was the most suitable data available for this assessment. Gauge X2H023Q01, With River @ Goedehoop, stopped monitoring in 1992 so is not suitable for a determination of present state. Data from a site below Klipkoppie Dam but upstream Longmere Dam (monitoring point 190747) was also checked for the assessment.

Summarized results: Water quality state for this reach is non-compliant for toxics, although there was only adequate data to assess the RQO for Mn and NH₃-N. Note that Mn were greatly elevated at the lower site, i.e. monitoring point 190747.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. Institute more frequent monitoring toxics to check compliance, as only ammonia and Mn could be assessed for present state. Other toxics monitored were at too low a frequency to be of use.

- Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts.

Impacts for SQR

- Presence of exotic fish species
- Invasive plant species
- Over abstraction of water due to land use practises
- Numerous instream dams and weirs
- Disrupted flow regime
- Excessive siltation and sedimentation
- Poor road drainage networking

See appendix E



Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category CD (61.86%)	Category D
Close to largely modified habitat with loss and change of natural habitat and biota occurred in terms of frequencies of occurrence and abundance.	Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions have occurred. The resilience of the system to sustain this category has not been compromised and the ability to deliver Ecosystem Services has been maintained.

TARGET MET 

Discussion:

This SQ reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is thus limited, as this site was not assessed in detail. The integrated Ecostatus of a Category D indicate that a more detailed assessment is required.

RIVER		TRIBUTARY OF	
White		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2WITR-VALLE		X22H	
REACH		X22H-00836	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Geomorphological Zone	
Latitude	Longitude	Upper Foothills	
S -25.40214	E 31.06811	671	
AQUATIC ECOREGION		Level II	
4. North Eastern Highlands		Level II	
4.04		4.04	
			
<p>Figure A-53. Upstream view of the White River site, X2WITR-VALLE (July 2017, G Diedericks).</p>		<p>Figure A-54. Downstream view of the White River site, X2WITR-VALLE (July 2017, G Diedericks).</p>	

Discussion Crocodile River Tributaries

Fish

The Crocodile River smaller tributaries are headwater tributaries of different sizes and adventitious tributaries which are low order tributaries to a large mainstem river (Thomas & Hays, 2006). Fish species diversity expected in these tributaries ranges from a minimum of eight species to a maximum of 16 species. The tributaries discussed are Kareekraalspruit, Lunsklip, Alex se Loop, Buffelskloofspruit, Houtbosloop, Gladdespruit, Visspruit, Nels and White River.

Kareekraalspruit, a headwater tributary not on a reach, has an expected reference species diversity of five of which only one species, *Enteromius cf. motebensis* was found in abundance. There is uncertainty regarding the taxonomic status of this species and further genetic studies need to be done for verification. The other headwater tributaries are the Lunsklip, Alex se Loop and Buffelskloofspruit. Within the Alex se loop and Buffelskloofspruit the IUCN endangered red data species, *Kneria sp. nova* 'South Africa' occurs in high abundance together with *Enteromius neefi*. In the Buffelskloofspruit severe water abstraction impacts on the instream habitat of the *Kneria* population. For the Lunsklip River below the escarpment the fish assemblage has been drastically reduced from the reference conditions as the result of aquaculture facility for trout impacting on the water quality. The presence of this NEMBA alien and invasive species impacts on the fish assemblage through predation, fish diseases and habitat competition.

During the 2012 survey, the endangered red data *Chiloglanis bifurcus* was not recorded in the Houtbosloop, as severe forest fires in the catchment in 2010 resulted in extreme siltation and sedimentation reducing available habitat for this and other fish species. During the recent survey sedimentation was not as evident but still present. *Chiloglanis bifurcus* was recorded during the present survey with a relative density in relation to other associated fish species of 6.25% and a CPUE of 0.12 individuals caught per minute. Visspruit, Gladdespruit, Nelsriver and White River are in close proximity of Nelspruit. All of these are heavily impacted on by forestry and urbanisation and species diversity throughout the SQ reaches was low (less than six species) for both the 2012 and 2017 surveys. Within the White River were stream regulation is severe as a result of numerous dams and weirs, the presence of the NEMBA alien and invasive exotic *Micropterus salmoides* further impacted on the fish assemblage.

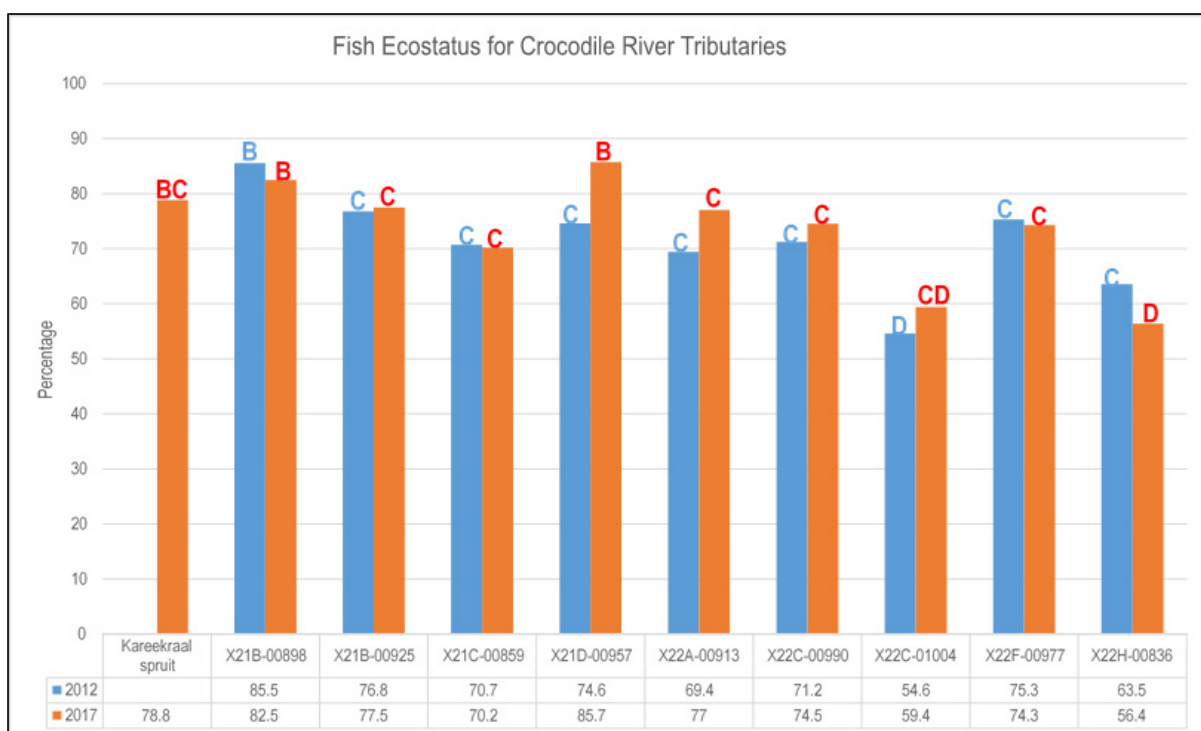


Figure 30: Comparison of the Fish Ecstatus of the Crocodile River tributaries in 2012 and 2017.

The Fish Ecological status for all of the Crocodile River smaller tributaries remains consistent to a Category C (73.6%) indicating a moderately impaired river system. These results remain consistent with the 2012 results (71.2%) also a Category C. Of concern is the low fish Ecstatus of the Lunsklip River (X21B-00925) as well as the White River (X22H-00836) (Figure 30).

Invertebrates

Table 58: A summary of MIRAI results for sites sampled on the tributaries of the Crocodile River in 2012, and 2017, indicating the number of available data on record for the different sampling seasons, and a summary of results for the PESEIS Reaches, indicating change between the 2012 and 2017 results with arrows. Change are indicated with arrows, e.g. ↑ = improvement, ↗ = slight improvement, → = similar conditions, ↘ = slight deterioration, and ↓ = deterioration.

SITE CODE	SITE NAME	YEAR		C	SAMPLING EVENTS					REACH CODE	YEAR		
		2012	2017		Au	Wi	Sp	Su	ALL		2012	2017	CHANGE
X2KAREE-GOLFB	Kareekraalspruit @ Golfcourse		76.7	C	1	4	1	0	6	Not on reach		76.7	
X2LUNS-VERLO	Lunsklip @ Verloren Valei	83.0	81.9	B/C	1	6	5	0	12	X21B-00898	83.0	81.9	↘
X2LUNS-UITWA	Lunsklip @ Uitwaakfontein	83.0	78.4	B/C	1	4	2	0	7	X21B-00925	83.0	78.4	↘
X2ALEX-RIETF	Alex-se-Loop @ Rietfontein	80.6	75.2	C	0	1	1	0	2	X21C-00859	80.6	75.2	↘
X2BUFF-SOMER	Buffelspruit @ In-da-Busshe	74.6	86.3	B	0	2	1	0	3	X21D-00957	74.6	86.3	↗
X2HOUT-SUDWA	Houtbosloop @ Sudwala	84.4	77.8	B/C	0	1	1	0	2	X22A-00913	84.4	77.8	↘
X2VISS-ALKMA	Visspruit @ Alkmaar	71.8	83.2	B	0	1	1	0	2	X22C-00990	71.8	83.2	↗
X2GLAD-HERMA	Gladdespruit @ Hermansburg	69.8	59.8	C/D	0	1	1	0	2	X22C-01004	69.8	59.8	↘
X2NELS-R40RO	Nelsriver @ R40 Bridge		76.4	C	1	2	1	0	4	X22F-00977		76.4	
X2WITR-VALLE	White River	70.9	67.0	C	0	1	1	0	2	X22H-00836	70.9	67.0	↘

SASS data from sites on nine tributaries of the Crocodile River was analysed for a total of 42 sampling events, spanning over a period of 18 years (1999 to 2017) (Table 58). Most of the sampling (55%) was carried out

during the winter, followed by spring (36%), and autumn (10%). In terms of high- and low flow conditions, this suggests 90% of the available data represents low flow conditions, and 10% high flows.

Based on SASS data from previous surveys (mainly 2012), conditions in the Buffelskloofspruit, Swartkoppiespruit, Visspruit rivers improved or were similar.

A deterioration in conditions (Figure 31) are indicated in the Lunsklip, Alex-se-Loop, Leeuspruit, Houtbosloop, Gladdespruit and White River. The main causes for deterioration is generally a combination of factors, but main causes attributed include the following:

- organic pollution (Lunsklip and Leeuspruit);
- habitat deterioration (Houtbosloop, and Gladdespruit);
- over abstraction (White River), and;
- Undetermined (Alex-se-Loop).

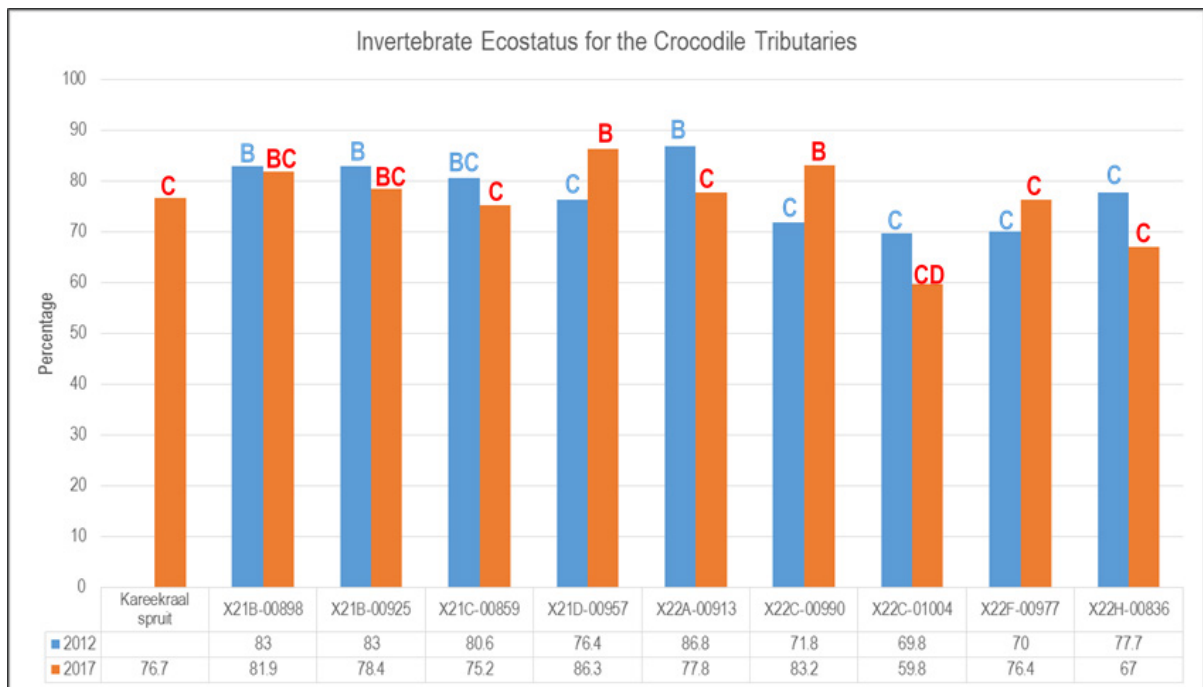


Figure 31: PESEIS Reach Invertebrate categories derived from the RIVDINT model summarised for the Crocodile River tributaries, comparing 2012 to 2017.

Water Chemistry

Conditions in the Gladdespruit and Witrivier tributaries show some deterioration in water quality state. Toxics guidelines were exceeded in the Gladdespruit and Witrivier. It should be noted that toxics monitoring is still poor for most variables. Results should be checked against biological monitoring.

Instream and Integrated Ecostatus Ratings for the Crocodile River Tributaries

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity. From Figure 32 it is evident that the Instream Ecostatus for the 2017 biomonitoring rated an overall Category C (74.9%) and is not consistent for the smaller tributaries of the Crocodile River, ranging from a category B (86%) to a category CD (59.6%). The Instream Ecostatus for 2012 surveys was a consistent C category (74.8%) with recent surveys indicate an improvement at X21D-00957 and decreases at X22C-01004 and X22H-00836 as a result of poor land use practices and mismanagement in the upper catchment primarily associated with forestry related activities.

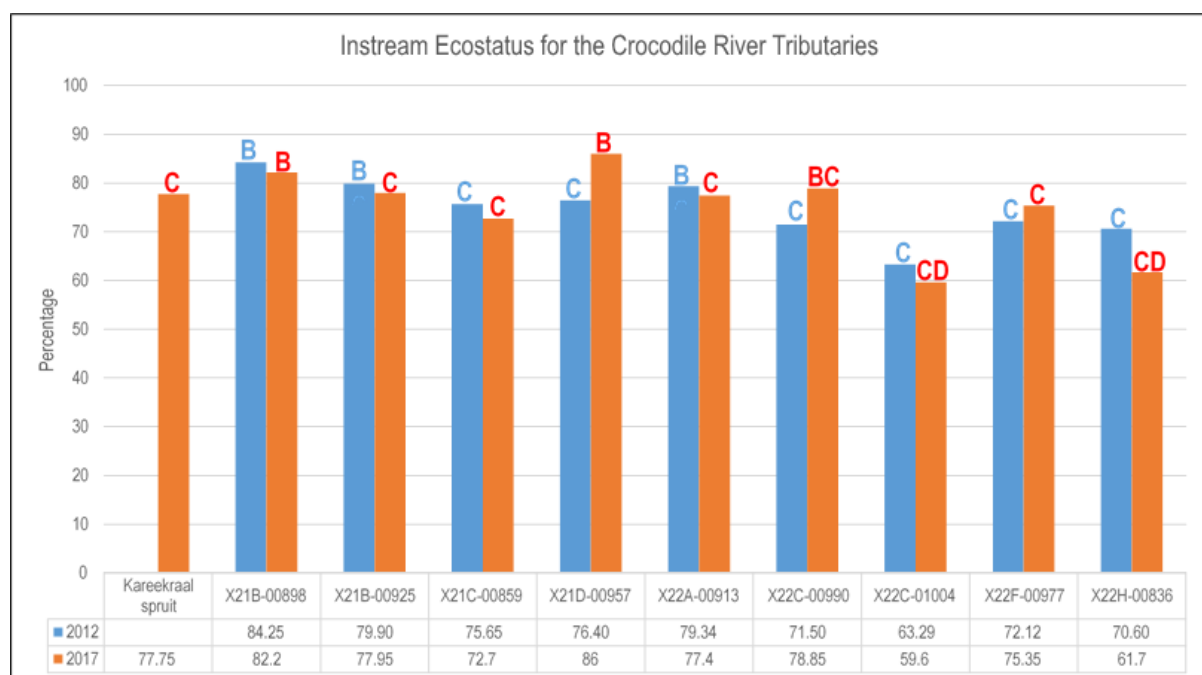


Figure 32: Instream Ecostatus derived from the RIVDINT model for the tributaries of the Crocodile River, comparing 2012 to 2017.

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model (Figure 33). The overall Integrated Ecostatus for the smaller Crocodile River Tributaries remained consistent throughout the 2017 (75.36%) and 2012 (72.46%) monitoring placing the tributaries in a Category C. For the 2017 biomonitoring the Integrated Ecostatus ranged from a category CD (61.86%) to a category B (85.3%) indicating a severely to slightly impaired habitat (Figure 27). Of concern is the low Integrated Ecostatus of the two SQ reaches in the Lunsklip River (X21B-00898 and X21B-00925) which is primarily influenced by the trout related industry where the NEMBA alien and invasive species is released and propagated impacting on the various biological indices. The Integrated Ecostatus of the White River (X22H-00836) has further decreased to a Category CD (61.86%) as a result of

numerous large instream dams severely affecting flow regulation as well as the presence of alien and invasive species in these impoundments.

When comparing the Integrated Ecostatus derived from the RIVDINT model with the Target Ecological Category within the various SQ reaches as per RQO's (DWA, 2014b) care should be taken with the interpretation as it should be noted that no EWR sites exist within these tributaries and the Target Ecological Categories were derived from a low confidence level desk-top assessment PES-EIS. Although it might appear that the targets are met for certain SQ reaches the results from biomonitoring contradict these TEC's indicating that further indepth assessments are required to amend Target Ecological Categories.

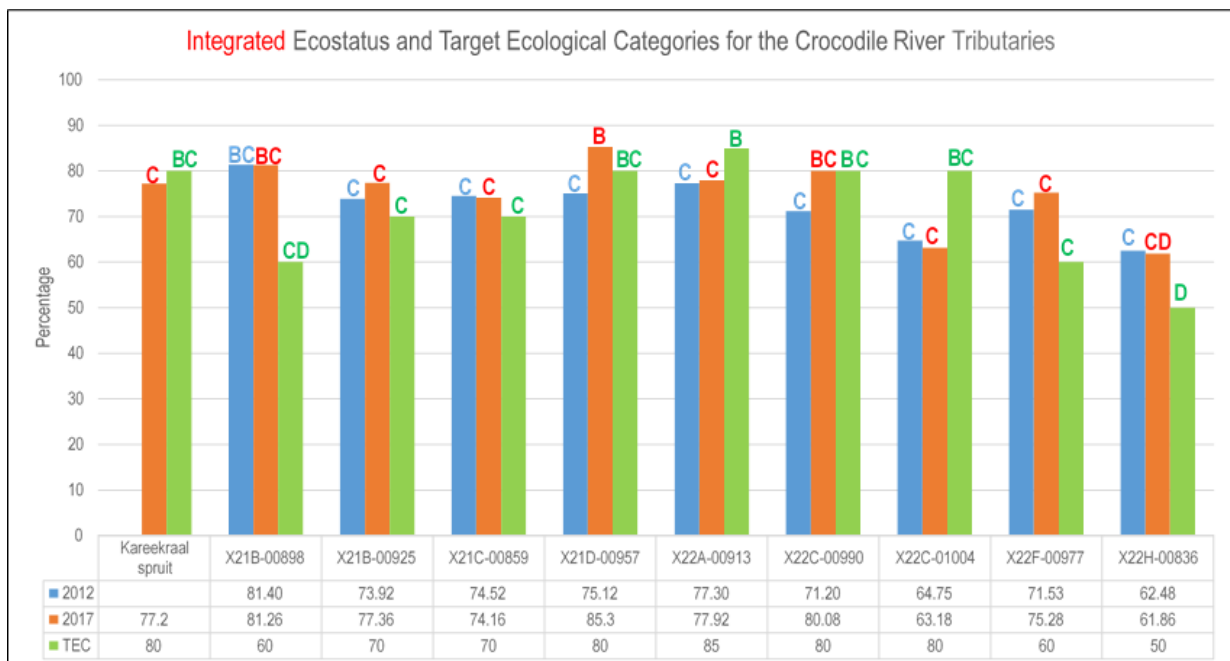


Figure 33: Integrated Ecostatus for the tributaries of the Crocodile River, comparing 2012 to 2017.

Elands River and Tributaries

The Elands River rises in a gentle sloping Highveld zone near the town of Machadodorp at an elevation of 1,904 m m.a.s.l., flowing first in a southerly and then an easterly direction towards its confluence with the Crocodile River at an elevation of 772 m m.a.s.l., located downstream from Montrose Falls and have a steeper gradient for most of its length. The total length of the Elands River is 118km from its source to its confluence with the Crocodile River. There are two natural barriers on the Elands River in the form of waterfalls, one at the Strijdom Tunnel between Waterval Boven and Waterval Onder, and one downstream from Ngodwana, before the river merges with the Crocodile (Figure 3). The water fall at Waterval Boven is an outstanding geomorphological feature of this river reach. It forms a natural, physical barrier to upstream migrating fish species. The river section from Waterval Boven to Ngodwana can be characterised by exceptional riffle and rapid habitats. The total Elands River Catchment area is 1,573 km², of which 22 % was reported as afforested and 0.8 % irrigated in 1994 (Midgley et al. 1994).

Eland River Mainstem

SQ REACH NUMBER X21F-01046

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21F-01046	X2ELAN-DEGOE	Elands	S-25.68720 E 30.19924	1 587	33.4	C	C 71.9%	AB 89.9%	B 83.90%	C 70%	BC 80.69%	C 70%	2012
							BC 78.2%	C 70.9%	C 74.55%	B 82.5%	C 76.14%		2016
							C 64.1%	AB 88.7%	C 76.4%	B 82.5%	BC 79.45%		2017

General description

Reach X21F-01046: Source – Leeuspruit

The source of the Elands River forms the upper boundary of this reach, while its confluence with the Leeuspruit, 36.4 km downstream from the source, forms the lower boundary. The Leeuspruit merge with the Elands River at an elevation of 1,514 m a.s.l. The source of the Elands River at an altitude of approximately 1,910 m. a.s.l. is on a grassland plateau, characterised by a narrow-incised channel. Numerous small farm dams stocked with exotic and invasive trout and bass are typical of this reach.

The De Goede site (X2ELAN-DEGOE) is located within this PESEIS reach. The upper portions of the reach falls within the Eastern Bankenveld (9.02) aquatic ecoregion, and the lower portion falls within the Northern Escarpment Mountains (10.03) aquatic ecoregion (Kleynhans et al. 2005). The entire reach falls within the

Lydenburg Montane Grassland (Gm 18) vegetation type (Mucina et al. 2006). The land cover comprise of 2.3% wetlands and 75.2% grasslands with cultivated commercial fields 11.1% and 7.2% commercial plantations (GEOTERRAIMAGE, 2015).

The Elands River at the De Goede site is 1 to 4 m wide, dominated by cobble, gravel, boulders, and mud-silt. Hydraulic biotopes include riffles, runs, pools, and glides.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21F-01046 was calculated at 80.12% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

All of the fish velocity depth classes was present at the site (X2ELAN-DEGOE) representative of the reach. Slow deep was moderately abundant with slow shallow and fast deep very sparse. Fast shallow habitat was the most abundant depth class present. Large boulders and rocks provided most of the cover for fish as substrate cover, but overhanging vegetation also provided some cover for the fish. Sedimentation was evident in the slow deep habitat which was very much silted up.

Table 59: Fish species expected based on the PESEIS Reach Code (X21F-01046) X2ELAN-DEGOE; is listed, and the numbers of fish species present during the different surveys are indicated.

X21F-01046	Expected Species	X2ELAN-DEGOE		
		2012	10/2016	07/2017
Cyprinidae (Barbs, Yellow-fishes and Labeos)				
<i>Enteromius anoplus</i>	x	-	-	-
Centrarchidae (Basses and sunfishes)				
<i>Micropterus salmoides</i>		-	-	1
Cichlidae (Cichlids)				
<i>Pseudocrenilabrus philander</i>	x	-	7	-
<i>Tilapia sparrmanii</i>	x	-	36	-
Number of species expected	3			
Number of species recorded		Not Sampled	2	1
Number of individuals			43	1
Electro-fishing time (minutes)			31	36
Catch/Unit Effort (CPUE)			1.39	0.03

Three indigenous fish species were expected to occur in this reach (Table 59). During the 2016 two of the expected fish species, the more tolerant cichlids, *Pseudocrenilabrus philander* and *Tilapia sparrmanii*, were recorded. However, no indigenous fish species were recorded during the present survey. Only the alien and invasive *Micropterus salmoides* was collected. None of the expected fish species are present within this resource

unit and the Frequency of Occurrence (FROC) of all species has been reduced from the reference conditions as a result of loss of instream habitat and the presence of alien and invasive fish species.


A Fish Ecstatus rating of 64.1.% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low diversity and abundance of species) indicating a deterioration in the fish assemblage from a Category BC (78.2 %) in 2016.

Invertebrates

Six SASS sampling events are on record for the De Goede site (X2ELAN-DEGOE), located on the Elands River. The sampling represents one autumn, three winters, and two spring sampling events. A total of 51 SASS taxa have been recorded during these five sampling events, of which 30 taxa in total were recorded during winter surveys and 42 in spring. The sensitive rated SASS taxa Baetidae > 2 sp., Heptageniidae, Leptophlebiidae, and Tricorythidae were recorded during all five sampling events. Of the total number of SASS taxa recorded at the site, 58 – 90% was recorded during winter surveys and 51 – 86% during spring surveys.

Taxa diversity increased since monitoring was initiated in 1999, from 17 SASS taxa in May 1999 to 37 in July 2017. Increased diversity could be linked to enrichment (increased food), but also due to slight changes in sampling methods. SASS4 combined all biotopes in one sample and one identification tray, while SASS5 splits biotopes into three samples and trays.

Table 60: Comparison of the 2016 and 2017 SASS5 results for SQ reach X21F-01046.

X21F-01046	X2ELAN-DEGOE	2012	2016	2017	Change
	Total SASS Score	Not sampled	197	236	
	No. of SASS Families		32	37	
	Average Score Per Taxon		6.2	6.4	
	MIRAI Value		Category C 70.9%	Category A/B 88.7%	
SQ REACH SUMMARY Invertebrate Ecstatus		Category C 70.9%	Category A/B 88.7%		

The 2017 SASS5 results indicates improved conditions when compared to 2016, and similar conditions when compared to 2012 (Table 60). The site in the 2016 survey was affected by a severe drought and low flow conditions (see Figure XX). Conditions in the PESEIS reach based on MIRAI were rated as largely natural to natural (Category A/B – 89%) in September 2012 and July 2017.

Riparian Vegetation

The X2ELAN-DEGOE site was assessed in this SQ reach

Marginal Zone: This zone is dominated by grass and sedge species. This include species like *Imperata cylindrica*, *Paspalm distichum*, *Juncus punctorius* and *Typha capensis*, This zone has low woody and high non-woody cover as well as abundance. The species composition does resemble the reference state but due to changes that include damming of river some woody species may have disappeared. The water quantity is

normal for this time of year and the quality is good. Some exotics were noted consisting mainly of *Pennisetum clandestinum*.

Non Marginal Zone: This zone is dominated by grass and some herb species. This zone has low woody and high non-woody cover as well as abundance. The species composition does resemble the reference state but some changes due to town development are expected. The dominant non-woody species include *Imperata cylindrica*, *Cynodon dactylon*, *Themedia triandra*, some exotics were noted consisting mainly of *Oenothera rosea* and *Verbena tenuisecta* and *Salix babylonica*

The Level III VEGRAI Assessment range for this EWR site assessed is 93.3% and is consistent with a Category A – largely natural with few modifications. The Riparian IHI was calculated at 77.52% rating this reach as a Category C indicating moderately modified with a loss and change of natural habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Impacts for SQR

- Presence of exotic fish species
- Invasive plant species
- Bank scouring and sedimentation

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category BC (79.45%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET



Discussion:

This is not a EWR site and the TEC is derived from a PES-EIS desktop assessment (DWA, 2014b) indicating the Ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail. The Integrated Ecostatus of a Category C would indicate that a more detailed assessment is required.

It is recommended that the TEC for this reach be adapted to reflect a Category BC through integrated catchment management.



RIVER		TRIBUTARY OF			
Elands		Crocodile			
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH	
X2ELAN-DEGOE		X21F		X21F-01046	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Longitude	Elevation (m. a.s.l.)	Geomorphological Zone	
S -25.68720		E 30.19924	1 587	Upper Foothills	
AQUATIC ECOREGION		Level I		Level II	
10. Northern Escarpment Mountain				10.3	
					

Figure A-55. Upstream view of the De Goede site, X2ELAN-DEGOE, on the Elands River (July 2017, G Diedericks).

Figure A-56. Downstream view of the De Goede site, X2ELAN-DEGOE, on the Elands River (July 2017, G Diedericks).

SQ REACH NUMBER X21G-01037 (EWR ER 1)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21G-01037	X2ELAN-WATER EWR ER1	Elands	S-25.63188 E 30.32415	1 390	19.7	D	C 72%	AB 88.1%	BC 80.05%	C 70%	BC 78.04%	B 85%	2012
	X2ELAN-DOORN		S-25.64619 E 30.37677	1 213			C 74.9%	CD 59%	C 66.95%	C 75%	C 68.56%		2016
							C 75.1%	C 76.9%	C 76%	C 75%	C 75.5%		2017

General description

Reach X21G-01037: Rietvleispruit - Weltevredepruit

The upper boundary of the PESEIS reach is from the Rietvleispruit confluence (1,505 m. a.s.l.) to the Weltevredepruit confluence at an elevation of 1,200 m a.s.l., at a length of 19.7 km. The PESEIS reach includes the Waterval Boven Waterfall, a natural barrier to fish movement. The Blouboskraalspruit and Joubertspruit represents some of the named tributaries entering the Elands River within this reach. Two sites are located within this PESEIS reach, X2ELAN-WATER and X2ELAN-DOORN. The X2ELAN-WATER is located 2.9 km upstream from the Waterval Boven Waterfall, and the X2ELAN-DOORN site 6.6 km downstream from the waterfall. Although both sites are located on one SQ reach X21G-01037 the fish assemblage in the upper section differ from that of the lower section of the reach. Furthermore the SQ reach is divided into two Resource Units with the X2ELAN-WATER located in RU1 and the X2ELAN-DOORN situated in RU2. X2ELAN-WATER is also and Environmental Water Requirement site (EWR ER1), used for the determination of Catchment Water Resource Classes and associated Resource Quality Objectives.

The reach falls within two level II aquatic ecoregions, namely the Eastern Bankenveld (9.02), and the Northern Escarpment Mountains (10.02, and 10.03) (Kleynhans et al. 2005). The PESEIS reach above the waterfall are within the Lydenburg Montane Grassland (Gm 18) vegetation type, while the river downstream from the waterfall is located within the Legogote Sour Bushveld (SVI 9) (Mucina & Rutherford 2006). Land cover comprise of thickets and dense bush (4%), open woodlands (2.2%) and grasslands (77.8%) with cultivated fields (3.2%) and plantations (9.2%) (GEOTERRAIMAGE, 2015).

The X2ELAND-WATER is located close to a cliff-face, which dominates a large portion of the left streambank. Shrubs dominate the immediate riparian vegetation and open grass dominated woodland the surrounding catchment area. The stream falls within the upper foothills geomorphical zone, dominated by alluvial bedrock, with cobbles and silt depositions in pools. Hydraulic biotopes were represented by cascades, rapids, riffles, runs,

glides, and pools. The Elands River at the Waterval Boven site is 3 - 10 m wide. Algal growth was dominant during the 2016 and 2017 site visits indicating high upstream inputs of nutrients. The stream canopy can be described as partially closed.

At the X2ELAN-DOORN site shrubs with grasses, reeds and herbaceous vegetation dominate the immediate riparian vegetation, and an open grass dominated woodland the surrounding area catchment. The stream falls within the upper foothill geomorphological zone dominated by alluvial bedrock with cobbles and silt depositions in the pools. The Elands River at the Doornhoek site is 4 - 10 m wide, dominated by cobble, gravel, boulders, sand, silt, and mud. Hydraulic biotopes included rapids, riffles, runs, glides, and pools. The submerged aquatic *Stuckenia pectinate* (previously *Potamogeton pectinatus*) or fennel-leaved pondweed, is present and abundant. The species is mostly indicative of slow flowing nutrient-rich waters (Cook 2004).

Instream Habitat Integrity

The Instream IHI for the SQ reach X21G-01037 was calculated at 74.44% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

Two sites were sampled (X2ELAN-WATER; X2ELAN-DOORN) representing the entire reach X21G-01037. Although both sites are located on one SQ reach, the fish assemblage in the upper section differs from the lower section. This is due to the natural migrational obstruction caused by the Waterval Boven waterfall, as well as the lower section classified as a transitional zone towards more temperate Lowveld species.

In the upper section X2ELAN-WATER (EWR ER1) the fish velocity depth classes consisted of slow shallow (moderate), fast shallow (abundant), fast deep (moderate) and slow deep (sparse). Most of the cover present was in the fast shallow habitat were overhanging vegetation, undercut banks and substrate (bedrock, rocks, boulders and pebbles) provided cover for fish. Most of this substrate was however covered with silt and algae, reducing the instream habitat availability to fish.

In this upper section a total of three indigenous fish species of an expected 5 fish species were recorded for the 2012, 2016 and 2017 surveys at varying abundance (Table 61). Two tolerant limnophilic species *Pseudocrenilabrus philander* and *Tilapia sparrmanii* were recorded in relative abundance. The abundance of the rheophilic and habitat specialist *Amphilius uranoscopus* was, however, recorded at extremely low abundances. This species has a flow depth preference for fast deep and fast shallow (4.6) biotopes and a high preference for substrate (5), with an intolerance to reduced water quality (4.8). The reduced water quality from the Emgwenya WWTW thus negatively impact on this species and further contribute to organic enrichment resulting in excessive

algae growth reducing available instream fish habitat. The CPUE for this upper section of the reach remained consistent from 2012 through to 2017 with the present survey calculated at 0.89 (41 individuals; 46 minutes). A Fish Ecstatus rating for this site based on all available information was calculated at 71.2%, placing this reach in an Ecological Category C (moderately impaired with a low abundance of fish).

At X2ELAN-DOORN in the lower section of the reach, below the waterfall, the fish velocity depth classes present was slow deep (sparse), slow shallow (moderate), fast shallow (abundant) and fast deep (sparse). Overhanging vegetation was very abundant with undercut banks and root wads present in the fast shallow habitats. Rapids, riffles and runs with bedrock, boulders and rocks provided good substrate cover for fish.

Table 61: Fish species expected based on the PESEIS Reach Code (X21G-01037) X2ELAN-WATER; X2ELAN-DOORN; is listed, and the numbers of fish species present during the different surveys are indicated.

X21G-01037	Expected Species	X2ELAN-WATER			Expected Species	X2ELAN-DOORN		
		2012	2016	2017		2012	2016	2017
Anguillidae (Freshwater Eels)								
<i>Anguilla mossambica</i>	x	-	-	-	x	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)								
<i>Enteromius anoplus</i>	x	-	-	-	x	-	4	3
<i>Enteromius crocodilensis</i>					x	-	-	-
<i>Enteromius paludinosus</i>					x	-	7	5
<i>Labeobarbus polylepis</i>					x	-	16	1
Amphiliidae (Mountain Catfishes)								
<i>Amphilius uranoscopus</i>	x	2	6	2	x	-	3	4
Mochokidae (Squeakers, suckermouth catlets)								
<i>Chiloglanis bifurcus</i>					x	-	-	3
<i>Chiloglanis pretoriae</i>					x	-	32	30
Cichlidae (Cichlids)								
<i>Pseudocrenilabrus philander</i>	x	1	29	6	x	-	14	7
<i>Tilapia sparrmanii</i>	x	8	14	33	x	-	3	13
Number of species expected	5				10			
Number of species recorded		3	3	3		Not Sampled	7	8
Number of individuals		11	49	41			79	66
Electro-fishing time (minutes)		43	32	46			43	44
Catch/Unit Effort (CPUE)		0.26	1.53	0.89			1.84	1.50

In the lower section representative of a transitional zone with more temperate species, eight of the expected 10 indigenous fish species were collected (Table 61). Three of the Cyprinidae species namely *Enteromius anoplus*, *Enteromius paludinosus* and *Labeobarbus polylepis* were recorded. Of the rheophilic habitat specialists three species were collected (*Amphilius uranoscopus*, *Chiloglanis bifurcus* and *Chiloglanis pretoriae*) at relative abundance. The presence of the endangered red data IUCN *Chiloglanis bifurcus* is of significance as it historically occurs in the Crocodile and Elands River and certain of its sub-tributaries (Elands, Ngodwana, Gladdespruit and Stadspruit) (Kleynhans, 1984). This species inhabit the interstitial spaces of loose rocks with a diameter ranging from 0.1m to 0.5m. They occur together with several other fish species which include *Amphilius*

uranoscopus and *Chiloglanis Pretoriae* (Kleynhans, 1984). The presence of the endangered IUCN red data species *Chiloglanis bifurcus* indicate the importance of this SQ reach as a refuge stream for this species, and should therefore be realised and receive special conservation measures. Two limnophilic Cichlidae species, *Pseudocrenilabrus philander* and *Tilapia sparrmanii* complete the fish assemblage. These species are intolerant to water quality changes with a preference to slow shallow and slow deep habitats. The CPUE for this lower section compared favourably with the 2016 results with the CPUE of 1.50 (66 individuals; 44 minutes) for the present survey. A Fish Ecstatus rating of 78.9% was calculated for this site, placing it in an Ecological Category BC (close to largely natural with few modifications most of the time).

An overall mean Fish Ecstatus rating for SQ reach X21G-01037 was calculated at 75.15 based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low abundance of fish) which is consistent with previous survey.


Invertebrates

At the Waterval Boven (X2ELAN-WATER) and Doornhoek (X2ELAN-DOORN), five SASS sampling events each are on record, carried out October 1996, August 2000, September 2012, October 2016, and July 2017. These represent two winter and three spring sampling events.

At the Waterval Boven site, a total of 46 SASS taxa have been recorded during these five sampling events, of which 26 taxa in total were recorded during winter surveys and 44 in spring. Sensitive rated SASS taxa recorded during all five sampling events included Baetidae >2 sp., Leptophlebiidae, and Tricorythidae. Tolerant taxa were dominant during most of the surveys.

At the Doornhoek site, a total of 45 SASS taxa have been recorded during the five sampling events, of which 37 taxa in total were recorded during the winter surveys and 39 in spring. Sensitive rated SASS taxa frequently recorded included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, and Tricorythidae.

Table 62: Comparison of the 2012, 2016 and 2017 SASS5 results for SQ reach X21G-01037.

X21G-01037	X2ELAN-WATER	2012	2016	2017	
	Total SASS Score	Not sampled	181	172	
	No. of SASS Families		33	28	
	Average Score Per Taxon		5.5	6.1	
	MIRAI Value		Category C 60.8%	Category C 71.1%	
	X2ELAN –DOORN	2012	2016	2017	
	Total SASS Score	184	169	218	
	No. of SASS Families	30	28	34	
	Average Score Per Taxon	6.1	5.8	6.4	
	MIRAI Value	Category A/B 88.1%	Category D 57.1%	Category B 82.7%	Change
SQ REACH SUMMARY Invertebrate Ecstatus	Category A/B 88.1%	Category CD 59.0%	Category C 76.7%		

At the Waterval Boven site (X2ELAN-WATER), conditions based on MIRAI were rated as moderately impaired in 2016 and 2017. The stream is dominated by algae and Porifera, which could indicate increased suspended solids and nutrients in well oxygenated waters, Porifera are filter feeders (Heeg 2002). Stream flow levels were extremely low during the 2016 site visit, and the poor water quality entering the river from the Emgwenya Waste Water Treatment Works (IUCMA 2015) were therefore more concentrated.

At the Doornhoek site (X2ELAN-DOORN), conditions based on MIRAI were rated as slightly impaired to natural (88%) in 2012, deteriorating to severely impaired (57%) in 2016, and improving to slightly impaired (82%) in 2017 (Table 62). Deterioration in 2016 are attributed to low stream flow conditions during the sampling period, with high density of aquatic plant growth (algae and pondweeds) and decomposing organic material most likely affecting available oxygen levels. Conditions in 2017 improved from the Waterval Boven to the Doornhoek site. The PESEIS reach, X21G-01037, was categorised as moderately impaired (77%), with impairment mostly attributed to the influence of the waste water management of the Emgwenya WWTWs on the Elands River.

Riparian Vegetation

The EWR ER1 (X2ELAN-WATER) site was assessed in this SQ reach X21G-01037.

Marginal Zone: This zone is dominated by shrubs with some grass and reed species present. This include species like *Salix mucronata*, *Cliffortia linearifolia*, and *Juncus effusus*. This zone has high woody and low non-woody cover as well as abundance. The species composition does resemble the reference state. The water quantity is normal for this time of year and the quality is good but signs of eutrophication are present. *Sesbania punicea* was noted in this zone as an exotic invader.

Non Marginal Zone: This zone is dominated by grass and some herb species. This zone has low woody and high non-woody cover as well as abundance. The species composition does resemble the reference state but some changes due to town development are expected. The dominant non-woody species include *Imperata cylindrica*, *Cynodon dactylon*, *Themedia triandra* and *Hypoxis hemerocallidea*. Exotics were noted consisting mainly of *Sesbania punicea*, *Eucalyptus grandis*, *Acacia dealbata* and *Verbena tenuisecta*.

The Level III VEGRAI Assessment range for this EWR ER1 site assessed is 77.6% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 81.36% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category C (75%) indicating that the riparian vegetation for this SQ reach is close to moderately modified.

Water Quality

IUA X2-3 - UPPER ELANDS AND TRIBUTARIES TO WATERVAL BOVEN

PRIORITY RATINGS



RUs	SQ number	River	PES	TEC	PR
MRU Elan A	X21F-01046	Elands	C	C	3 3WQ
	X21F-01081	Elands	C	C	
	X21G-01037 ER 1	Elands	B	B	
RU C7	X21F-01100	Leeuspruit	C	C	3WQ
	X21F-01091	Rietveispruit	C	C	2
	X21F-01092	Leeuspruit	C/D	C/D	

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	✓
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).	✓
Ensure that pH stays within Ideal limits.	5 th and 95 th percentiles of pH data must be between 6.5 and 8.0 (aquatic ecosystems: driver).	Slightly elevated over 8.0 (8.6)
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996b) and DWAF (2008b).	Ammonia in a B category
Ensure that Cr-VI levels are within Ideal limits or A categories.	95 th percentile of the data must be less than 0.014 mg/L Cr-VI (aquatic ecosystems: driver).	No data
Ensure that Mn levels are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).	✓

The original water quality assessment was conducted as part of the 2000 Elands River Intermediate Reserve study (DWAF, 2000) and the 2004 re-assessment of the results by Environmentek, CSIR, as part of the Elands Catchment Comprehensive Reserve Determination Study. EcoSpecs and TPCs were not prepared as part of either these studies.

Data collected at the DWS monitoring point *Elands River upstream of Waterval Boven s/w* was used for the assessment. Note that data used was from 2004-2016 and that no Reference Condition (RC) data were available. Categories in benchmark tables (DWAF, 2008) were therefore used as RC.

Summarized results for EWR ER1: Water quality at this site has met most of the RQOs, but with pH and ammonia elevated slightly above the RQO. Note that few toxics data were available for analysis.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts, considering the few data points available for a number of parameters.

2. Institute Cn monitoring at this monitoring point.
3. Evaluate the sources of elevated pH and ammonia levels, particularly if impacts are evident in the biotic data.

Impacts for SQR

- Reduced water quality due to impacts from WWTW
- Invasive plant species
- Organic enrichment
- Excessive algae and macrophytes growth
- Domestic waste in stream and riparian zone
- Siltation and sedimentation from land use practises in upper catchment

See appendix E

Integrated Ecstatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (75.5%)	Category B (85%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural with few modifications



TARGET NOT MET 



Possible reasons:

- Reduced water quality due to WWTW
- Impact of residential and industrial areas
- Urban run off as well as other urban environmental pollutions
- Sedimentation impact on habitat diversity

Chiloglanis bifurcus (endangered IUCN red data) occurs within this reach. The Elands River and its tributaries has been identified as a priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPA) (Driver *et al.* 2011). Integrated Catchment Management should therefore address all problems in order to meet the Resource Quality Objects as gazetted (DWA, 2017).

This SQ Reach should be managed at a TEC of 85% Category B as set in RQO's.

RIVER		TRIBUTARY OF	
Elands		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2ELAN-WATER (EWR ER1)		X21G	X21G-01037
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Elevation (m. a.s.l.)	Geomorphological Zone
	S -25.63188	1 390	Upper Foothills
AQUATIC ECOREGION		Level I	Level II
10. Northern Escarpment Mountains			10.3
			
<p>Figure A-57 Upstream view of the Waterval Boven site, X2ELAN-WATER, on the Crocodile River (July 2017, G Diedericks).</p>		<p>Figure A-58. Downstream view of the Waterval Boven site, X2ELAN-WATER, on the Crocodile River (July 2017, G Diedericks).</p>	

RIVER		TRIBUTARY OF	
ELANDS		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2ELAN-DOORN		X21G	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude		X21G-01037	
S -25.64619		Geomorphological Zone	
Longitude		Upper Foothill	
E 30.37677		Level II	
AQUATIC Ecoregion		Level II	
10. Northern Escarpment Mountains		10.2	
			
<p>Figure A-59. Upstream view of the Doornhoek site, X2ELAN-DOORN, on the Elands River (July 2017, G Diedericks).</p>		<p>Figure A-60. Downstream view of the Doornhoek site, X2ELAN-DOORN, on the Elands River (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X21J-01013

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21J-01013	X2ELAN-HEMLO	Elands	S-25.60042 E 30.55969	991	35	C	C 76%	AB 88.9%	B 82.45%	D 50%	C 75.96%	BC 80%	2012
							C 77.2%	D 51.6%	C 64.4%	C 75%	C 66.52%		2016
							C 77.2%	C 69%	C 73.1%	C 75%	C 73.5%		2017

General description

Reach X21J-01013: Swartkoppiespruit - Ngodwana

The Swartkoppiespruit confluence at an elevation of 1,167 m a.s.l. forms the upper boundary of this PESEIS reach, flowing for 35.2 km to its downstream boundary at the Elands' confluence with the Ngodwana River (903 m. a.s.l.). Several unnamed tributaries contribute to the volume of water in the Elands River, with named tributaries including the Swartkoppiespruit, Skoonspruit, Goedverwagchtingspruit, Sycamore Valley, Mahonamien, and the Rietspruit. The Hemlock site (X2ELAN-HEMLO) falls within this reach, and the two level II aquatic ecoregions. These level II aquatic ecoregions (10.2 and 10.3) are both in the Northern Escarpment Mountains (Kleynhans et al. 2005), with the entire PESEIS reach falling within the Legogote Sour Bushveld (SVI 9) vegetation type (Mucina & Rutherford 2006). Landcover comprise of indigenous forest (2.8%), thickets and dense bush (20%), woodlands and open bush (3.2%) and grasslands (32.7%). Land use practises in the reach include cultivated commercial fields of 2.44% and commercial plantations of 36.54% (GEOTERRAIMAGE, 2015). Citrus orchards and small communities are the main upstream landuses. A substantial amount of water at the Hemlock weir are diverted into a ground base channel towards a pump house on the farm Vlakplaats 476 JT. Over-abstraction at this site appear to be a major problem. The Hemlock site is located upstream from the Sappi Ngodwana Pulp and Paper Mill, as well as the influence of the irrigated return flow of the mills' irrigated effluent.

The Elands River at the Hemlock site is 6 – 30 m wide and the stream falls within the upper foothill geomorphological zone, dominated by alluvial cobble bed, riffles, runs, glides and pools. The riparian zone are dominated by reeds, invasive weeds, grasses, herbaceous plants, shrubs and trees and the stream canopy can be described as partially shaded. Invasive plants are abundant with the degree of infestation estimated at 20 – 40%.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21J-01013 was calculated at 75.72% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The X2ELAN-HEMLO has been sampled regularly since 2012 and the instream habitat remained consistent over the period consisting a high diversity of habitat types consisting of both fast and shallow flow velocity depth classes ideally for flow dependent species. Higher flow conditions were encountered during the present survey compared to the 2016 low flow conditions. Substrate cover for fish was provided by boulders, rocks and cobbles. Cover was also moderately present as overhanging vegetation, undercut banks and root wads and aquatic macrophytes.

Table 63: Fish species expected based on the PESEIS Reach Code (X21J-01013) X2ELAN-HEMLO; is listed, and the numbers of fish species present during the different surveys are indicated.

X21J-01013	Expected Species	X2ELAN-HEMLO				
		2012	2013	2014	2016	2017
Anguillidae (Freshwater Eels)						
<i>Anguilla mossambica</i>	x	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)						
<i>Enteromius anoplus</i>	x	-	-	-	-	-
<i>Enteromius crocodilensis</i>	x	52	82	71	36	37
<i>Enteromius paludinosus</i>		-	-	-	-	13
<i>Labeobarbus polylepis</i>	x	28	6	7	-	-
Characidae (Characins)						
<i>Micralestes acutidens</i>		-	-	-	783	-
Amphiliidae (Mountain Catfishes)						
<i>Amphilius uranoscopus</i>	x	7	28	11	53	7
Mochokidae (Squeakers, suckermouth catlets)						
<i>Chiloglanis bifurcus</i>	x	-	-	3	-	-
<i>Chiloglanis pretoriae</i>	x	13	107	88	89	59
Cichlidae (Cichlids)						
<i>Pseudocrenilabrus philander</i>	x	3	5	14	4	6
<i>Tilapia sparrmanii</i>	x	11	12	9	59	33
Number of species expected	9					
Number of species recorded		6	6	7	6	6
Number of individuals		114	240	203	1024	155
Electro-fishing time (minutes)		40	30	32	38	56
Catch/Unit Effort (CPUE)		2.85	8.00	6.34	26.95	2.77

Nine indigenous fish species is expected to occur in this reach of which six were collected during this survey (Table 63). The species abundance remained consistent apart from the 2016 survey during the drought low flow conditions when *Micralestes acutidens* were confined to a pool and collected in extreme abundance, skewing the CPUE for that survey. During the present survey the endangered IUCN red data species *Chiloglanis bifurcus* was not recorded, previously recorded in 2014 when three individuals were collected. For the other rheophilic habitat

specialists *Amphilius uranoscopus* and *Chiloglanis pretoriae*, the trend indicate a decrease in abundance. The absence or reduced abundance of these flow sensitive species that is highly intolerant to reduced water qualities indicate a skewed fish assemblage for this reach. Of concern is the absence of the large barb, *Labeobarbus polylepis*, which was not found during the last two surveys (2016 and 2017). Their absence can be related to disrupted instream flow requirements as a result of over-abstraction of water and reduced water quality. Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of species recorded has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has declined as a result of over-abstraction and flow regulation, loss of instream habitat due to sedimentation, as well as reduced water quality.

The catch per unit effort (CPUE) was recorded as 2.77 (155 individuals; 56 minutes) indicating a reducing trend in abundance of fish since 2012. A Fish Ecstatus rating of 77.2% was determined placing the reach in an Ecological Category C (moderately impaired with low abundance of fish) which is consistent to what was found during the previous surveys.

Invertebrates

Twenty SASS sampling events are on record for the Hemlock site (X2ELAN-HEMLO) on the Elands River, carried out since July 1993. These represent three autumns, seven winters, and ten spring sampling events. A total of 58 SASS taxa have been recorded during these 20 sampling events, of which 44 was recorded during autumn, 51 during winter, and 53 during spring surveys. On average, 46% of the taxa previously recorded are present during each sampling event. Sensitive rated SASS taxa recorded during most sampling events (high frequency of occurrence) included Heptageniidae, Leptophlebiidae, and Tricorythidae.

Table 64: Comparison of the 2012, 2016 and 2017 SASS5 results for SQ reach X21J-01013.

X21J-01013	X2ELAN-HEMLO	2012	2016	2017	Change
	Total SASS Score	192	151	171	
	No. of SASS Families	29	26	28	
	Average Score Per Taxon	6.6	5.8	6.1	
	MIRAI Value	Category A/B 88.9%	Category D 51.6%	Category C 69.0%	↓
SQ REACH SUMMARY Invertebrate Ecstatus	Category A/B 88.9%	Category D 51.6%	Category C 69.0%		

Based on the 2017 SASS5 results, MIRAI indicates deterioration in conditions compared to 2012, but an improvement compared to 2016 (Table 64). In 2012, conditions based on MIRAI was categorised as slightly impaired (89%), severely impaired (52%) in 2016, and moderately impaired (69%) in 2017. Low flow conditions combined with poor water quality, and high numbers (>1 000 individuals) of an introduced omnivorous fish species (*Micralestes acutidens*) might be the cause of deteriorated conditions at the Hemlock site in 2016.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 64.18% rating this reach as a Category C indicating a moderately modified habitat with loss and change of natural habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (75%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

X21G-01073; X21J-01013 (MRU ELAN B): ELANDS RIVER

IUA X2-4 - ELANDS RIVER AND TRIBS DS OF WATERVAL BOVEN TO NGODWANA CONFLUENCE

PRIORITY RATINGS



RUs	SQ number	River	PES	REC	PR
RU C8	X21G-01090	Weltevredespruit	C	C	2
	X21G-01016	Swartkoppiespruit	C	C	
RU C10	X21K-01007	Lupelule	B	B	2
RU C9	X21H-01060	Ngodwana	B*	B	2
MRU Elan B	X21G-01073	Elands	C	C	3 3WQ
	X21J-01013	Elands	C	B/C	

*EC relevant for upstream of the dam.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).	✓
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	Not available (aquatic ecosystems: driver).	No data
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	X

Data collected at the monitoring point *At Hemlock u/s Sappi Ngodwana on Elandsrivier* was used for the assessment for this RU (representative of water quality for SQR X21J-01013).

Water quality role players in this area include Assmang (ferrous metals plant (ferro-chrome smelter) in Machadodorp), WWTW and urban impacts from Machadodorp. Water quality issues were identified as elevated nutrients, salt and toxics.

Summarized results for X21J-01013: Water quality state for this reach is non-compliant in terms of a number of parameters.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. Institute more frequent monitoring toxics to check compliance, e.g. Zn and Pb exceed the TWQR, but n=4. Ammonia levels are also non-compliant. Mn is monitored and meets the RQO.
3. Institute turbidity monitoring as it has been flagged as a water quality issue.
4. Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts.

Impacts for SQR

- Invasive plant species
- Reduced water quality from upstream land use practices
- Over-abstraction of water
- Disrupted flow regulation
- Domestic waste in stream and riparian zone

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (73.5%)	Category BC
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural most of the time.

TARGET NOT MET 

Possible reasons:

- Combined effect of reduced water quality from upstream urban run off
- Non-functional WWTW at Emgwenya impacting water quality
- Over-abstraction of water from the Elands River for irrigational purposes
- Sedimentation and siltation from forestry related activities

RIVER	TRIBUTARY OF			
ELANDS	Crocodile			
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH		
X2ELAN-HEMLO	X21J	X21J-01013		
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.s.l.)	Geomorphological Zone
	S -25.60042	E 30.55969	991	Upper Foothills
AQUATIC ECOREGION	Level I		Level II	
	10. Northern Escarpment Mountains		10.2	



Figure A-61. Upstream view of the Hemlock site, X2ELAN-HEMLO, on the Elands River (July 2017, G Diedericks).



Figure A-62. Downstream view of the Hemlock site, X2ELAN-HEMLO, on the Elands River (July 2017, G Diedericks).

SQ REACH NUMBER X21K-01035 (EWR ER2)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21K-01035	X2ELAN-ROODE EWR ER2	Elands	S-25.56797 E 30.66669	910	9.4	D	B 82.7%	B 87.7%	B 85.20%	D 50%	BC 78.16%	B 85%	2012
	X2ELAN-GOEDG		S-25.52798 E 30.69781	852			C 76.4%	CD 60.6%	C 68.5%	C 72.5%	C 69.3%		2016
							C 77.6%	C 70.3%	C 73.95%	C 72.5%	C 73.66%		

General description

Reach X21K-01035: Ngodwana to Lupelule

The 9.9 km PESEIS reach starts at the Eland Rivers' confluence with the Ngodwana River at an elevation of 903 m a.s.l., to its confluence with the Lupelule River (857 m a.s.l.). Major named tributaries supplying the Elands River with additional water includes the Ngodwana and Battery Creek. Two sampling points, X2ELAN-ROODE, and X2ELAN-GOEDE are located within this PESEIS reach. The vegetation type of the reach is classified as Legogote Sour Bushveld (Mucina & Rutherford 2006), in the Northern Escarpment Mountains (10.02) aquatic ecoregion (Kleynhans et al. 2005). Land cover comprise of 3.3 % indigenous forest, 41% thickets and dense bush, 12% woodlands open bush and 4% grasslands. The land use practices include 36.2% commercial forestry plantations.

The Ngodwana Pulp and Paper Mill is located within this reach, with return flow of the mills' irrigated effluent entering the river through various underground eyes. In September 1998 part of the Ngodwana, Elands and Crocodile rivers were polluted by an effluent spill from the SAPPI Kraft pulp and Paper mill at Ngodwana resulting in large mortalities of fish and aquatic insects. According to various surveys conducted subsequently to the spill, some 18 indigenous fish species were affected. The Inkomati rock catlet suckermouth, *Chiloglanis bifurcus*, IUCN endangered species was most seriously affected being eradicated over 38% of its natural range. This species did recover but never to its former status and abundances.

The X2ELAN-ROODE is located on the Elands River downstream from the Bambi Bridge from the Ngodwana Mill and Ngodwana River. This site is also an Environmental Water Requirement site (ER2) used for the determination of Catchment Water Resource Classes and associated Resource Quality Objectives for Resource Unit 2. Stream flow at the Roodewal site is considerably higher than at the upstream sites as a result of return flows from Ngodwana Mills irrigated water through four known spring locations, Eye X, Eye Y, Northern Eye and Allan's Eye. This reach falls within the upper foothill geomorphological zone which is dominated by alluvial bedrock and consist of cobble bed, riffles, runs and pools. Elands River at the Roodewal site is 20 - 30 m wide

and backwater pools are present but limited. Algae growth on the rocky substrates is considerable, but more prevalent during lower flow conditions. Reeds, shrub and herbaceous weeds with grasses dominate large portions of the immediate riparian zone. A commercial pine plantation (right bank facing downstream) are located within the riparian zone. The stream canopy can be described as open. The Ngodwana Pulp and Paper mill, Ngodwana village, commercial forestry and citrus orchards are the main upstream land uses.

The X2ELAN-GOEDG is situated 9.2km further downstream from the Roodewal site. The Battery Creek and Rd Acres are the major tributaries contributing to water quantity both flowing from the Eastern side from the Elands River. This river reach forms part of the upper foothills geomorphological zone which is dominated by alluvial cobble beds. The Elands River at the Goedgeluk site is 15 - 30 m wide with the hydraulic biotopes consisting of rapids, riffles, runs, glides, and backwater pools. The substrate consist of large boulders, cobble, gravel, sand, silt, and mud Reeds, shrubs, trees and herbaceous plants with limited grasses dominate large portions of the riparian zone. Large *Eucalyptus* trees with several other wees species dominate the rest of the riparian zone. Eucalyptus compartments, citrus orchards, small settlement, commercial forestry and the Pulp and Paper mill are the main upstream land uses.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21K-01035 was calculated at 58.75% rating this SQ reach as a CD category indicating that the instream habitat integrity is close to largely modified most of the time with a large loss of natural habitat, biota and basic ecosystem functions has occurred. (RIVDINT model Crocodile River System, 2017).

Fish

X2ELAN-ROODE and X2ELAN-GOEDG were monitored to be representative of SQ Reach X21K-01035 monitored regularly since 2012. All of the fish velocity depth classes were present to sample and cover for fish was mainly boulders, rocks and cobbles providing substrate cover for especially the rheophilic fish species. Reeds provided some cover for the more limnophilic fish species.

The fish assemblage recorded included *Enteromius crocodilensis*, *Micralestes acutidens*, *Amphilius uranoscopus*, *Chiloglanis bifurcus*, *Chiloglanis pretoriae*, *Pseudocrenilabrus philander* and *Tilapia sparrmanii* (Table 65). All these species were collected at relative abundance ranging from low to moderate abundance. Of the rheophilic species, the two species *Enteromius crocodilensis* and *Chiloglanis pretoriae* were recorded at a moderate abundance, whilst the *Amphilius uranoscopus* and *Chiloglanis bifurcus* were absent or recorded at extreme low abundance. One indigenous fish species (*Micralestes acutidens*) which was not expected to occur was found during the last two surveys. Of concern is that the indigenous small scale yellowfish species, *Labeobarbus polylepis*, has been absent from this reach since 2014. This migratory species has a flow depth

preference for fast deep (3.7), fast shallow (4.3) and slow deep (4.2) habitat with a high cover preference for substrate (5). Their absence can be attributed to disrupted stream flow, reduced water qualities and reduced instream habitat due to algae and sedimentation limiting preferred biotopes. The CPUE (catch per unit effort) for the two sites ranged between 3.37 (91 individuals; 27 minutes) at the X2ELAN-ROODE site and 2.98 (131 individual; 44 minutes) at the X2ELAN-GOEDG indicating a relative species diversity at a low abundance.

Table 65: Fish species expected based on the PESEIS Reach Code (X21K-01035) X2ELAN-ROODE; X2ELAN-GOEDG; is listed, and the numbers of fish species present during the different surveys are indicated.

X21K-01035	Expected Species	X2ELAN-ROODE					X2ELAN-GOEDG				
		2012	2013	2014	2016	2017	2012	2013	2014	2016	2017
Anguillidae (Freshwater Eels)											
<i>Anguilla mossambica</i>	x	-	-	-	-	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)											
<i>Enteromius anoplus</i>	x	-	-	-	-	-	-	-	-	-	-
<i>Enteromius crocodilensis</i>	x	8	120	7	37	7	60	66	16	39	59
<i>Labeobarbus polylepis</i>	x	-	-	-	-	-	1	14	9	-	-
Characidae (Characins)											
<i>Micralestes acutidens</i>		-	-	-	-	42	-	-	-	17	7
Amphiliidae (Mountain Catfishes)											
<i>Amphilius uranoscopus</i>	x	3	-	-	-	3	24	3	4	4	4
Mochokidae (Squeakers, suckermouth catlets)											
<i>Chiloglanis bifurcus</i>	x	2	-	-	3	1	1	-	1	4	3
<i>Chiloglanis pretoriae</i>	x	9	7	10	19	19	19	34	14	22	45
Cichlidae (Cichlids)											
<i>Pseudocrenilabrus philander</i>	x	-	3	-	5	5	-	-	6	-	2
<i>Tilapia sparmanii</i>	x	-	18	8	16	14	2	8	6	7	11
Number of species expected	9										
Number of species recorded		4	4	3	5	7	6	5	6	6	7
Number of individuals		22	148	25	80	91	107	126	50	93	131
Electro-fishing time (minutes)		40	40	35	42	27	52	30	30	38	44
Catch/Unit Effort (CPUE)		0.55	3.70	0.71	1.90	3.37	2.06	4.20	1.67	2.45	2.98

A mean Fish Ecstatus rating of 77.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low abundance of species) which is consistent to 2016 results.

Invertebrates

Nine SASS sampling events are on record for the Roodewal site (X2ELAN-ROODE) in the Elands River. These represent two autumns, three winters, and four spring sampling events. A total of 52 SASS taxa have been recorded during the nine sampling events, of which 30 were recorded during the two autumn surveys, 44 taxa in total during winter surveys and 46 in spring. Sensitively rated SASS taxa recorded during more than seven of the sampling events included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, and Tricorythidae, and Psephenidae. The family Tricorythidae was the most obvious absentee since the September 2012 survey.

Thirteen SASS sampling events are on record for the Goedgeluk site (X2ELAN-GOEDG) on the Elands River. These represent two autumns, two winters, eight springs, and one summer sampling events. A total of 58 SASS

taxa have been recorded during these 13 sampling events, of which 31 taxa in total were recorded during autumn surveys, 38 in winter, and 51 in spring. Sensitive rated SASS taxa recorded during all 13 sampling events included Perlidae, Baetidae >2 sp., Heptageniidae, Philopotamidae, and Elmidae.

The 2017 SASS5 results, based on MIRAI, indicates deterioration at the Roodewal site in 2016 and 2017 to moderately impaired (C) when compared to the 2012 results (slightly impaired – B).

At the Goedgeluk site, MIRAI suggests a slight improvement in conditions in 2016 and 2017, but still rated as moderately impaired (Table 66).

Table 66: Comparison of the 2012, 2016 and 2017 SASS5 results for SQ reach X21K-01035.

X21K-01035	X2ELAN-ROODE	2012	2016	2017
	Total SASS Score	193	180	181
	No. of SASS Families	29	30	27
	Average Score Per Taxon	6.7	6.0	6.7
	MIRAI Value	Category B 87.7%	Category C 61.1%	Category C 67.4%
	X2ELAN –GOEDG	2012	2016	2017
	Total SASS Score	239	195	195
	No. of SASS Families	36	31	31
	Average Score Per Taxon	6.6	6.3	6.3
	MIRAI Value	Category A/B 88.5%	Category C 60.1%	Category C 73.2%
SQ REACH SUMMARY Invertebrate Ecstatus	Category B 87.7%	Category C 60.6%	Category C 70.3%	

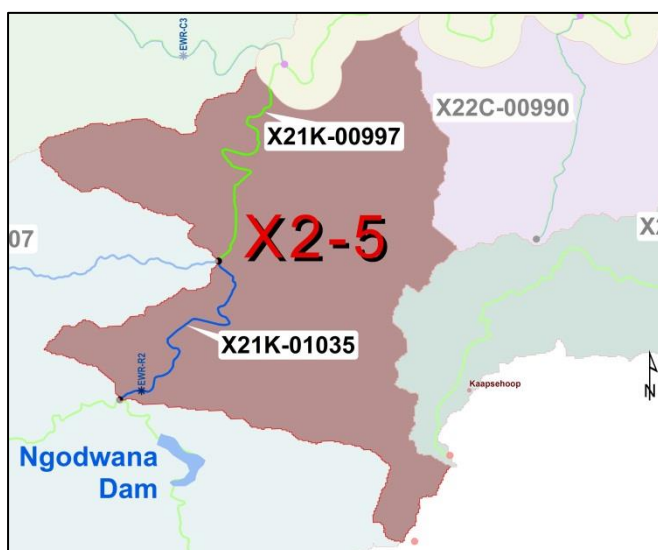
The 2017 MIRAI for the PESEIS reach indicates moderately impaired (73%) conditions, which represents considerable deterioration when compared to the slightly impaired conditions in 2012 (88%). The deterioration is attributed to changes in water chemistry (i.e. total dissolved solids, chlorides), increased abstraction, associated with increases in the biomass of exotic gastropods and introduced fish.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 72.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 75.12% rating this reach as a Category C indicating a moderately modified habitat with a loss and change of natural habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

IUA X2-5 - ELANDS RIVER DOWNSTREAM OF THE NGODWANA RIVER



PRIORITY RATINGS

RUs	SQ number	River	PES	REC	PR
MRU Elan B	X21K-01035 ER 2	Elands	B	B	3
	X21K-00997	Elands	C	C	3WQ

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 55 mS/m (aquatic ecosystems: driver).	X
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).	No data
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	Ammonia elevated above an A category.

The original water quality assessment was conducted as part of the 2000 Elands River Intermediate Reserve study (DWAF, 2000) and the 2004 re-assessment of the results by Environmentek, CSIR, as part of the Elands Catchment Comprehensive Reserve Determination Study. EcoSpecs and TPCs were not prepared as part of either these studies.

Data collected at the DWS monitoring point 192552: *Bambi at road bridge on Elands River near Ngodwana* was used for the assessment.

Summarized results for EWR ER2: Water quality state for this reach is non-compliant. Ortho-phosphate results at this site are 0.5 mg/L, and Electrical Conductivity data shows a 95th percentile of 104.65 mS/m. Both are well above the RQOs set for these variables. Note that few toxics data were available for analysis, but ammonia (NH₃-N) showed concentrations well above the aquatic ecosystem guideline.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts, considering the few data points available for a number of parameters.
2. Institute monitoring for turbidity.

- Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts. *A range of water quality role players are present in the area, i.e. SAPPI (Ngodwana Mill), WWTW; with identified water quality issues being elevated nutrients, salts and toxics; and high turbidity levels.*

Impacts for SQR

- Poor road drainage networking
- Invasive plant species
- Commercial trees in riparian zone
- Domestic waste in stream and riparian zone
- Reduced water quality from industrial related return flows
- Increased siltation and sedimentation from forestry related activities
- Urban run off as well as urban environmental pollution

See appendix E

Integrated Ecstatus Category and Target Ecological Category (TEC)



INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (74.9%)	Category B
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural most of the time with few modifications



TARGET NOT MET 

Possible reasons:

- Reduced water quality from industrial related return flows
- Reduced instream habitat
- Flow regulation

The TEC for this SQ Reach should be managed at a Category B (85%) through integrated water management. The distribution range of *Chiloglanis bifurcus* is entirely within privately owned land without any formal conservation protection and impacted by land use practices in the catchment. The two sub-populations remaining for this species need to be given priority for conservation efforts. Land and water use practices need to be carefully managed.

RIVER		TRIBUTARY OF	
ELANDS		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	REACH
X2ELAN-ROODE (EWR ER2)		X21K	X21K-01035
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Elevation (m. a.s.l.)	Geomorphological Zone
	S -25.56797	910	Upper Foothills
AQUATIC ECOREGION	Level I	Level II	
	10. Northern Escarpment Mountains	10.2	
			
<p>Figure A-63. Upstream view of the Roodewal site, X2ELAN-ROODE, on the Elands River (July 2017, G Diedericks).</p>		<p>Figure A-64. Downstream view of the Roodewal site, X2ELAN-ROODE, on the Elands River (July 2017, G Diedericks).</p>	

RIVER		TRIBUTARY OF	
ELANDS		Crocodile	
SITE NUMBER		REACH	
X2ELAN-GOEDG		X21K	X21K-01035
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Geomorphological Zone	
Latitude	Longitude	Upper Foothills	
S -25.52798	E 30.69781	Level II	
AQUATIC ECOREGION		Level II	
10. Northern Escarpment Mountains		10.2	
			
<p>Figure A-65. Upstream view of the Goedegeeluk site, X2ELAN-GOEDG, on the Elands River (July 2017, G Diedericks).</p>		<p>Figure A-66. Downstream view of the Goedegeeluk site, X2ELAN-GOEDG, on the Elands River (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X21K-00997

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecstatus	Instream Ecostatus	Riparian Vegetation Ecstatus	Integrated Ecstatus	TEC	Biomonitoring Year
X21K-00997	X2ELAN-EHOEK	Elands	S-25.49440 E 30.70222	832	11.0	C	B 84%	B 86.9%	B 85.45%	C 70%	B 82.36%	C 70%	2012
							BC 79.1%	CD 60.6%	C 69.85%	C 77.5%	C 71.38%		2016
							C 76.4%	C 72.7%	C 74.55%	C 77.5%	C 75.14%		2017

General description

Reach X21K-00997: Lupelule to Crocodile confluence

The upper boundary of this PESEIS reach is the Lupelule River, at an elevation of 857 m a.s.l. The lower boundary is the confluence of the Elands River with the Crocodile River downstream from Montrose Falls, at an elevation of 772 m a.s.l. The fluvial length of the Elands River between these two points is 11 km, with a waterfall between the Elandshoek site (X2ELAN-EHOEK) and the Elands merger with the Crocodile River. Named tributaries entering the Elands River between the PESEIS reach boundaries include the Lupelule and Starvation Creek.

The largest portion (upper) of the reach falls within the Northern Escarpment Mountains (10.02) aquatic ecoregion, and the lowest portion within the North Eastern Highlands (4.04) aquatic ecoregion. The entire reach falls within the Legogote Sour Bushveld. The land cover comprise of 3.3% indigenous forest, 12.7% thickets and dense bush, 11.7% woodlands and open bush with 4.6% grasslands. The land use practices consist mainly of 66.6% commercial plantations (GEOTERRAIMAGE, 2015). One site was sampled in this reach (X2ELAN-EHOEK). The river in this reach is impacted upon by agricultural crops, human settlements, and effluent from the upstream pulp and paper mill.

The Elands River in this reach is characterised as a steep gradient river of the upper foothills geomorphological zone. The river at the Elandshoek site is 15 - 20 m wide. The reach is dominated by alluvial cobble-bed, rapids, riffles, runs, glides and shallow pools, as well as some riffles and runs in the side channels. The cover includes large cobble, gravel, boulders, sand, silt, and mud. Reeds, shrubs, trees and herbaceous plants with limited grasses dominate large portions of the immediate riparian zone. The stream canopy can be described as open.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21K-00997 was calculated at 75.48% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota

have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

At the X2ELAN-EHOEK site the habitat remained consistent with the 2012 biomonitoring results. All of the fish velocity depth classes were present with fast deep (sparse), fast shallow (abundant), slow deep (sparse) and slow shallow (moderately abundant). Overhanging vegetation and undercut banks were sparse as fish cover although abundant aquatic macrophytes provided instream habitat to fish. Boulders, rocks and cobbles provided the necessary in-stream cover for especially the flow dependant species.

Table 67: Fish species expected based on the PESEIS Reach Code (X21K-00997) X2ELAN-EHOEK; is listed, and the numbers of fish species present during the different surveys are indicated.

X21K-00997	Expected Species	X2ELAN-EHOEK		
		2012	2016	07/2017
Anguillidae (Freshwater Eels)				
<i>Anguilla mossambica</i>	x	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)				
<i>Enteromius anoplus</i>	x	-	-	-
<i>Enteromius crocodilensis</i>	x	7	33	9
<i>Enteromius paludinosus</i>		17	-	-
<i>Labeobarbus polylepis</i>	x	3	-	-
Characidae (Characins)				
<i>Micralestes acutidens</i>		-	14	-
Amphiliidae (Mountain Catfishes)				
<i>Amphilius uranoscopus</i>	x	3	5	3
Mochokidae (Squeakers, suckermouth catlets)				
<i>Chiloglanis bifurcus</i>	x	-	2	-
<i>Chiloglanis pretoriae</i>	x	13	49	22
Cichlidae (Cichlids)				
<i>Pseudocrenilabrus philander</i>	x	4	7	7
<i>Tilapia sparmanii</i>	x	3	25	26
Number of species expected		9		
Number of species recorded		7	7	5
Number of individuals		50	135	67
Electro-fishing time (minutes)		43	41	28
Catch/Unit Effort (CPUE)		1.16	3.29	2.39

A total of nine indigenous species of fish are expected to occur in this reach of which five were collected during the present survey (Table 67), a decline of two species from the previous surveys. Of concern is the absence of *Labeobarbus polylepis* and *Enteromius paludinosus*. For the rheophilic species the absence of *Chiloglanis bifurcus* and the decrease in abundance of *Chiloglanis pretoriae* indicate disruptions in the flow regime and reduced water quality standards to sensitive species. Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of species recorded has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has declined as a result of flow regulation, loss of instream habitat, as well as reduced water quality. The CPUE for the present survey was calculated at 2.39 (67 individuals; 28 minutes) indicating a decrease in species diversity and abundance.

A Fish Ecstatus rating of 76.4% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) which is a category lower than 2012 survey results (Category B – 84%).

Invertebrates

Twelve SASS sampling events are on record for the Elandshoek site (X2ELAN-EHOEK) on the Elands River. These represent one autumn, six winters, and five spring sampling events. A total of 59 SASS taxa have been recorded during these 12 sampling events, of which 50 taxa in total were recorded during the winter survey and 53 in spring surveys. Sensitively rated SASS taxa recorded during almost every sampling event included Baetidae >2 sp., Heptageniidae, Leptophlebiidae, and Psephenidae. The family Tricorythidae was only recorded in surveys pre-dating 1997.

Table 68: Comparison of the 2012, 2016 and 2017 SASS5 results for SQ reach X21K-00997.

X21K-00997	X2ELAN-EHOEK	2012	2016	2017	Change
	Total SASS Score	230	175	211	
	No. of SASS Families	36	30	35	
	Average Score Per Taxon	6.4	5.8	6.0	
	MIRAI Value	Category B 86.9%	Category C 60.6%	Category C 72.7%	↓
SQ REACH SUMMARY Invertebrate Ecstatus	Category A/B 86.9%	Category D 60.6%	Category C 72.7%		

The 2017 SASS5 results indicate deterioration from slightly (B) to moderately impaired (C) when compared to 2012 (Table 68). Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C - 73%) in July 2017. The deterioration is mainly attributed to water high in total dissolved solids, from the Elands River entering the Crocodile River further upstream. The Elands River was determined to be one of the fastest deteriorating rivers in Mpumalanga, based on the analysis of long-term chemical water quality data (Griffin et al. 2014). It is clear that the Target Water Quality Range of TDS values in the Elands River far exceeds the 15% Guideline for Aquatic Ecosystems.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 77.4% rating this reach as a Category C indicating a moderately modified riparian zone. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Removal of riparian vegetation
- Invasive plant species
- Bank scouring and bank instability
- Domestic waste in stream and riparian zone
- Poor road drainage network
- Effluent from upstream pulp and paper mill

See appendix E

Integrated Ecstatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (75.14%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET





Discussion:

The SQ Reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. The information for setting targets is limited as this site was not assessed in detail and the Integrated Ecstatus Category of C indicate that a more detailed assessment is required before any further water use licenses can be issued.

Although it would appear that the target is met, the Ecological Category can improve to a Category B through:

- Proper integrated water management in the upper reaches
- Improved and responsible water management from pulp and paper mill

RIVER		TRIBUTARY OF	
ELANDS		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2ELAN-EHOEK		X21K	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude	Longitude	X21K-00997	
S -25.49440	E 30.70222	Geomorphological Zone	
Elevation (m. a.s.l.)		Upper Foothills	
832		Level II	
AQUATIC ECOREGION		Level II	
10. Northern Escarpment Mountains		10.2	
			
<p>Figure A-67. Upstream view of the Elandshoek site, X2ELAN-EHOEK, on the Elands River (July 2017, G Diedericks).</p>		<p>Figure A-68. Downstream view of the Elandshoek site, X2ELAN-EHOEK, on the Elands River (July 2017, G Diedericks).</p>	

Elands River Tributaries

SQ REACH NUMBER X21F-01100

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X21F-01100	X2LEEU-GELUK	Leeuspruit	S-25.66180 E 30.25766	1 517	12.9	C	C 75.8%	C 76.7%	C 75.80%	C 70%	C 74.64%	C 70%	2012
							C 78%	C 69.1%	C 73.6%	BC 80%	C 74.8%		2017

General description

Reach X21F-00100: Source to Leeuspruit tributary

The Leeuspruit originates at an elevation of 1,740 m. a.s.l., flowing in a northerly direction towards the Elands River. The PESEIS reach X21F-00100 starts at the source, and ends at an insignificant tributary (PESEIS reach X21F-01096), at an elevation of 1,530 m a.s.l. The catchment area upstream from the sampling point, X2LEEU-GELUK is 91.83 km², falling into three level II aquatic ecoregions. These include the Northern Escarpment Mountains (10.02, 10.03), and the Eastern Bankenveld (9.02) aquatic ecoregions. The entire Leeuspruit catchment falls within the Lydenburg Montane Grassland (Gm 18). The land cover comprise of 1.8% wetlands and 84% grasslands (GEOTERRAIMAGE, 2015). Land use practices include cultivated commercial fields (5.8%) commercial plantations (1.3%) and some mining activities. Numerous small farm dams with bass and stocked with trout are characteristic of this catchment. The malfunctioning Machadodorp (Entokozweni) sewerage works is located upstream from the biomonitoring site.

The Leeuspruit at the Geluk site is 2 to 5 m wide, dominated by large cobble, gravel, boulders, sand, silt, and mud. Algae growth on the marginal vegetation and substrate is considered high. Hydraulic biotopes include riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21F-01100 was calculated at 64.6% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

On the Leeuspruit (X2LEEU-GELUK) biomonitoring site the only biotopes monitored was slow shallow and fast shallow in the form of riffles and runs with shallow pools. Boulders, rocks and cobbles provided good substrate

cover for fish. Overhang vegetation with undercut banks and aquatic macrophytes were also present creating habitat for limnophilic species.

Table 69: Fish species expected based on the PESEIS Reach Code (X21F-01100) X2LEEU-GELUK; is listed, and the numbers of fish species present during the different surveys are indicated.

X21F-01100	Expected Species	X2LEEU-GELUK	
		2012	07/2017
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius anoplus</i>	x	-	10
Amphiliidae (Mountain Catfishes)			
<i>Amphilius uranoscopus</i>	x	2	2
Cichlidae (Cichlids)			
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparrmanii</i>	x	7	3
Number of species expected	5		
Number of species recorded		2	3
Number of individuals		9	15
Electro-fishing time (minutes)		47	21
Catch/Unit Effort (CPUE)		0.19	0.71

The fish assemblage at this monitoring site consisted of three of an expected five indigenous species (Table 69) that included *Enteromius anoplus*, *Amphilius uranoscopus* and *Tilapia sparrmanii*. The abundance for the collected species were extremely low, although instream fish habitat was abundant. The reason for the low species diversity and abundance can be related to poor water quality due to upstream land use activities. The catch per unit effort (CPUE) was recorded as 0.71 (15 individuals; 21 minutes) indicating, as with the previous survey, a low abundance of fish.

A Fish Ecstatus rating of 78.0% was calculated for this monitoring point based on all available information, placing it in an ecological Category C (moderately impaired with low diversity and abundance of species) which is consistent with the 2012 survey results.

Invertebrates

Three SASS sampling events are on record for the Leeuspruit site (X2LEEU-GELUK). These represent two winters, and one spring sampling event. A total of 40 SASS taxa have been recorded during the three sampling events, of which 30 taxa in total were recorded during winter surveys and 29 in the one spring survey. Sensitive rated SASS taxa recorded during all three sampling events included Baetidae >2 sp., Leptophlebiidae, Tricorythidae, and Aeshnidae.

Table 70: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21F-01100.

X21F-01100	X2LEEU-GELUK	2012	2017	Change
	Total SASS Score	157	127	
	No. of SASS Families	29	25	
	Average Score Per Taxon	5.4	5.1	
	MIRAI Value	Category C 76.7%	Category C 69.1%	↘
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 76.7%	Category C 69.1%		

The 2017 SASS5 results indicate similar conditions when compared to 2012 (Table 70). Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C - 69%) in July 2017. The modified conditions are mainly attributed to effluents from the upstream Waste Water Treatment Works.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 80% and is consistent with a Category BC – close to largely natural with few modifications most of the time. The Riparian IHI was calculated at 77.52% rating this reach as a Category C indicating a moderately modified habitat with loss and change of natural habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach is close to largely natural with a few modifications most of the time.

Water Quality

IUA X2-3 - UPPER ELANDS AND TRIBUTARIES TO WATERVAL BOVEN

PRIORITY RATINGS



RUs	SQ number	River	PES	TEC	PR
MRU Elan A	X21F-01046	Elands	C	C	3 3WQ
	X21F-01081	Elands	C	C	
	X21G-01037 ER 1	Elands	B	B	
RU C7	X21F-01100	Leeuspruit	C	C	3WQ
	X21F-01091	Rietvleispruit	C	C	2
	X21F-01092	Leeuspruit	C/D	C/D	

Narrative RQO	Numerical RQO	Notes
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver).	Conductivity just exceeded RQO
Ensure that pH stays within Ideal limits.	5 th and 95 th percentiles of pH data must be between 6.5 and 8.0 (aquatic ecosystems: driver).	pH exceeded upper limit (8.15)
Ensure that toxics are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	Zn and Pb exceed the TWQR and A categories, but n=3

Narrative RQO	Numerical RQO	Notes
Ensure that Cr-VI levels are within Ideal limits or A categories.	95 th percentile of the data must be less than 0.014 mg/L Cr-VI (aquatic ecosystems: driver).	No data
Ensure that Mn levels are within Ideal limits or A categories or TWQR.	95 th percentile of the data must be within the TWQR of 0.180 mg/L Mn (aquatic ecosystems: driver).	✓
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	X

Data collected at the monitoring point 1-3177: *Leeuspruit @ bridge 50 m d/s Emthonjeni s/w* was used for the assessment. Note that this point is downstream from the biomonitoring site and as it is the most downstream monitoring point on the Leeuspruit, it will incorporate impacts from Assmang, Machadadorp town and Emthonjeni settlement, including WWTWs. Other options are DWS gauging weir X2H12Q01, but this is downstream of the confluence with X21F-01096.

Summarized results: Water quality state for this reach is non-compliant in terms of many parameters.

The water quality recommendations are as follows:

1. Evaluate biota scores at the biological monitoring point to assess impacts.
2. Institute monitoring for Cr-VI at the monitoring point.
3. Institute more frequent monitoring toxics to check compliance, e.g. Zn and Pb exceed the TWQR, but n=4. Ammonia levels are also non-compliant. Mn is monitored and meets the RQO.
4. Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts.

Impacts for SQR

- Alien and invasive fish species
- Domestic waste in stream and riparian zone
- Reduced water quality due to upstream land use practices
- Malfunctioning WWTW's

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (74.8%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET



Discussion:

- Low species diversity and abundance indicate that water quality standards are not met.

RIVER		TRIBUTARY OF	
LEEUSPRUIT		Elands	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2LEEU-GELUK	X21F	X21F-01100	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Longitude	Elevation (m. a.s.l.)	Geomorphological Zone
	E 30.25766	1 517	Upper Foothills
AQUATIC ECOREGION	Level I	Level II	
	9. Eastern Bankenveld	9.02	



Figure A-69. Upstream view of the Leeuspruit site, X2LEEU-GELUK (July 2017, G Diedericks).



Figure A-70. Downstream view of the Leeuspruit site, X2LEEU-GELUK (July 2017, G Diedericks).

SQ REACH NUMBER X21G-01016

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecotatus	Invertebrate Ecotatus	Instream Ecotatus	Riparian Vegetation Ecotatus	Integrated Ecotatus	TEC	Biomonitoring Year
X21G-01016	X2SWAR-KINDE	Swartkoppies spruit	S-25.61036 E 30.40119	1 163	28.3	C	B 84.1%	C 76.4%	BC 80.25%	C 70%	BC 78.20%	C 70%	2012
							C 75.9%	B 85.9%	BC 80.9%	B 82.5%	BC 81.2%		2017

General description

Reach X21G-01016: Source to Elands confluence

The Swartkoppiespruit originates at an elevation of 1,900 m. a.s.l., flowing in a south-easterly direction towards the Elands River. The PESEIS reach starts at the source, and ends at the Swartkoppiespruit's confluence with the Elands River at an elevation of 1,152 m a.s.l. The upper portion of the Swartkoppiespruit falls within the Eastern Bankenveld (9.02) aquatic ecoregion, and the lower portion in the Northern Escarpment Mountains (10.03). The sampling point, X2SWAR-KINDE, is located on the farm Kindergoed. The entire Swartkoppiespruit catchment falls within the Lydenburg Montane Grassland (Gm 18) vegetation type. Land cover comprise of 1.9% wetlands, 7.2 % thickets and dense bush with 2.06% woodlands and open bush. Grasslands (43.1%) dominate the reach. Commercial forestry plantation (pine) (39.2%) is the main land use practice with 4.7% cultivated commercial fields (GEOTERRAIMAGE, 2015). Numerous small farm dams and weirs stocked with trout are located in the upper portion of this catchment.

The Swartkoppiespruit at the Kindergoed sampling point is 4 to 6 m wide, dominated by large cobble, gravel, boulders, sand, silt, and mud. The stream is impounded at an old crossing, and a new dam (barrier to fish movement), was recently constructed downstream from the sampling point. Hydraulic biotopes include riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21G-01060 was calculated at 80.16% rating this SQ reach as a BC Category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

Three fish velocity depth classes were sampled at the X2SWAR-KINDE site representing this reach namely, slow deep (moderate), slow shallow (moderate) and fast shallow (abundant). Very little cover was present in the form of overhanging vegetation and undercut banks and root wads. Substrate provided the best cover for fish.

Table 71: Fish species expected based on the PESEIS Reach Code (X21G-01016) X2SWAR-KINDE; is listed, and the numbers of fish species present during the different surveys are indicated.

X21G-01016	Expected Species	X2SWAR-KINDE		
		2012	2016	07/2017
Anguillidae (Freshwater Eels)				
<i>Anguilla mossambica</i>	x	1	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)				
<i>Enteromius anoplus</i>	x	41	-	-
<i>Enteromius crocodillensis</i>	x	-	-	-
<i>Labeobarbus polylepis</i>	x	-	-	-
Amphiliidae (Mountain Catfishes)				
<i>Amphilius uranoscopus</i>	x	12	-	3
Mochokidae (Squeakers, suckermouth catlets)				
<i>Chiloglanis bifurcus</i>	x	-	-	-
<i>Chiloglanis pretoriae</i>	x	19	-	55
Cichlidae (Cichlids)				
<i>Pseudocrenilabrus philander</i>	x	-	-	-
<i>Tilapia sparrmanii</i>	x	-	-	2
Number of species expected	9			
Number of species recorded		4	Not Sampled	3
Number of individuals		73		60
Electro-fishing time (minutes)		42		28
Catch/Unit Effort (CPUE)		1.74		2.14

In total three indigenous fish species of a reference expected nine species were recorded for this site (Table 71). The fish assemblage indicate a loss of the Cyprinidae species with other species recorded at low abundance, *Amphilius uranoscopus* (3 individuals) and *Tilapia sparrmanii* (2 individuals). *Chiloglanis pretoriae* were collected at relative abundance, as this is a flow sensitive species indicating that instream flow regime is adequate. The low abundance of collected species and loss of species diversity can be related to the impact of regular stocking of the predatory alien and invasive NEMBA species trout. The catch per unit effort (CPUE) was calculated at 2.14 (60 individuals; 28 minutes) indicating a low abundance of fish.

A Fish Ecstatus rating of 75.9% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low diversity and abundance of species). This is a much lower Ecological Category recorded during the present survey compared to the 2012 survey (Ecological Category B), and can be contributed to regular stocking of alien and invasive fish species.

Invertebrates

Two SASS sampling events are on record for the Swartkoppiespruit site (X2SWAR-KINDE), representing one spring and one winter survey. A total of 36 SASS taxa have been recorded during the two sampling events, of

which 33 taxa in total were recorded during the winter survey and 23 in the spring survey. Sensitive taxa recorded during both sampling events included Atyidae, Baetidae >2 sp., Heptageniidae, Leptophlebiidae, Tricorythidae, Aeshnidae, Philopotamidae, and Elmidae.

Table 72: Comparison of the 2012 and 2017 SASS5 results for SQ reach X21G-01016.

X21G-01016	X2SWAR-KINDE	2012	2017	Change
	Total SASS Score	148	198	
	No. of SASS Families	23	33	
	Average Score Per Taxon	6.4	6.0	
	MIRAI Value	Category C 76.4%	Category B 85.9%	↑
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 76.7%	Category B 85.9%		

The 2017 SASS5 results indicate improved conditions when compared to 2012 (Table 72). Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C - 76%) in September 2012, improving to slightly impaired (86%) in July 2017.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 81.56% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Impacts for SQR

- Presence of alien and invasive fish species
- Numerous instream structures (weirs) creating habitat to alien and invasive species
- Sedimentation and siltation
- Bank scouring and instability
- Stream crossing creates upstream impoundment
- Stream crossing physical barrier during low flow conditions

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category BC (81.2%)	Category C
Close to largely natural most of the time	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged.

TARGET MET



Discussion:

Although it appears that the TEC is met, this reach should be managed at a Category B.

This SQ reach is not a EWR site and the TEC for this site is derived from the PES-EIS desktop assessment (DWA, 2014b) indicating the ecological sensitivity and importance. An integrated Ecostatus Category C indicate that a more detailed assessment is required.

RIVER		TRIBUTARY OF	
Swartkoppiespruit		Elands	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2SWAR-KINDE		X21G	
REACH		X21G-01016	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Geomorphological Zone	
Latitude	S -25.61036	Elevation (m. a.s.l.)	Upper Foothills
Longitude	E 30.40119	Level I	Level II
AQUATIC ECOREGION		10.3	
10. Northern Escarpment Mountains			






Figure A-71. Upstream view of the Swartkoppiespruit site, X2SWAR-KINDE (July 2017, G Diedericks).

Figure A-72. Downstream view of the Swartkoppiespruit site, X2SWAR-KINDE (July 2017, G Diedericks).

SQ REACH NUMBER X21H-01060

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecstatus	Instream Ecostatus	Riparian Vegetation Ecstatus	Integrated Ecstatus	TEC	Biomonitoring Year
X21H-01060	X2NGOD-NOOIT	Ngodwana	S-25.66244 E 30.67236	1 071	25.4	C	D 57.4%	C 69%	C 64.03%	C 70%	C 65.33%	B 85%	2012
							B 87.2%	BC 79.3%	B 83.25%	B 82.5%	B 83.1%		2016
							B 82.6%	C 66%	C 74.3%	B 82.5%	C 75.9%		2017

General description

Reach X21H-01060: Source to Elands confluence

The Ngodwana River originates at an elevation of 1,665 m. a.s.l., mostly flowing in a northerly direction towards the Ngodwana Dam and Elands River. The PESEIS reach starts at the source, and ends at the Ngodwana River's confluence with the Elands River at an elevation of 902 m a.s.l. The Ngodwana catchment falls within the Northern Escarpment Mountains (10.02) aquatic ecoregion. The sampling point, X2NGOD-NOOIT, is located upstream from the Ngodwana Dam. The entire Ngodwana catchment falls within the Lydenburg Montane Grassland (Gm 18) vegetation type. The land cover comprise of wetlands (2.09%), indigenous forest (3.6%), thickets and dense bush (14%) and open woodlands (2.08%) with grasslands dominating (39%) (GEOTERRAIMAGE, 2015). Agricultural livestock and commercial forestry (37%) are the dominant land-uses in the catchment upstream from Ngodwana Dam.

This reach falls within the upper foothills geomorphological zone dominated by alluvial cobble-bed, rapids, riffles, runs, glides and pools. Tree, shrubs, herbaceous plants and grasses dominate the marginal zone, with grasslands with scattered trees and shrubs the surrounding landscape. The Ngodwana River at the Nooitgedacht sampling point is 4 to 8 m wide. The Ngodwana Dam serves as a man-made barrier to fish movement, and the dam has been stocked with exotic fish species, as well as indigenous species that are not natural to the system.

Instream Habitat Integrity

The Instream IHI for the SQ reach X21H-01060 was calculated at 48.4% rating this SQ reach as a D Category indicating that the instream habitat integrity is largely modified. A large loss and change of natural habitat, biota and basic ecosystem functions have occurred. The resilience of the system to sustain this category has not been compromised and the ability to deliver Ecosystem Services has been maintained. (RIVDINT model Crocodile River System, 2017).

Fish

The X2NGOD-NOOIT site which is representative for this reach, was sampled and consist of most fish velocity depth classes: slow deep (sparse), fast deep (sparse), slow shallow (moderate) and fast shallow (abundantly). The fish cover present was mainly provided by large boulders, rocks and cobbles providing substrate cover. Overhanging vegetation and undercut banks and root wads, as well as aquatic macrophytes also provided additional cover for fish.

Table 73: Fish species expected based on the PESEIS Reach Code (X21H-01060) X2NGOD-NOOIT; is listed, and the numbers of fish species present during the different surveys are indicated.

X21H-01060	Expected Species	X2NGOD-NOOIT		
		2012	2016	07/2017
Anguillidae (Freshwater Eels)				
<i>Anguilla mossambica</i>	x	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)				
<i>Enteromius anoplus</i>	x	-	27	41
<i>Enteromius crocodilensis</i>	x	-	489	68
<i>Labeobarbus polylepis</i>	x	-	11	3
Amphiliidae (Mountain Catfishes)				
<i>Amphilius uranoscopus</i>	x	-	103	11
Mochokidae (Squeakers, suckermouth catlets)				
<i>Chiloglanis bifurcus</i>	x	-	3	4
<i>Chiloglanis pretoriae</i>	x	-	410	67
Salmonidae (Trout)				
<i>Oncorhynchus mykiss</i>		-	1	-
Cichlidae (Cichlids)				
<i>Pseudocrenilabrus philander</i>	x	-	-	-
<i>Tilapia sparrmanii</i>	x	-	-	-
Number of species expected	9			
Number of species recorded		NS	6 + 1	6
Number of individuals			1044	194
Electro-fishing time (minutes)			88	53
Catch/Unit Effort (CPUE)			11.86	3.66

In total six of the expected nine indigenous fish species were recorded at this biomonitoring site (Table 73). The recorded fish assemblage indicate only the absence of the Cichlidae species as well as *Anguilla mossambica*. This catadromous species breed in the ocean, enters rivers as larvae and migrate upstream as far as they can go where they develop further. Adult eels return to the ocean at some stage to breed. Disruption of the river continuity, especially due to large impoundments, result in the decline of abundance of this species as migration to headwaters following their larval stage in the ocean is obstructed by weirs and impoundments. Their absence within their reach can be related to the presence of the Ngodwana Dam creating an obstruction of their natural migration route. The high abundance of *Enteromius crocodilensis* indicate successful breeding and all age classes (juveniles, sub-adults and adults) were collected. The presence of the endangered IUCN red data species *Chiloglanis bifurcus* (4 individuals) is highly significant and indicates a sustainable population within this river reach. The Elands River and its tributaries has been identified as a priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPAs) (Driver et al. 2011). However, the presence of the NEMBA alien and invasive fish species (trout) is of serious

concern as their presence threatens the survival of this unique population. The CPUE (catch per unit effort) was calculated at 3.66 (194 individuals; 53 minutes) indicating relative biodiversity and abundance.

A Fish Ecstatus rating of 82.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category B (largely natural with few modifications) which is consistent with the 2016 survey (87.2%).

Invertebrates

Eight SASS sampling events are on record for the Ngodwana River site at Nooitgedacht, representing one autumn and summer samples, and five spring surveys. A total of 50 SASS taxa have been recorded during the eight sampling events, of which 29 to 30 were recorded during the autumn, winter, and summer surveys, and 48 in spring surveys. Sensitively rated SASS taxa recorded during both sampling events included Baetidae >2 sp., Heptageniidae, Tricorythidae, Chlorocyphidae, Elmidae, and Psephenidae.

Table 74: Comparison of the 2016 and 2017 SASS5 results for SQ reach X21H-01060.

X21H-01060	X2NGOD-NOOIT	2012	2016	2017	Change
	Total SASS Score	Not sampled	222	181	
	No. of SASS Families		32	29	
	Average Score Per Taxon		6.9	6.2	
	MIRAI Value		Category BC 79.3%	Category C 66.0%	↓
SQ REACH SUMMARY Invertebrate Ecstatus		Category BC 79.3%	Category C 66.0%		

The site was not sampled during the 2012 assessment (Table 74). In 2017, conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C - 66%), with several taxa expected and previously recorded absent (i.e. Hydra carina, Perlidae, Prosopistomatidae, Aeshnidae, Naucoridae). The cause for the deterioration in conditions is not yet clear.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 74.8% rating this reach as a Category C indicating a moderately modified habitat with loss and change of natural habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with a few modifications.

Impacts for SQR

- Presence of alien and invasive fish species
- Siltation and sedimentation due to catchment land use practices.
- Invasive plant species
- Bank scouring and instability

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (75.9%)	Category B
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural most of the time with few modifications



TARGET NOT MET



Possible reasons:

- Forestry related activities result in excessive sedimentation and siltation impacting on habitat biodiversity
- Presence of NEMBA alien and invasive fish species impacting on fish assemblage
- Impact of Ngodwana dam creating a total obstruction to fish migration

The distribution range of *Chiloglanis bifurcus* is entirely within privately owned land without any formal conservation protection. The two sub-populations remaining for this species need to be given priority for conservation efforts. Land and water use practices need to be carefully managed and stocking of alien organisms need to be stopped. Probably the best way to effect this would be through conservancy agreements with riparian land owners and Mpumalanga Parks Board. The Elands River and its tributaries has been identified as a priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPA) (Driver et al. 2011).

RIVER		TRIBUTARY OF	
Ngodwana		Elands	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2NGOD-NOOIT		X21H-01060	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Elevation (m. a.s.l.)	
Latitude S -25.66244		1 071	
Longitude E 30.67236		Upper Foothills	
AQUATIC ECOREGION		Geomorphological Zone	
Level I 10. Northern Escarpment Mountains		Level II 10.2	
			
<p>Figure A-73. Upstream view of the Ngodwana River site, X2NGOD-NOOIT (July 2017, G Diedericks).</p>		<p>Figure A-74. Downstream view of the Ngodwana River site, X2NGOD-NOOIT (July 2017, G Diedericks).</p>	

Discussion of Elands River and Tributaries

Fish

A total of nine indigenous reference fish species is expected to occur in the Elands River mainstem and tributaries of which eight species were recorded. *Anguilla mossambica* was the fish species not recorded during the survey, but was recorded for the 2012 survey and was also found during the 2016 survey. This catadromous species breed in the ocean, enters rivers as larvae and migrate upstream as far as they can go where they develop into adults. Adult eels return to the ocean at some stage to breed. Disruption of the river continuity, especially due to large impoundments, result in the decline of abundance of this species as migration to headwaters following their larval stage in the ocean is obstructed by weirs and impoundments. Two extralimital indigenous fish species, *Enteromius paludinosus* and *Micralestes acutidens*, were recorded during the 2017 and 2016 surveys.

The rheophilic, flow intolerant *Chiloglanis pretoriae* was collected in relative abundance together with *Enteromius crocodilensis*. The IUCN endangered red data species *Chiloglanis bifurcus* (Roux & Hoffmann, 2017a) was recorded at two sites during the 2012 survey and at four sites for the 2016 survey. It was also recorded during the 2017 survey at four sites namely the X2ELAN-DOORN (X21G-01037), X2ELAN-GOEDG and X2ELAN-ROODE (X21K-01035) and X2NGOD-NOOIT (X21H-01060). A relative density in relation to other associated fish species of 1.1% - 4.55% and a CPUE of 0.04 – 0.08 individuals caught per minute was calculated which compares well with what was described by Kleynhans (1984), (2.8% with CPUE of 0.18), indicating that this species is naturally found at low population densities. The distribution range of *Chiloglanis bifurcus* is entirely within privately owned land without any formal conservation protection. The two sub-populations remaining for this species need to be given priority for conservation efforts. Land and water use practices need to be carefully managed and stocking of alien organisms need to be stopped. Probably the best way to effect this would be through conservancy agreements with riparian land owners, IUCMA and Mpumalanga Parks Board. The Elands River and its tributaries has been identified as a priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPAs) (Driver et al. 2011).

Of a concern is the decline of the large barb, *Labeobarbus polylepis*. During the 2012 survey this species was recorded on the mainstem river at three sites and at only two sites for 2016 surveys with 27 individuals. In the recent 2017 survey this species has been recorded at 2 sites in extreme low abundance (4 individuals). Their low abundance can be attributed to reduced water quality from upstream industrial land use practices and flow regulation disruptions due to over-abstraction of water. Based on historic records the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions for The Elands River and its tributaries. The Resource Unit (RU2) below the Mill has been altered following the Ngodwana Pulp and Paper Mill spill in

September 1989, and the Frequency of Occurrence (FROC) of the recorded species in RU2 has furthermore been changed.

Introduced fish species in this River system is of serious concern as alien and invasive species and extralimital species have been recorded during recent surveys. The main source of these species is from irresponsible stocking that have taken place in the Ngodwana Dam. The introduction of fish species into river systems, indigenous or exotic, is a great risk to overall biological diversity, uniqueness and integrity of aquatic ecosystems (Cucherousset & Olden, 2011).

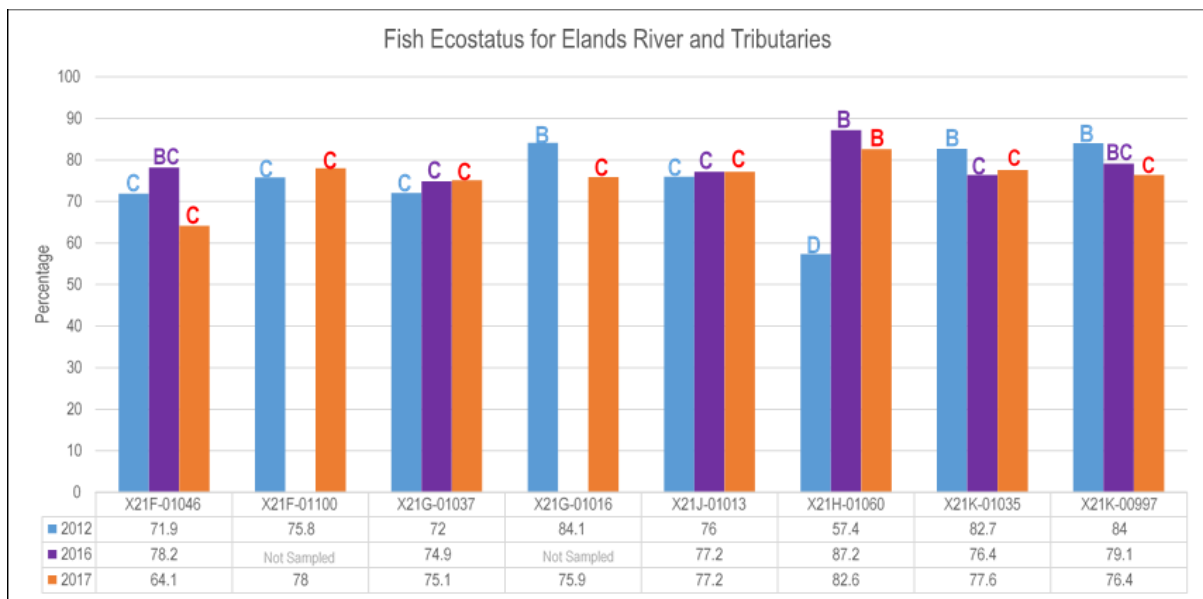


Figure 34: Fish Ecostatus rating derived from the RIVDINT model summarised for the Elands River and Tributaries, comparing 2012, 2016 to 2017.

Figure 34 summarise the Fish Ecostatus categories for the eight SQ reaches on the Elands River mainstem and tributaries. It shows that the overall Fish Ecostatus percentage for 2017 is 75.86% placing it in a category C consistent with the 2012 results of 75.49%. This is, however, a slight deterioration when compared to the 2016 results where the mean Fish Ecostatus derived a rating of 78.8% placing it in a category BC. The Target Fish Ecological Status for the Elands River as indicated by the two EWR sites (EWR ER1 and EWR ER2), should be managed at a Category B (85%) indicating that a present the fish assemblage does not meet the set requirement and is impacted by reduced water quality, reduced available instream habitat, flow regulation as well as introduced alien and invasive fish species.

Invertebrates

Table 75: A summary of MIRAI results for sites sampled on the Elands River and some of its tributaries in 2012, 2016, and 2017. Results indicate the number of available data on record for the different sampling seasons (Au – autumn, Wi – winter), Sp – spring, and Su – summer), and a summary of results for the PESEIS Reaches, indicating change between the 2012 and 2017 results with arrows. Change are indicated with arrows, e.g. ↑ = improvement, ↗ = slight improvement, → = similar conditions, ↘ = slight deterioration, and ↓ = deterioration.

SITE CODE	SITE NAME	YEAR				SAMPLING EVENTS					REACH CODE	YEAR			
		2012	2016	2017		Au	Wi	Sp	Su	ALL		2012	2016	2017	CHANGE
X2ELAN-DEGOE	De Goede	89.9	70.9	88.7	A/B	1	3	2		6	X21F-01046	89.9	70.9	88.7	→
X2ELAN-WATER	Waterval Boven	60.8	71.1	C		1	1	3		5	X21G-01037	88.1	59.0	76.9	↓
X2ELAN-DOORN	Doornhoek	88.1	57.1	82.7	B		2	3		5	X21J-01013	88.9	51.6	69.0	↓
X2ELAN-HEMLO	Hemlock	88.9	51.6	69.0	C	3	7	10		20	X21K-01035	87.7	60.6	70.3	↓
X2ELAN-ROODE	Roodewal	87.7	61.1	67.4	C	2	3	4		9	X21K-00997	86.9	60.6	72.7	↓
X2ELAN-GOEDG	Goedgeluk	60.1	73.2	C		2	2	8	1	13	X21F-01100	76.7		69.1	↘
X2ELAN-EHOEK	Lindenau	86.9	60.6	72.7	C	1	6	5		12	X21G-01016	76.4		85.9	↑
X2LEEU-GELUK	Leeuspruit @ Machadodorp	76.7		69.1	C	0	2	1	0	3	X21H-01060		79.3	66.0	↘
X2SWAR-KINDE	Swartkoppiespruit @ Kindergoed	76.4		85.9	B	0	1	1	0	2					
X2NGOD-NOOIT	Ngodwana @ Nooitgedaght	79.3	66.0	C		1	1	5	1	8					

SASS data from seven sites on the Elands River and three of its tributaries was analysed (Table 75) for a total of 83 sampling events, spanning over a period of 19 years (1997 to 2017). Most of the sampling (51%) was carried out during spring, followed by winter (31%), autumn (13%), and summer (2%). In terms of high- and low flow conditions, this suggests 84% of the available data represents low flow conditions, and 16% high flows.

Based on SASS data from previous surveys, conditions in the Elands River deteriorated considerably from 2012 to 2016, and improved slightly from 2016 to 2017. The 2016 survey was carried out during extreme low flow conditions, combined with over-abstraction (see 2016 Elands River Catchment Biomonitoring report - Roux et al., 2016). The Elands River macro-invertebrates deteriorate between the De Goede (X2ELAN-DEGOE) and Waterval Boven (X2ELAN-WATER) sites, and do not appear to recover further downstream (Figure 36). Deteriorating conditions in the upper reach is attributed to poor waste water management from the towns Machadodorp and Waterval Boven (IUCMA 2015) (Figure 35), and elevated total dissolved solids, chlorides, magnesium, and sulphates downstream from where Ngodwana Mill's irrigated effluent return flow through groundwater eyes. A slight recovery in the macro-invertebrates occurs after the X2ELAN-ROODE site, which is attributed to the dilution effect of inflowing tributaries, e.g. Battery Creek, Red Acres, Lupelule, and Starvation Creek. These listed tributaries, represents 10% of the total Elands River catchment area.

In terms of SASS taxa, the exotic family Physidae (*Physa acuta* - Sewage Snail) was present at the Waterval Boven (X2ELAN-WATER) and Elandshoek (X2ELAN-EHOEK) sites, both locations where sewage pollution are highly likely. The exotic invasive Thiaridae (*Tarebia granifera* – Quilted melania), was first recorded at the Roodewal site (X2ELAN-ROODE) in 2005, benefiting from increased salinity. Its distribution in the Elands River also and appears to be moving upstream, with the first records at the Grootfontein site (X2ELAN-GROOT) sampled in October 2016. SASS sampling at the Grootfontein site was initiated in September 1998, with the last survey prior to 2016 in January 2007. The Ephemeroptera family Tricorythidae (*Tricorythus discolor* – Stout crawlers) was absent from the September 2012 survey onwards, and is steadily decreasing in frequency of

occurrence at the sites located further downstream, Goedgeluk (X2ELAN-GOEDG) and Elandshoek (X2ELAN-EHOEK).

In the Elands Rivers' tributaries, deterioration in conditions are indicated in the Leeuspruit, and Ngodwana River. Deterioration in the Leeuspruit are mainly attributed to organic pollution. The reason for deterioration of the Ngodwana River upstream from Ngodwana Dam (X2NGOD-NOOIT) from 2016 to 2017 is currently not clear.

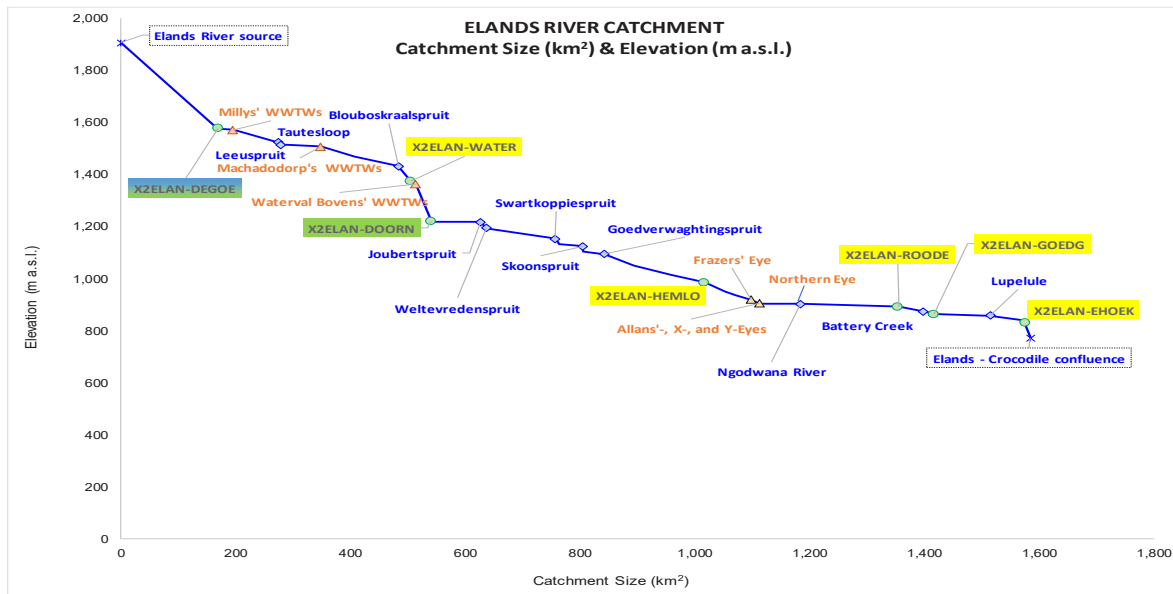


Figure 35: The Elands River is plotted on catchment size against elevation. Sites sampled in 2017 are indicated as green circles, and labeled with the site code. The points where tributaries merge with the Elands are indicated as blue diamonds, and the tributaries are labeled. The location of Waste Water Treatment Works (WWTWs) and known groundwater eyes near Ngodwana Mill are indicated as orange triangles.

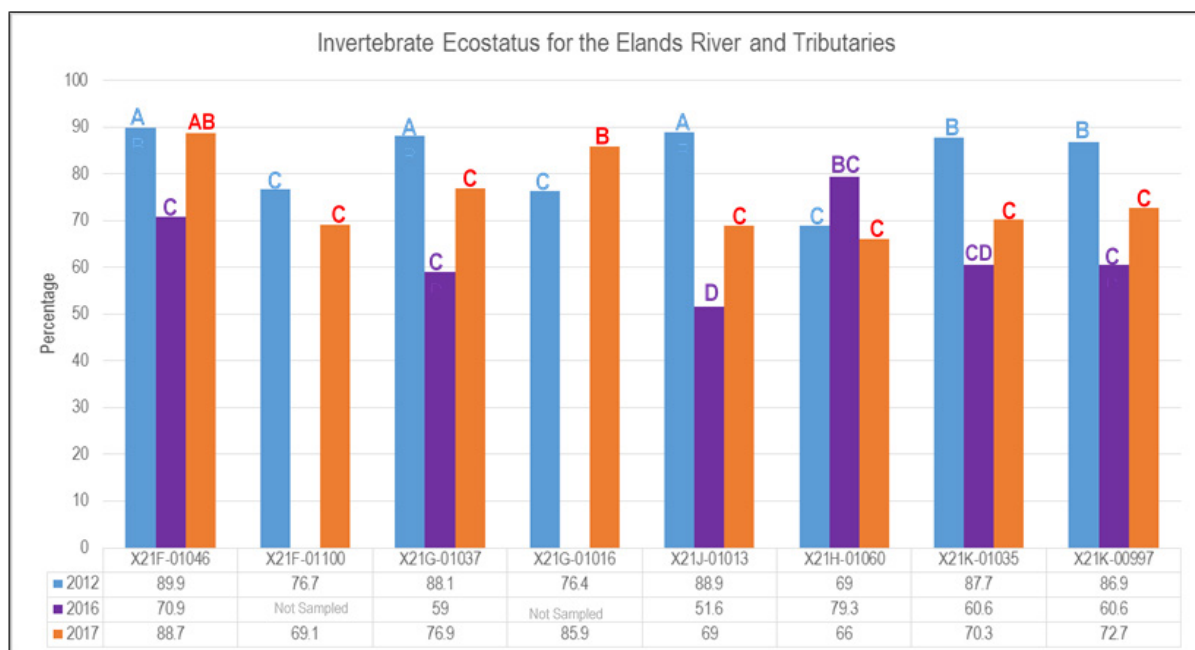


Figure 36: Invertebrate Ecostatus rating derived from the RIVDINT model summarised for the Elands River and Tributaries, comparing 2012, 2016 and 2017.

Water Chemistry

There are four High Priority water quality sites in the Elands River catchment. These are (1) the Leeuspruit tributary (a water quality high priority site), (2) SQR with EWR ER1 in the Upper Elands River (including Watervalboven), (3) another High Priority water quality site below Watervalboven to the confluence with the Ngodwana River (MRU Elan B, incorporating X21G-01073 and X21J-01013), and EWR ER2 downstream of the Ngodwana River confluence and Sappi Ngodwana.

Phosphate levels are exceeded in the Leeuspruit, while conditions at EWR ER1 have maintained a good water quality state. Conditions at EWR ER2 and MRU Elan B have deteriorated, with a number of parameters not meeting the RQOs gazetted in 2016. **There are a number of impacting activities in these stretches of river, with further assessments needed to identify and act on non-compliance.** Based on the above-mentioned it is recommended that more frequent biomonitoring be conducted in the Elands River Catchment. It would appear that the industrial activities of the Paper Mill at Ngodwana have an serious impact on the water quality and the biological component. Therefore the owners of the Paper Mill should act responsible and the IUCMA should endorse on this water licence that regular bi-annual biomonitoring should be conducted as part of their compliance. These results should be made available to the IUCMA and MTPA to assess and identify changes in the Ecstatus downstream of the above-mentioned industry.

Instream and Integrated Ecstatus Ratings for the Elands River and Tributaries

The Instream Ecstatus rating is derived from the Fish Ecstatus, Invertebrate Ecstatus and Instream Habitat Integrity assessment. From Figure 37 it is evident that the Instream Ecstatus remains consistent throughout the Elands River system ranging from a category BC (80.9%) to a category C (73.1%) with a mean Instream Ecstatus Rating of 75.3% representing a Category C. This remains consistent with the Instream Ecstatus for 2016 surveys at (71.25% Category C), but indicates a decrease from the 2012 survey results placing the Elands River system in a Category BC (79.6%).

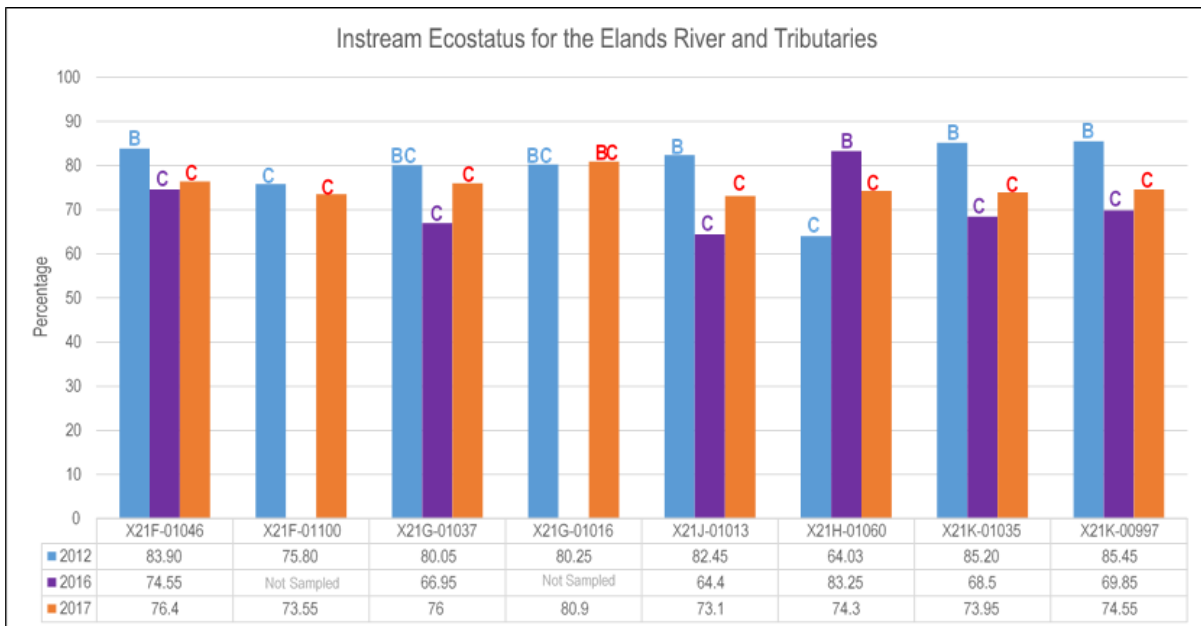


Figure 37: Instream Ecostatus derived from the RIVDINT model summarised for the Elands River and Tributaries, comparing 2011, 2016 and 2017.

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model. The overall Integrated Ecostatus for the Elands River and tributaries (Figure 38) remained consistent throughout the 2012 (76.67%), 2016 (72.5%) and 2017 (76.15%) monitoring with a category C indicating a moderately impaired habitat with a low diversity and low abundance of species. This is, however, a contradicting representation of the biomonitoring results as some of the SQ reaches present with very low C Category values influencing the overall calculation, neglecting SQ Reaches that achieved a Category B. When comparing the 2017 biomonitoring with previous surveys (Figure 38) at an SQ Reach level, it is evident that the Integrated Ecostatus of five SQ Reaches (X21F-01046, X21G-01037 EWR ER1, X21H-01060, X21K-01035 EWR ER2 and X21K-00997) declined from a Category B to a Category C. Factors contributing to this can be related to inefficient catchment management as a result of industry related impacts and land use practices negatively affecting instream habitat and reduced water quality standards. Whereas flow regulation and over-abstraction as well as the combined effect of reduced water quality contribute to a decline in Ecological Categories.

When comparing the Integrated Ecostatus with the Target Ecological Category (TEC) within the various SQ reaches and EWR sites as per gazetted RQO's, it is evident that the set targets are not met for most of the SQ reaches in the Elands River and tributaries, including the two EWR sites. The Elands River and its tributaries has been identified as a priority freshwater environment for fish conservation (presence of endangered IUCN red data spp. *Chiloglanis bifurcus*) and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPA) (Driver et al. 2011). It is therefore recommended that this catchment should be managed at an Ecological Category B (85%). As the TEC's are not met for most of the SQ reaches within this river system it is

suggested that the catchment management be reviewed and before any additional water use licenses be issued a comprehensive Reserve Determination must be conducted. In addition, the TEC's for all the other SQ Reaches (not EWR) derived from the PES-EIS desktop assessment with low confidence level, need to be reviewed and revised based on sound scientific data.

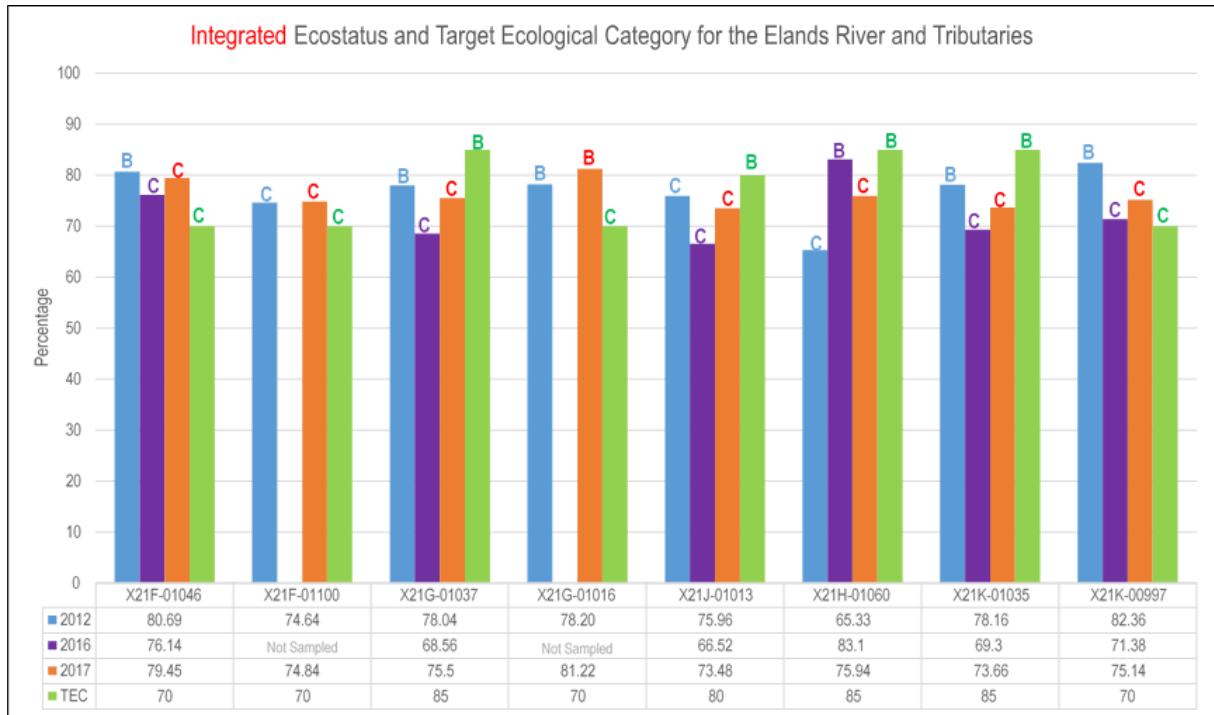


Figure 38: Integrated Ecostatus derived from the RIVDINT model summarised for the Elands River and Tributaries, comparing 2012, 2016 and 2017.

Kaap River and Tributaries

The Kaap River sub-catchment, with a total surface area of 1,640 km², is fed from two main tributaries, the Noord Kaap and Suid-Kaap Rivers. The Queens River is a tributary of the Suid-Kaap. Commercial forestry dominates the upstream catchments of these rivers, with small holding agriculture (crops and livestock), settlement areas, and mining the main land-uses. Irrigation agriculture increase further downstream.

SQ REACH NUMBER X23E-01154

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecosystem	Invertebrate Ecosystem	Instream Ecosystem	Riparian Vegetation Ecosystem	Integrated Ecosystem	TEC	Biomonitoring Year
X23E-01154	X2QUEE-HILVE	Queens	S-25.79068 E 30.91542	745	43.4	C	C 68.6%	C 75%	C 71.34%	D 50%	C 66.67%	BC 80%	2012
							C 77.8%	C 75.5%	C 76.7%	C 77.5%	C 76.8%		2017

General description

Reach X23E-01154: Suid Kaap

The Queens River originates at an elevation of 1520 m.a.s.l. and flows just north of the town Barberton to the confluence with the Suid-Kaap River at an elevation of 630 m.a.s.l. The instream habitat of the upper part of the reach is dominated by bedrock and boulders. The lower part of the reach is dominated by pools fringed by reeds. The reach falls within the Great Escarpment Mountains and Lowveld aquatic ecoregions. The land cover comprise of 5.3% wetland, 3.1% indigenous forests, 18.8% thickets and dense bush, 3.7% woodlands and open bush and grasslands 17.8% (GEOTERRAIMAGE, 2015). The land use practices in the reach consists mainly of commercial forestry (plantations 41.2%) and intensive mining for minerals.

The Queens River at the Hilversum site is 4 - 10 m wide, dominated by cobble, boulders, gravel, and sand with silt and mud. There are several bare lateral sand bars, suggesting relatively recent sediment inputs. Hydraulic biotopes include rapids, riffles, runs, glides, and pools.

Instream Habitat Integrity

The Instream IHI for the SQ reach X23E-01154 was calculated at 78.68% rating this SQ reach as a BC Category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

All fish velocity depth classes were present at the (X2QUEE-HILVE) site, with both slow deep and slow shallow sparse, fast deep moderate and fast shallow abundant. There was no overhanging vegetation or aquatic macrophytes and the cover for fish was undercut banks with prominent root wads. Boulders and large rocks provided very good substrate cover.

Table 76: Fish species expected based on the PESEIS Reach Code (X23E-01154) X2QUEE-HILVE; is listed, and the numbers of fish species present during the different surveys are indicated.

X22J-01154	Expected Species	X2QUEE-HILVE	
		2012	07/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius crocodilensis</i>	x	-	-
<i>Enteromius eutaenia</i>	x	-	16
<i>Enteromius trimaculatus</i>	x	-	-
<i>Enteromius unitaeniatus</i>	x	-	11
<i>Enteromius viviparus</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	-
<i>Labeo molybdinus</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	-	74
<i>Labeobarbus (Varicorhinus) nelspruitensis</i>	x	-	32
<i>Opsaridium peringueyi</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	4	3
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	1	29
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparmanii</i>	x	-	4
Number of species expected	20		
Number of species recorded		2	7
Number of individuals		5	169
Electro-fishing time (minutes)		21	22
Catch/Unit Effort (CPUE)		0.24	7.68

This reach is representative of a transitional zone with more temperate Lowveld fish species expected. In total seven of an expected 20 indigenous fish species (Table 76) were collected, which consisted of four Cyprinidae, one Amphiliidae, one Mochokidae and one Cichlidae species. The dominant species recorded included *Labeobarbus marequensis* and *Labeobarbus nelspruitensis* both rheophilic species, both intolerant to flow regulation. Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of

Occurrence (FROC) of the recorded species has furthermore been altered as a result of loss of instream habitat due to siltation and sedimentation.

The CPUE calculated was 7.68 (169 individuals; 22 minutes) indicates a relative abundance of fish. The species diversity was however low (7 out of 20 expected species).

A Fish Ecstatus rating of 77.8% was calculated for this monitoring point based on all available information, placing it in an Ecological Category C (moderately impaired with a low diversity of species).

Invertebrates

Table 77: 2017 SASS5 results for SQ reach X23E-01154.

X23E-01154	X2QUEE-HILVE	2012	2017	Change
	Total SASS Score	Not sampled	173	
	No. of SASS Families		28	
	Average Score Per Taxon		6.2	
	MIRAI Value		Category C 75.5%	
SQ REACH SUMMARY Invertebrate Ecstatus			Category C 75.5%	Not applicable

The 2017 sampling event is the only one record. A total of 28 SASS were recorded during the 2017 sampling event, of which sensitive SASS taxa recorded included Hydraenidae, Perlidae, Baetidae >2 sp., Heptageniidae, Leptophlebiidae, Tricorythidae, Chlorocyphidae, Philopotamidae, and Elmidae.

Conditions at the site were categorised as moderately impaired (76%) in 2017 (Table 77). Habitat disturbance from sediment deposits and movement, are considered the main source of impairment.

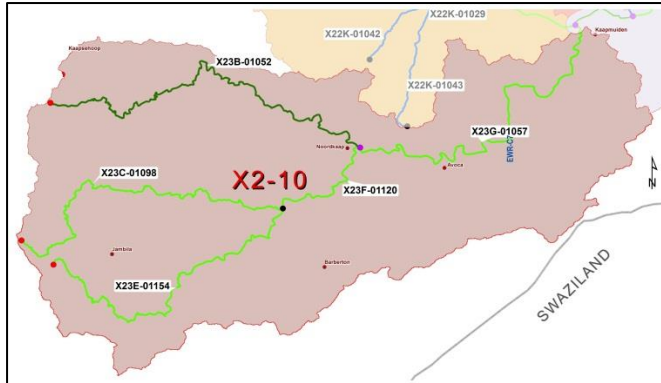
Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 75.92% rating this reach as a Category C indicating a moderately modified habitat with a loss and change of habitat, the resilience of the system to recover has not been lost and its ability to recover to a moderately modified condition has been maintained. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating a moderately modified habitat.

Water Quality

X23C-01098, X23E-01154, X23F-01120 (RU C17): SUID-KAAP AND QUEENS RIVERS

IUA X2-10 - KAAP RIVER SYSTEM



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
RU C16	X23B-01052	Noordkaap	D	C	3WQ 2
RU C17	X23C-01098	Suidkaap	C	B/C	3WQ 2
	X23E-01154	Queens	C	B/C	
	X23F-01120	Suidkaap	C	C	
MRU Kaap A	X23G-01057 EWR C7	Kaap	C	C	3WQ 3

Two data sources were used for this evaluation, i.e. X2H031Q01 (Suid-Kaap River) and X2H008Q01 (Queens River). The following applies to both sites.

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	✓
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).	✓
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).	No data

Impacts for SQR

- Forestry related impacts
 - siltation and sedimentation
 - loss of available fish habitat
- Reduced instream habitat and riparian vegetation
- Invasive plant species
- Domestic waste in stream and riparian zone
- Poor road drainage networks
- Mining related activities
 - reduced water quality

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)



INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (76.8%)	Category BC
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural most of the time with few modifications

TARGET NOT MET



Possible reasons:

- Forestry related activities in catchment
- Mining activities impacting on reduced water quality

RIVER		TRIBUTARY OF	
Queens		Kaap	
SITE NUMBER	QUATERNARY SUB-CATCHMENT	REACH	
X2QUEE-HILVE	X23E	X23E-01154	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Longitude	Elevation (m. a.s.l.)	Geomorphological Zone
	E 30.91542	745	Upper Foothills
AQUATIC ECOREGION	Level I	Level II	
	4.North Eastern Highlands	4.04	
			
Figure A-75. Upstream view of the Hilversum site on the Queens River, X2QUEE-HILVE (July 2017, G Diedericks).	Figure A-76. Downstream view of the Hilversum site on the Queens River, X2QUEE-HILVE (July 2017, G Diedericks).		

SQ REACH NUMBER X23C-01098

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X23C-01098	X2SUID-DAISY	Suid Kaap	S-25.73033 E 30.98429	646	44.3	D	C 72.5%	C 68.6%	C 69.90%	D 50%	C 65.31%	BC 80%	2012
							C 76.7%	C 77.1%	C 76.9%	C 73.8%	C 76.3%		2017

General description

Reach X23C-01098: Suid-Kaap

The Suid-Kaap originates at an elevation of 1 660 m a.s.l., merging with the Queens River at an elevation of 630 m a.s.l., and with the Noord-Kaap at an elevation of 574 m a.s.l. The PESEIS reach within which the sampling point (X2SUID-DAISY) starts at the origin of the Suid-Kaap and ends at the Suid-Kaap's confluence with the Queens. The upper portion of the Suid-Kaap falls within the Northern Escarpment Mountains (10.02) aquatic ecoregion, and the lower portion in the North Eastern Highlands (4.04) aquatic ecoregion. In terms of vegetation types, the Northern Escarpment Quartzite Sourveld (Gm 23) makes up the upper portion of the Suid-Kaap while the bulk of the catchment falls within the Legogote Sour Bushveld (SVI 9) vegetation type. The land cover comprise of wetlands (3.6%), thickets and dense bush (18.1%), woodlands and open bush (2.8%) with grasslands (10.6%) (GEOTERRAIMAGE, 2015). Commercial forestry (plantations 51.6%) is the main land-use in the upper catchment, with small holdings, agricultural crops (cultivated fields 5.5% and cultivated orchards 3.4%), and livestock the dominant land-uses further downstream.

The Suid-Kaap at the sampling site is 4 to 12 m wide, dominated by cobble, sand, gravel, boulders, and mud-silt. A weir is located upstream from the site, covered in water hyacinth (*Eichhornia crassipes*) and dominated with sand. Hydraulic biotopes downstream from the weir include riffles, runs, pools, and glides.

Instream Habitat Integrity

The Instream IHI for the SQ reach X23C-01098 was calculated at 78.68% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. Flow regime has been slightly to moderately modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The (X2SUID-DAISY) site is representative of this reach and consisted of riffles, runs, glides and pools. The fish velocity depth classes comprised of sparse slow deep and fast deep habitats present. The slow shallow habitat was moderately abundant and fast shallow habitat abundant. Aquatic macrophytes and overhanging vegetation offered very good cover for fish with large rocks and cobbles providing the necessary substrate cover.

Table 78: Fish species expected based on the PESEIS Reach Code (X23C-01098) X2SUID-DAISY; is listed, and the numbers of fish species present during the different surveys are indicated.

X22J-01098	Expected Species	X2SUID-DAISY	
		2012	08/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	-	17
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius crocodilensis</i>	x	-	-
<i>Enteromius eutaenia</i>	x	3	9
<i>Enteromius trimaculatus</i>	x	1	4
<i>Enteromius unitaeniatus</i>	x	2	-
<i>Enteromius viviparus</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	-
<i>Labeo molybdinus</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	5	21
<i>Labeobarbus (Varicorhinus) nelspruitensis</i>	x	-	-
<i>Opsaridium peringueyi</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	-	25
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	6	15
<i>Tilapia sparrmanii</i>	x	-	5
Number of species expected	20		
Number of species recorded		5	7
Number of individuals		17	96
Electro-fishing time (minutes)		26	28
Catch/Unit Effort (CPUE)		0.65	3.43

A total of 20 indigenous fish species is expected to occur in this reach. Seven were collected during the present survey (Table 78) which included *Marcusenius macrolepidotus*, *Enteromius eutaenia*, *Enteromius trimaculatus*, *Labeobarbus marequensis*, *Chiloglanis pretoriae*, *Pseudocrenilabrus philander* and *Tilapia sparrmanii*. Only three of the expected ten Cyprinidae species were collected in low abundance. The snout fish, *Marcusenius macrolepidotus*, is rarely collected in abundance, although during this survey 17 individuals were collected, ranging from juveniles to adults. This indicates a viable population breeding successfully. Few of the expected

fish species in relative low abundance are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The CPUE was calculated at 3.43 (96 individuals; 28 minutes) indicating a relative abundance of fish but a low diversity of species.

A Fish Ecstatus rating of 76.7% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species).

Invertebrates

Two SASS sampling events are on record for the Suid-Kaap site, X2SUID-DAISY. The sampling represents two winter sampling events. A total of 35 SASS taxa have been recorded during these six sampling events, of which 36 taxa in total were recorded during the two surveys. The sensitive rated SASS taxa Hydra carina, Baetidae > 2 sp., Heptageniidae, and Leptophlebiidae were recorded during both sampling events.

Table 79: 2017 SASS5 results for SQ reach X23C-01098.

X23C-01098	X2SUID-DAISY	2012	2017	Change
	Total SASS Score	Data not available	181	
	No. of SASS Families		30	
	Average Score Per Taxon		6.0	
	MIRAI Value	Category C 68.6%	Category BC 77.1%	↗
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 68.6%	Category BC 77.1%		

Conditions at the X2SUID-DAISY site in 2017 (Table 79), based on MIRAI, were rated as slightly to moderately impaired (Category BC – 77%). Sedimentation of instream habitat is attributed to impaired conditions. The presence of Eichhornia crassipes further suggest upstream nutrient inputs.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 73.75% and is consistent with a Category C – moderately modified habitat with loss and change of natural vegetation. The Riparian IHI was calculated at 75.92% rating this reach as a Category C indicating a moderately modified habitat. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (73.75%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Impacts for SQR

- Siltation and sedimentation
- Invasive plant species
- Domestic waste in stream and riparian zone
- Forestry related impacts

See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)



INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (76.1%)	Category BC
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural most of the time with few modifications

TARGET NOT MET



Possible reasons:

- Loss of available habitat biodiversity due to excessive siltation and sedimentation
- Suspected reduced water quality

RIVER		TRIBUTARY OF	
Suid-Kaap		Kaap	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2SUID-DAISY		X23C	
REACH		X23C-01098	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		Geomorphological Zone	
Latitude	Longitude	Upper Foothills	
S -25.73033	E 30.98429	646	
AQUATIC ECOREGION		Level II	
4. North Eastern Highlands		Level II	
4.04		4.04	
			
<p>Figure A-77. Upstream view of the Suid-Kaap site, X2SUID-DAISY (July 2017, G Diedericks).</p>		<p>Figure A-78. Downstream view of the Suid-Kaap site, X2SUID-DAISY (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X23B-01052

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	TEC	Biomonitoring Year
X23B-01052	X2NOOR-RIVER	Noord Kaap	S-25.61009 E 30.97639	664	53.8	D	C 65.4%	C 75.2%	C 70.30%	D 50%	C 66.24%	C 70%	2012
							C 74.7%	BC 79.7%	C 77.2%	C 72.5%	C 76.3%		2017

General description

Reach X23B-01052: Noord-Kaap

The Noord-Kaap originates as a small mountain stream at an elevation of 1,700 m a.s.l., flowing in an easterly direction towards the Suid-Kaap River. The two rivers merge at an elevation of 573 m a.s.l., to form the Kaap River. The entire Noord-Kaap River (59 km) falls within the X23B-01052 PESEIS reach. The upper portion of the Noord-Kaap falls within the Northern Escarpment Mountains (10.02) aquatic ecoregion, and the lower portions into the North Eastern Highlands (4.04). In terms of vegetation types, the Northern Escarpment Quartzite Sourveld (Gm 23) makes up the upper portion of the Noord-Kaap, the Legogote Sour Bushveld (SVI 9) vegetation type the bulk of the catchment, with a small portion close to the Suid-Kaap confluence within the Granite Lowveld (SVI 3). The land cover comprise of wetlands (2.3%) and indigenous forests (3.17%) with thickets and dense bush (36%) and grasslands (10%) with limited woodlands and open bush (3.4%) (GEOTERRAIMAGE, 2015). The upper portion of the catchment is dominated by commercial forestry (34%) as a land use, with small holdings, agricultural crops (cultivated fields 3.85% and cultivated orchards 3.9%), agricultural livestock, and mining dominant land-uses further downstream (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The Instream IHI for the SQ reach X23B-01052 was calculated at 76.08% rating this SQ reach as a C Category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The site (X2NOOR-RIVER) is downstream from the Barberton Nature Reserve and is representative for this reach. All the fish velocity depth classes (slow deep, fast shallow and slow shallow) were sampled ranging from moderate to abundant, except for fast deep that was absent. The most prominent cover for fish was the substrate with rocks and cobbles offering good cover for fish with aquatic macrophytes in slow shallow biotope.

Table 80: Fish species expected based on the PESEIS Reach Code (X23B-01052) X2NOOR-RIVER; is listed, and the numbers of fish species present during the different surveys are indicated.

X23B-01052	Expected Species	X2NOOR-RIVER	
		2012	08/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius crocodilensis</i>	x	-	-
<i>Enteromius eutaenia</i>	x	-	56
<i>Enteromius trimaculatus</i>	x	-	-
<i>Enteromius unitaeniatus</i>	x	-	-
<i>Enteromius viviparus</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	-
<i>Labeo molybdinus</i>	x	-	-
<i>Labeobarbus marequensis</i>	x	3	7
<i>Labeobarbus (Varicorhinus) nelspruitensis</i>	x	-	-
<i>Opsaridium peringueyi</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	1	3
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	-
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	74	23
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	7	-
<i>Pseudocrenilabrus philander</i>	x	39	5
<i>Tilapia sparrmanii</i>	x	-	4
Number of species expected	20		
Number of species recorded		5	6
Number of individuals		124	98
Electro-fishing time (minutes)		29	28

A total of 20 indigenous species of fish are expected to occur in this reach of which only six were collected during the present survey and five during the 2012 survey (Table 80). The most abundant fish species during the recent survey was the small barb, *Enteromius eutaenia*, the only small barb found. This species has a preference for fast shallow habitats (4.7) and overhanging vegetation cover (4.1), it is furthermore intolerant to no flow conditions (4.6) and reduced water quality (4.9). Based on these preferences it indicates that the instream habitat is adequate with no disruptions in flow or reduced water quality standards. Therefore the absence of the *Labeo* species (*Labeo cylindricus* and *Labeo molybdinus*), *Labeobarbus nelspruitensis* and *Opsaridium peringueyi* is of concern as adequate habitat is present and these species have not been recorded since 2012. Few of the expected fish species (6 of 20 expected species) are present within this resource unit and therefore the Frequency of Occurrence (FROC) of most species have been reduced from the reference conditions. The low abundance of species collected indicate that the Frequency of Occurrence (FROC) of the recorded species has been altered. During both the surveys done was the CPUE remained consistent with 4.28 (124 individuals; 29

minutes) in 2012 and 4.08 (98 individuals; 28 minutes) in 2017 survey. These results indicate a relative abundance of fish but a rather low diversity of fish species.

A Fish Ecstatus rating of 74.7% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species) which is consistent with the 2012 survey (Fish Ecstatus of 65.4% and an Ecological Category C).

Invertebrates

Three SASS sampling events are on record for the Riversdale site (X2NOOR-RIVER) on the Noord-Kaap River. These represent one autumn, winter, and spring sample each. A total of 38 SASS taxa have been recorded during these three sampling events, with the highest taxa diversity (30) recorded during the 2017 winter sampling, and the lowest (20) during September 2011 spring event. Sensitively rated SASS taxa recorded during most all three sampling events included Perlidae, Baetidae >2 sp., Heptageniidae, Philopotamidae, and Athericidae.

Table 81: Comparison of the 2012 and 2017 SASS5 results for SQ reach X23B-01052.

X23B-01052	X2NOOR-RIVER	2012	2017	Change
	Total SASS Score	178	210	
	No. of SASS Families	26	30	
	Average Score Per Taxon	6.8	7.0	
	MIRAI Value	Category C 75.2%	Category BC 79.7%	➔
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 75.2%	Category BC 79.7%		

Based on the 2017 SASS5 results (Table 81), MIRAI indicates improved conditions compared to 2012. In 2012, conditions based on MIRAI was categorised as moderately impaired (75%), and as slightly to moderately impaired (80%) in 2017.

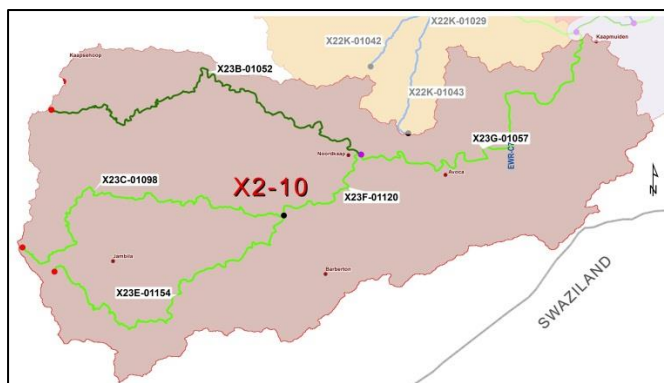
Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 72.5% and is consistent with a Category C – moderately modified with a loss and change of natural vegetation. The Riparian IHI was calculated at 75.92% rating this reach as a Category C indicating a moderately modified riparian zone. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

X23B-01052: NOORD-KAAP RIVER

IUA X2-10 - KAAP RIVER SYSTEM



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
RU C16	X23B-01052	Noordkaap	D	C	3WQ 2
RU C17	X23C-01098	Suidkaap	C	B/C	3WQ 2
	X23E-01154	Queens	C	B/C	
	X23F-01120	Suidkaap	C	C	
MRU Kaap A	X23G-01057 EWR C7	Kaap	C	C	3WQ 3

Two data sources were used for this evaluation, i.e. X2H010Q01 (Noord-Kaap River at Bellevue) and X2H080Q01 (Segalla, u/s of Consort Gold Mine).

At X2H080Q01:

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).	X
Ensure that turbidity/clarity or TSS levels stay within Acceptable limits.	A moderate change from present with temporary high sediment loads and turbidity (aquatic ecosystems: driver).	No data

At X2H010Q01:

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Acceptable limits.	50 th percentile of the data must be less than 0.025 mg/L PO ₄ -P (aquatic ecosystems: driver).	✓
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95 th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).	✓

Summarized results: The two sets of results clearly show significant changes along the length of the Noord-Kaap River. The conditions are much better at the top of the system at X2H010Q01, with a deterioration in phosphate and salt levels down toward X2H080Q01 at the lower end of the system.

The water quality recommendations are as follows:

1. Monitoring for RQOs for the Noord-Kaap River should be conducted at the lower end of the SQR, using monitoring point X2H080Q01 so as to evaluate the whole length of the reach.
2. Evaluate biota scores at the biological monitoring point to assess impacts.
3. Institute turbidity monitoring as it has been flagged as a water quality issue.
4. Act on non-compliance with RQOs. Load calculations should be done to evaluate flow-related concentrations and determine the source of impacts.

Impacts for SQR

- Invasive plant species
- Domestic waste in stream and riparian zone
- Forestry related activities in catchment
- Impact of mining related activities
- Siltation and sedimentation



See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (76.3%)	Category C
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET



RIVER		TRIBUTARY OF	
Noord-Kaap		Kaap	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2NOOR-RIVER		X23B	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
X23B-01052		X23B-01052	
AQUATIC ECOREGION		Geomorphological Zone	
4. North Eastern Highlands		Upper Foothills	
Level I		Level II	
4.04		4.04	
			
<p>Figure A-79. Upstream view of the Riverside site, X2NOOR-RIVER, on the Noord-Kaap River (July 2017, G Diedericks).</p>		<p>Figure A-80. Downstream view of the Riverside site, X2NOOR-RIVER, on the Noord-Kaap River (July 2017, G Diedericks).</p>	

SQ REACH NUMBER X23G-01057 EWR 7

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecosystem	Invertebrate Ecosystem	Instream Ecosystem	Riparian Vegetation Ecosystem	Integrated Ecosystem	TEC	Biomonitoring Year
X23G-01057	X2KAAP-HONEY EWR 7	Kaap	S-25.64947 E 31.24286	453	48.1	D	C 72.2%	C 74.4%	C 73.52%	D 50%	C 66.99%	C 70.09%	2012
							C 71.2%	C 76.1%	C 73.7%	C 72.5%	C 73.4%		2017

General description

Reach X23G-01057: Kaap

The PESEIS reach starts at the Suid-Kaap and Noord-Kaap confluence (573 m a.s.l.), to where the Kaap River merge with the Crocodile River at an elevation of 330 m a.s.l., representing 48 km. The Kaap River flows through mining and irrigated agricultural areas (3.7% cultivated orchards and 3.1% cultivated commercial cane) with commercial forestry at 3.5%. The sampling site, X2KAAP-HONEY, is an Ecological Water Reserve site – EWR 7 – and is located a few kilometres upstream from the rivers confluence with the Crocodile River. The entire portion of the PESEIS reach falls within the North Eastern Highlands (4.04) aquatic ecoregion, and within the Granite Lowveld (SVI 3) vegetation type. The land cover is dominated by thickets and dense bush (71.3%) with areas of woodlands and open bush (8.3%) and grasslands (6.7%) (GEOTERRAIMAGE, 2015).

The Honeybird site on the Kaap River is 2 - 8 m wide, dominated by bedrock, boulders, cobble, and gravel, sand, silt, and mud. Hydraulic biotopes include rapids, riffles, runs, and glides.

Instream Habitat Integrity

The Instream IHI for the SQ reach X23G-01057 was calculated at 76.08% rating this SQ reach as a C Category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (RIVDINT model Crocodile River System, 2017).

Fish

The EWR 7 site (X2KAAP-HONEY) was sampled on this relative long reach. The river has a high gradient at the point sampled with high velocity water over boulders and large rocks. Rapids and runs provided both fast deep and fast shallow habitat in abundance. Substrate cover in the form of boulders and rocks in the rapids and runs provided adequate cover for fish.

Table 82: Fish species expected based on the PESEIS Reach Code (X23G-01057) X2KAAP-HONEY; is listed, and the numbers of fish species present during the survey is indicated.

X23G-01057	Expected Species	X2KAAP-HONEY	
		2012	08/2017
Mormyridae (Snout fishes)			
<i>Marcusenius macrolepidotus</i>	x	-	-
<i>Petrocephalus wesselsi</i>	x	-	-
Anguillidae (Freshwater Eels)			
<i>Anguilla mossambica</i>	x	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)			
<i>Enteromius eutaenia</i>	x	-	-
<i>Enteromius paludinosus</i>	x	-	-
<i>Enteromius trimaculatus</i>	x	-	29
<i>Enteromius unitaeniatus</i>	x	-	-
<i>Enteromius viviparus</i>	x	-	-
<i>Labeo cylindricus</i>	x	-	-
<i>Labeo molybdinus</i>	x	-	54
<i>Labeobarbus marequensis</i>	x	-	42
<i>Opsaridium peringueyi</i>	x	-	-
Characidae (Characins)			
<i>Micralestes acutidens</i>	x	-	-
Amphiliidae (Mountain catfishes)			
<i>Amphilius uranoscopus</i>	x	-	-
Schilbeidae (Butter catfishes)			
<i>Schilbe intermedius</i>	x	-	-
Clariidae (Air-breathing catfishes)			
<i>Clarias gariepinus</i>	x	-	1
Mochokidae (Squeakers, suckermouth catlets)			
<i>Chiloglanis pretoriae</i>	x	-	8
Cichlidae (Cichlids)			
<i>Coptodon rendalli</i>	x	-	-
<i>Oreochromis mossambicus</i>	x	-	-
<i>Pseudocrenilabrus philander</i>	x	-	-
<i>Tilapia sparrmanii</i>	x	-	2
Number of species expected	21		
Number of species recorded		NS	6
Number of individuals			136
Electro-fishing time (minutes)			23
Catch/Unit Effort (CPUE)			5.91

The fish assemblage of this long reach comprises of elements of both temperate and tropical fish species. However, only six of an expected 21 indigenous species of fish (Table 82) were collected during this survey. The fish assemblage consisted primarily of Cyprinidae of which three of an expected nine species were collected (*Enteromius trimaculatus*, *Labeo molybdinus* and *Labeobarbus marequensis*) in relative abundance. For the rheophilic flow sensitive species *Amphilius uranoscopus* and *Chiloglanis pretoriae* was either absent or collected in relative low abundance. The recorded habitat biotope surveyed at this site was marginal for the distribution of both these species as a result of loss of interstitial spaces between substrate cover causing a loss of available instream fish habitat. Not all of the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of loss of instream habitat and reduced water quality. The CPUE for the present survey was calculated at 5.91 (136 individuals: 23 minutes)

indicating a high abundance of fish. This is, however, a skewed representation of the fish assemblage as the fish recorded represents the more tolerant species with a loss of intolerant rheophilic fish species and fish diversity.

A Fish Ecstatus rating of 71.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species).

Invertebrates

The 2017 SASS sampling event was the only one that could be traced for the X2KAAP-HONEY sampling point. A total of 30 SASS taxa have been recorded during the 2017 sampling event. Sensitive taxa were present, but recorded at low abundances. The salt tolerant exotic Gastropod, *Tarebia granifera*, were present and abundant.

Table 83: 2017 SASS5 results for SQ reach X23G-01057.

X23G-01057	X2KAAP-HONEY	2012	2017	Change
	Total SASS Score	Data not available	217	
	No. of SASS Families		30	
	Average Score Per Taxon		7.2	
	MIRAI Value	Category C 74.4%	Category C 76.1%	➔
SQ REACH SUMMARY Invertebrate Ecstatus	Category C 74.4%	Category C 76.1%		

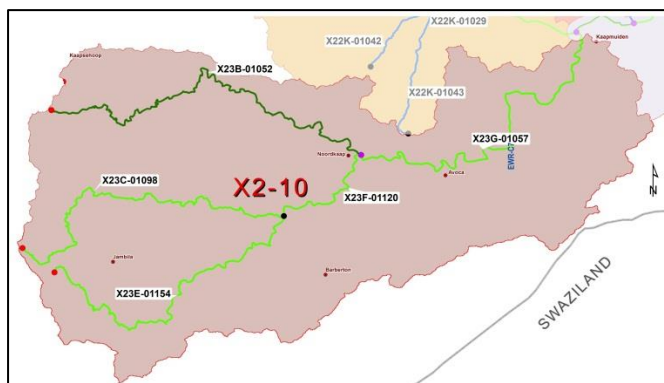
The 2017 SASS5 results, based on MIRAI, indicates moderately impaired (76%) conditions in 2017 (Table 83).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 72.5% and is consistent with a Category C – moderately modified with a loss and change of natural habitat. The Riparian IHI was calculated at 78.88% rating this reach as a Category BC indicating a close to largely natural reach with few modifications most of the time. The overall Riparian Ecstatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (72.5%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

IUA X2-10 - KAAP RIVER SYSTEM



PRIORITY RATINGS

RUs	SQ number	River	PES	TEC	PR
RU C16	X23B-01052	Noordkaap	D	C	3WQ 2
RU C17	X23C-01098	Suidkaap	C	B/C	3WQ 2
	X23E-01154	Queens	C	B/C	
	X23F-01120	Suidkaap	C	C	
MRU Kaap A	X23G-01057 EWR C7	Kaap	C	C	3WQ 3

Narrative RQO	Numerical RQO	Notes
Ensure that nutrient levels are within Tolerable limits.	50 th percentile of the data may be at 0.125 mg/L PO ₄ -P (aquatic ecosystems: driver).	✓
Ensure that nutrient levels are within Tolerable limits.	The 50 th percentile of the data must be ≤ 4.0 mg/L TIN-N (aquatic ecosystems: driver).	X
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95 th percentile of the data must be less than or equal to 200 mS/m (Aquatic ecosystems: driver). <i>Note this is a naturally salinised system.</i>	✓
Ensure that toxics (other than As and Cn) are within Ideal limits or A categories.	95 th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008b). Numerical limits can be found in DWAF (1996c) and DWAF (2008b).	✓ Limited data
Ensure that As levels are within Ideal limits or A categories.	95 th percentile of the data must be less than 0.020 mg/L As (aquatic ecosystems: driver).	No data
Ensure that (free) Cn levels are within Ideal limits or A categories.	95 th percentile of the data must be less than 0.004 mg/L Cn (aquatic ecosystems: driver).	No data

Reserve and Classification studies: Data used for water quality assessments should be collected from X2H022Q01.

Summarized results for EWR 7: Water quality at this site has met most of the RQOs, other than an elevation in Total Inorganic Nitrogen levels (0.648 mg/L as calculated for present state (data from 2000 to 2017)). Note that few toxics data are available.

The water quality recommendations are as follows:

- Evaluate biota scores at the biological monitoring point to assess impacts for turbidity and temperature. Data are not available to evaluate these impacts other than on a qualitative basis.
- Limited toxics data were available for evaluation.
- Institute the monitoring of As and Cn at X2H022Q01.
- Evaluate the sources of elevated nitrogen data. Analyse for this variable on a more regular basis.

Impacts for SQR

- Invasive plant species
- Domestic waste in stream and riparian zone
- Impacts of mining activities in catchment
- Forestry related impacts



See appendix E

Integrated Ecostatus Category and Target Ecological Category (TEC)

INTEGRATED ECOSTATUS	TARGET ECOSTATUS
Category C (73.4%)	Category C (70.09%)
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota

TARGET MET



RIVER		TRIBUTARY OF	
Kaap		Crocodile	
SITE NUMBER		QUATERNARY SUB-CATCHMENT	
X2KAAP-HONEY (EWR 7)		X23G	
GPS CO-ORDINATES (WGS84 – dd.ddddd):		REACH	
Latitude		X32G-00565	
S -25.64947		Geomorphological Zone	
Longitude		Upper Foothills	
E 31.24286		Level II	
AQUATIC ECOREGION		Level II	
4.North Eastern Highlands		4.04	
			
<p>Figure A-81. Upstream view of the Honeybird site, X2KAAP-HONEY, on the Kaap River (July 2017, G Diedericks).</p>		<p>Figure A-82. Downstream view of the Honeybird site, X2KAAP-HONEY, on the Kaap River (July 2017, G Diedericks).</p>	

Discussion for Kaap River and tributaries

FISH

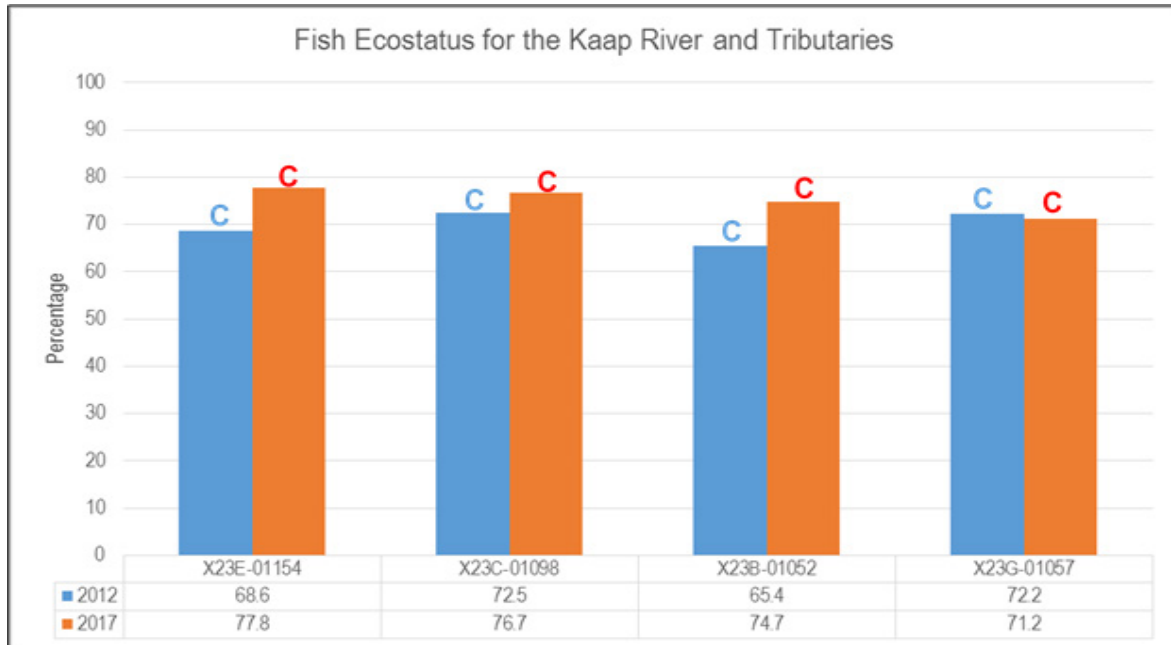


Figure 39: Fish Ecostatus derived from the RIVDINT model summarised for the Kaap River and Tributaries, comparing 2012 to 2017.

In total 12 of an expected 21 indigenous reference fish species was recorded in the Kaap River mainstem and tributaries. This is a decrease of four species from the 2012 survey. The fish assemblage remains consistent with previous surveys at a Category C (75.1%). However, the recommended Fish Ecological Target for the EWR 7 (X23G-01057) is a Category B (85%). Based on these results the Frequency of Occurrence (FROC) of most species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of loss of instream habitat due to siltation and sedimentation.

The Fish Ecostatus categories calculated for each of the four SQ reaches on the Kaap River mainstem and tributaries is summarised in Figure 39. It shows that the overall Fish Ecostatus percentage for 2017 is 75.1 placing it in a category C. This indicates a slight improvement in the Fish Ecostatus when compared to the 2012 results where the mean Fish Ecostatus derived a rating of 69.7% placing it in a lower category C.

Invertebrates

Table 84: A summary of MIRAI results for sites sampled on the Kaap River catchment in 2012, and 2017. Results indicate the number of available data on record for the different sampling seasons (Au – autumn, Wi – winter), Sp – spring, and Su – summer), and a summary of results for the PESEIS Reaches, indicating change between the 2012 and 2017 results with arrows. Change are indicated with arrows, e.g. ↑ = improvement, ↗ = slight improvement, → = similar conditions, ↘ = slight deterioration, and ↓ = deterioration.

SITE CODE	SITE NAME	YEAR		C	SAMPLING EVENTS					REACH CODE	YEAR		
		2012	2017		Au	Wi	Sp	Su	ALL		2012	2017	CHANGE
X2QUEE-HILVE	Queensriver		75.5	C	0	1	0	0	1	X23E-01154		75.5	
X2SUID-DAISY	Suid Kaap	68.6	77.1	B/C	0	2	0	0	2	X23C-01098	68.6	77.1	↗
X2NOOR-RIVER	Noord Kaap	75.2	79.7	B/C	1	1	1	0	3	X23B-01052	75.2	79.7	↗
X2KAAP-HONEY	Kaap	74.4	76.1	C	0	1	0	0	1	X23G-01057	74.4	76.1	→

SASS data from four sites in the Kaap River catchment was analysed for seven sampling events (Table 84). Most of the sampling (71%) was carried out during winter, followed by autumn (14%) and spring (14%). In terms of high- and low flow conditions, this suggests 86% of the available data represents low flow conditions, and 14% high flows.

Based on the SASS data, conditions improved slightly at all four sites sampled (Figure 40). In the Queens River (X2QUEE-HILVE) newly formed lateral and mid channel sand and gravel bars, suggests continuous upstream sediment inputs.

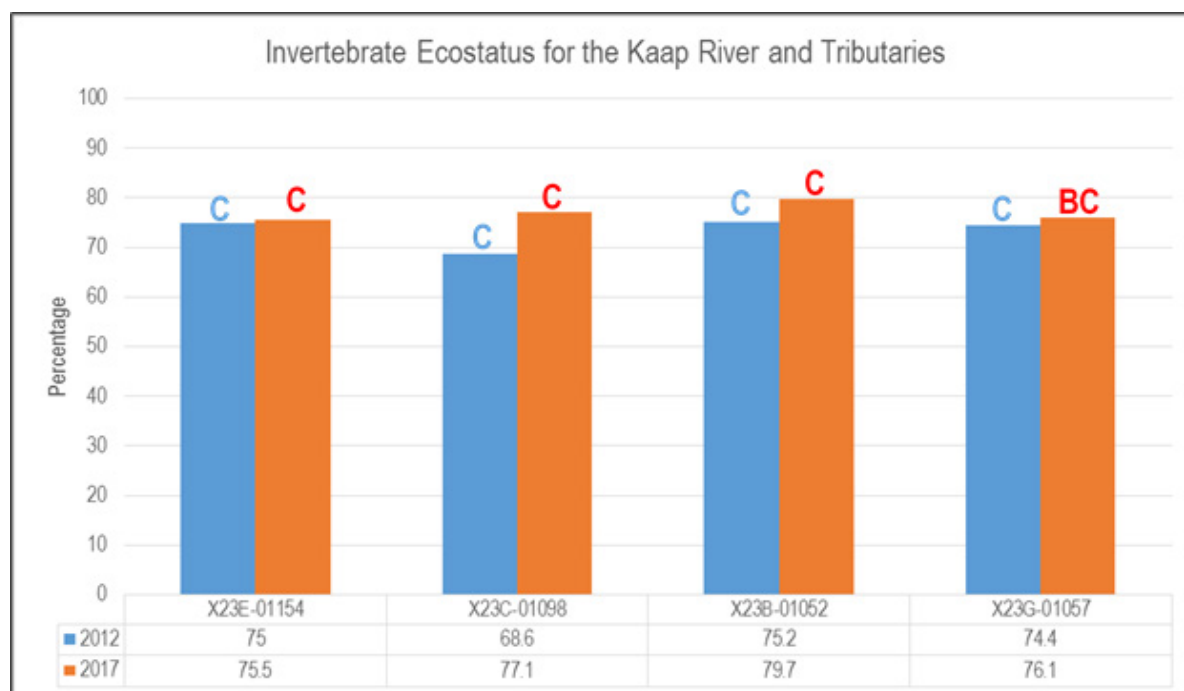


Figure 40: Invertebrate Ecostatus derived from the RIVDINT model summarised for the Kaap River and Tributaries, comparing 2012 to 2017.

Water Chemistry

Although water quality state in the lower Kaap River has been maintained, a number of issues were noted along the length of the Noord-Kaap River. The conditions were much better at the top of the system at X2H010Q01, with a deterioration in phosphate and salt levels down toward X2H080Q01 at the lower end of the system.

RQOs were met in the Suid-Kaap and Queens rivers, with a maintenance in water quality state.

Instream and Integrated Ecstatus Ratings for the Kaap River and Tributaries

The Instream Ecstatus rating is derived from the Fish Ecstatus, Invertebrate Ecstatus and Instream Habitat Integrity assessment. From Figure 41 it is evident that the Instream Ecstatus for the Kaap River and tributaries is a consistent Category C and range from 73.65% to 77.2%. The Instream Ecstatus for the 2017 survey calculated a mean Category C (76.1%) consistent with the 2012 results of a Category C (71.2%).

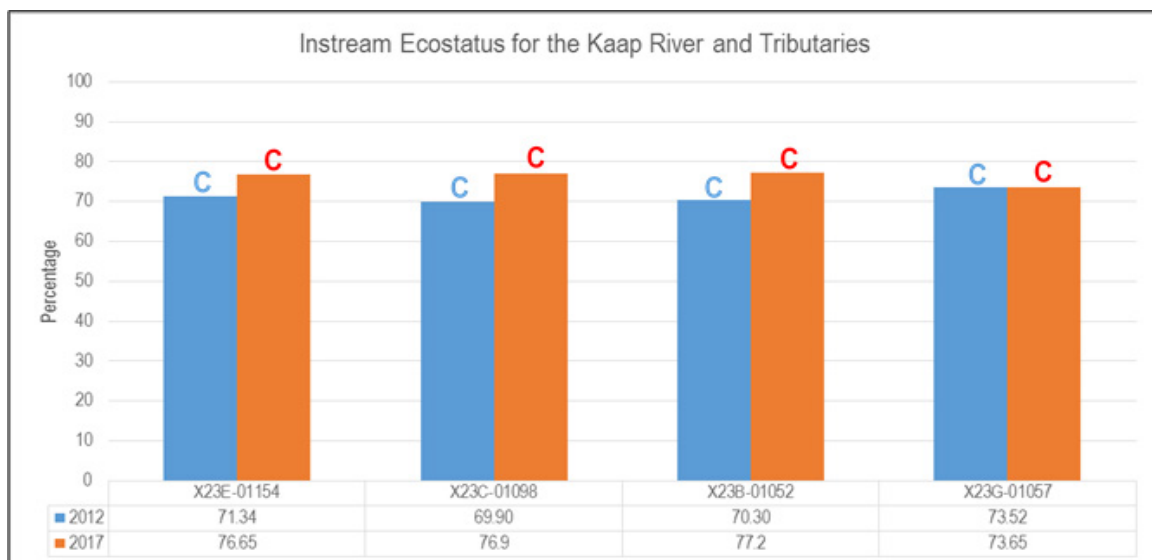


Figure 41: Instream Ecstatus derived from the RIVDINT model summarised for the Kaap River and Tributaries, comparing 2012 to 2017.

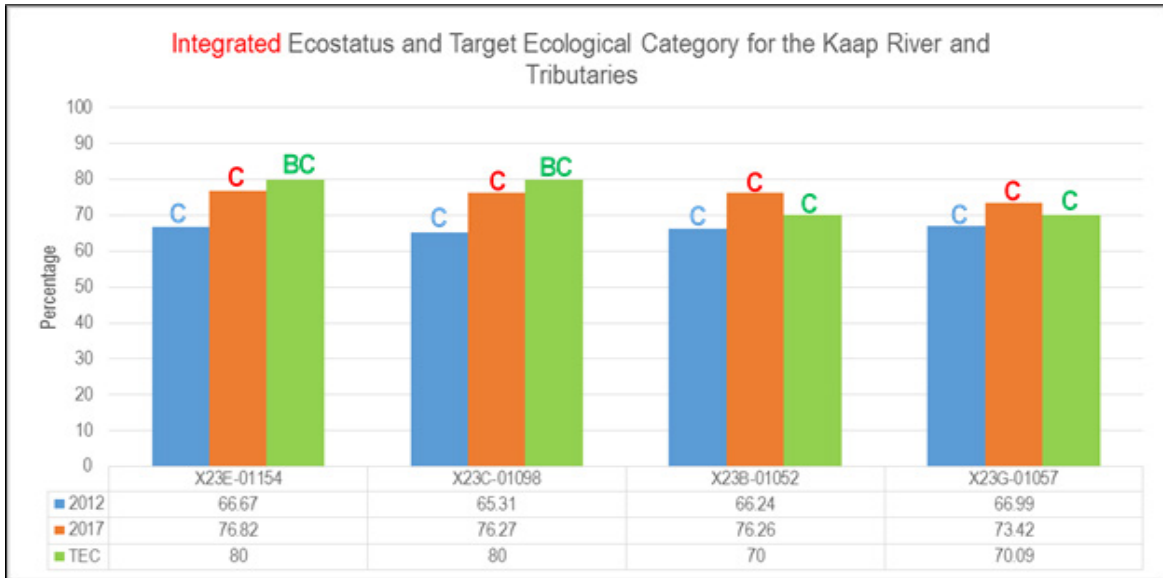


Figure 42: Integrated Ecostatus derived from the RIVDINT model summarised for the Kaap River and Tributaries, comparing 2012 to 2017.

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model (Figure 42). The Integrated Ecostatus for the Kaap River and tributaries remained consistent throughout the 2017 and 2012 monitoring ranging from a low category C to a high Category C indicating a moderately impaired habitat (Figure 42). The Integrated Ecostatus derived from the RIVDINT model in comparison to the Target Ecological Category within the various SQ reaches as per RQO's (DWA, 2014b) indicate that 50% of the targets are met. The SQ-reach X23E-01154 and X23C-01098 did not meet the TEC requirement of a Category BC (80%) whilst the X23B-01052 and X23G-01057 EWR7 met the set requirements of a Category C.

5. CONCLUSION

During this survey (2017) 35 Sub-quaternary reaches (consisting of 40 biomonitoring sites) were surveyed with a total length of 902 km. Table 85 and Figure 39 summarise all the SQ data which include the Fish Ecostatus, the Invertebrate Ecostatus, Riparian and Vegetation Ecostatus, Instream Ecostatus and Integrated Ecostatus, Instream Habitat Integrity, as well as the Riparian IHI comparing the 2012 and 2017 surveys. This calculated biomonitoring results indicate a decrease in the overall PES Category from a Category C (61.4%) in 2012 to a Category CD (60%) in 2017. The overall Fish Ecostatus remains consistent at a Category C (2012: 74.2%; 2017: 74.9%). The Invertebrate Ecostatus indicate a slight decrease from a Category BC (78.5%) in 2012 to a Category C (75.7%) in 2017. The Instream Habitat Integrity that was conducted for the first time during 2017 rated a Category C at 73.7%. The Instream Ecostatus that is derived from the Fish and Invertebrate Ecostatus, as well as the Instream Habitat Integrity remained consistent with an overall Instream Ecostatus Category of C (2012: 76.6%; 2017: 75.3%). VEGRAI surveys were conducted at ten sites in the Crocodile River system (primarily EWR sites) and the sites not assessed were derived from the PES-model, it was therefore possible to calculate the Integrated Ecostatus which is a combination between the Fish Ecostatus, Invertebrate Ecostatus, the Riparian and Vegetation Ecostatus, as well as the Riparian IHI. The overall Integrated Ecostatus for the Crocodile River system was calculated at a Category C (75.6%) which is slightly lower than the Integrated Ecostatus calculated for 2012 at a Category C (76.7%) (Table 85 and Figure 43). These results indicate a noticeable deterioration in the Ecological condition of the Crocodile River catchment.

Table 85: Summary of the Ecostatus for the Crocodile River catchment and a comparison between 2012 and 2017 biomonitoring

X2: 2012	Total PES	Fish Ecostatus	Invertebrate Ecostatus	Riparian Vegetation Ecostatus	Instream Ecostatus	Riparian Ecostatus	Integrated Ecostatus	Instream IHI	Riparian IHI
Nr of SQ Reaches Assessed	45	36	37	44	36	44	36	Not assessed	Not assessed
Total Length of SQ Reaches Assessed	964	849	876	957	964	957	849		
Overall Rating	64.1	74.2	78.5	78.8	76.6	78.8	76.7		
Overall Category	C	C	BC	BC	C	BC	C		
X2: 2017	Total PES	Fish Ecostatus	Invertebrate Ecostatus	Riparian Vegetation Ecostatus	Instream Ecostatus	Riparian Ecostatus	Integrated Ecostatus	Instream IHI	Riparian IHI
Nr of SQ Reaches Assessed	35	35	35	35	35	35	35	35	35
Total Length of SQ Reaches Assessed	902	902	902	902	902	902	902	902	902
Overall Rating	60.0	74.9	75.7	77.5	75.3	76.5	75.6	73.7	76.0
Overall Category	CD	C	C	C	C	C	C	C	C

The water quality evaluation conducted for the High Priority sites in the Crocodile system indicated a number of points where RQOs have been exceeded. There are difficulties in terms of data collection where metals and toxics are not monitored to the required frequency to make evaluations, and areas where monitoring of a High Priority water quality site, e.g. the Gutshwa River (X24B-00903), has not yet started despite the gazetted of water quality RQOs. It is assumed that a management intervention will now take place at points of exceedance, firstly to identify sources of impact, and secondly, to manage these impact points.

Important developments in the Crocodile River catchment in terms of water quality assessments is the work of Slaughter and Hughes and the testing of the Water Quality Systems Assessment Model (WQSAM). The aim is for this water quality model to work in conjunction with both the WReMP or WRYM yield models and the Pitman model, to simulate the frequency of certain water quality concentration thresholds being exceeded, using predominantly available observed data, and a simplified conceptual framework (Slaughter and Hughes, 2013).

Conceptually, WQSAM consists of four levels:

- Interfacing with the Yield Model so as to input yield model flows and replicate nodal structure within WQSAM.
- Monthly incremental flow disaggregation to daily.
- Baseflow separation of daily incremental flow into surface water flow, interflow and ground water flow components.
- Water quality modelling modules including water temperature, salinity, sediment and nutrients.

The model has been set up for the Crocodile catchment and can aid in understanding impacts, sources of impacts and an assessment of scenarios.

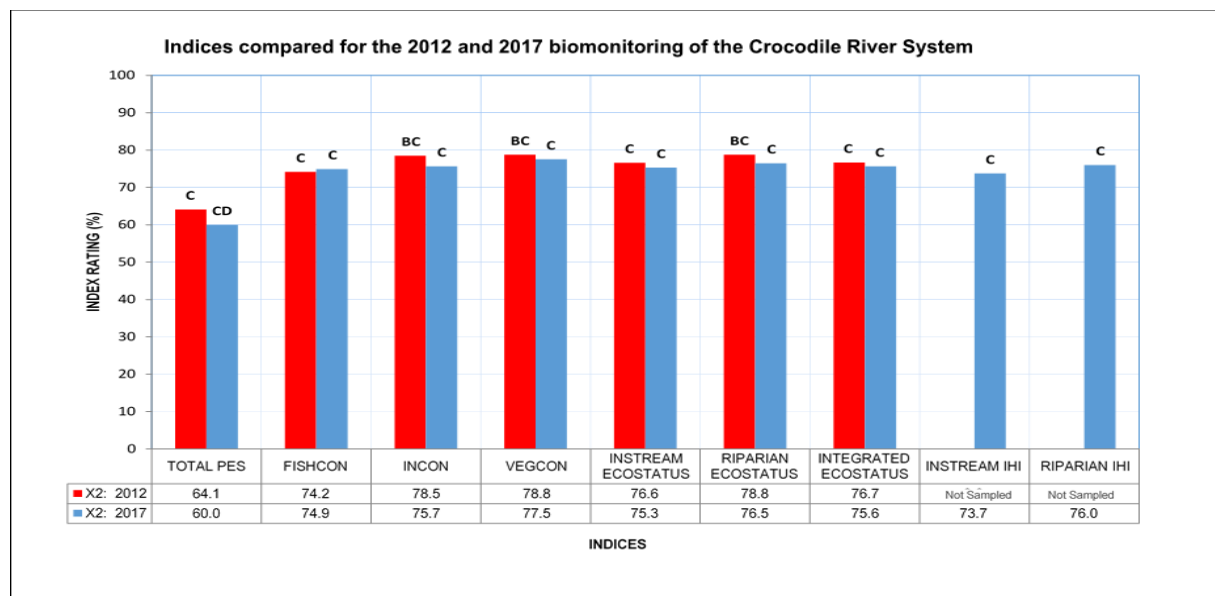


Figure 43: Summary of the Ecstatus for the Crocodile River catchment and a comparison between 2012 and 2017 biomonitoring.

When comparing the results of the Integrated Ecostatus with the TEC's for the Crocodile River Catchment, which comprises of 35 SQ reaches (9 EWR sites), it is evident that 65.7% (23 of 35 SQ reaches) of SQ reaches in the Crocodile River system met the set TEC, while 34.2% of targets (12 of 35 SQ reaches) were not met. Results for the nine EWR sites indicate that only 44.4% of set targets are met. On the Crocodile mainstem for the six EWR sites targets were not met at the X21A-00930 (X2CROC-VALY, EWR1); X21E-00943 (X2CROC-POPLA, EWR3) and X24H-00934 (X2CROC-NKONG, EWR6) sites. For both the EWR sites on the Elands River – X21G-01037 (ELAN-WATER, EWR ER1) and X21K-01035 (ELAN-ROODE, EWR ER2) the targets was not met, whilst the remaining EWR site in the Kaap River (X23G-01057, X2KAAP-HONEY, EWR 7) met the TEC. Factors contributing to this can be impacted instream habitats, flow regulation and reduced water quality standards as a result of surrounding land use practises.

6. RECOMMENDATIONS

Table 86: Integrated Ecostatus for the Crocodile River catchment for the 2012 and 2017 biomonitoring results. A comparison between Integrated Ecostatus and TEC followed by suggested targets and comments to clarify suggestions are indicated.

Reach Code	Site Code	Integrated Ecostatus 2012	Integrated Ecostatus 2017	TEC	Target Met ?	Suggested Target	Comments
Crocodile River mainstem							
X21A-00930	X2CROC-VERLO	BC 79.44%	B 83.3%	AB 90.9%	✗		
	X2CROC-VALY1* EWR 1						
X21B-00962	X2CROC-DONKE	C 76.96%	B 82.4%	B 86.5%	✓	A	Reach can be improved to Category A
	X2CROC-GOEDE* EWR 2						
X21D-00938	X2CROC-DOORN	C 64.16%	BC 81.9%	C 70%	✓	B	Reach already in a Class BC exceeding set target. Can improve to Category B
X21E-00943	X2CROC-RIETV						
	X2CROC-POPLA* EWR 3	C 69.56%	C 76.8%	BC 78.5%	✗		
	X2CROC-MONTR						
X22B-00888	X2CROC-RIVUL	BC 78.60%	C 76.8%	C 70%	?	BC	Reaches exceeded the set category in 2012 indicating that an improved target is possible with proper management. Recommended that this reach be managed at Category BC
X22C-00946	X2CROC-STRKS	BC 78.19%	C 77.7%	C 70%	✓	BC	
X22J-00958	X2CROC-KAMAG	C 74.84%	C 74.3%	C 70%	✓	BC	
X22K-01018	X2CROC-N4ROA* EWR 4	C 77.44%	C 76.7%	C 72.78%	✓	BC	Reaches can improve to a Category BC with proper management
X24C-01033	X2CROC-KAAPM	C 73.68%	C 73.5%	C 70%	?	BC	
X24D-00994	X2CROC-MALEL* EWR 5	C 73.01%	C 73.3%	C 73.7%	✓	B	
X24F-00953	X2CROC-MARO2	C 73.66%	C 71.7%	C 70%	?	B	These reaches are situated within Conservation areas - the Kruger National Park and should be managed at a Category B
X24H-00880	X2CROC-MYAMB	C 68.87%	C 73.3%	C 70%	?	B	
X24H-00934	X2CROC-NKONG* EWR 6	C 66.74%	C 72.2%	C 73.11%	✗	B	
Crocodile River Tributaries							
Not on reach	X2KARE-GOLFC	Not sampled	C 77.2%	BC 80%	✗		
X21B-00898	X2LUNS-VERLO	BC 81.40%	BC 80.62%	CD 60%	?	B	
X21B-00925	X2LUNS-UITWA	C 73.92%	C 77.4%	C 70%	✓	B	Endangered IUCN red data species <i>Kneria</i> sp. nov. 'South Africa' endemic to area.
X21C-00859	X2ALEX-RIETF	C 74.52%	BC 79.3%	C 70%	✓	B	Reaches identified as priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPA) (Driver et al. 2011).
X21D-00957	X2BUFF-SOMER	C 75.12%	B 85.3%	BC 80%	✓	B	
X22A-00913	X2HOUT-SUDWA	C 77.30%	C 77.9%	B 85%	✗		

Reach Code	Site Code	Integrated Ecostatus 2012	Integrated Ecostatus 2017	TEC	Target Met ?	Suggested Target	Comments	
X22C-00990	X2VISS-ALKMA	C 71.20%	BC 80.1%	BC 80%	✓			
X22C-01004	X2GLAD-HERMA	C 64.75%	C 68.9%	BC 80%	✗			
X22F-00977	X2NELS-R40RO	C 71.53%	C 75.3%	CD 60%	?	BC	Reach already exceeded the desktop assessment target. Recommended that a more detailed assessment be done and that reach be managed at a Category BC	
X22H-00836	X2WITR-VALLE	C 62.48%	C 66.2%	D 50%	?	BC		
Kaap River and Tributaries								
X23E-01154	X2QUEE-HILVE	C 66.67%	C 76.8%	BC 80%	✗			
X23C-01098	X2SUID-DAISY	C 65.31%	C 76.3%	BC 80%	✗			
X23B-01052	X2NOOR-RIVER	C 66.24%	C 76.3%	C 70%	✓			
X23G-01057	X2KAAP-HONEY EWR 7	C 66.99%	C 73.4%	C 70.09%	✓			
Elands River and Tributaries								
Reach Code	Site Code	Integrated Ecostatus 2012	Integrated Ecostatus 2016	Integrated Ecostatus 2017	TEC	Target Met ?	Recommended TEC	Comments
X21F-01046	X2ELAN-DEGOE	BC 80.69%	C 76.14%	C 77.6%	C 70%	✓	BC	Reaches exceeded the set category in 2012 indicating that an improved target is possible with proper management. Its recommended that a detailed assessment be done and the reach managed at a Category BC
X21F-01100	X2LEEU-GELUK	C 74.64%	Not sampled	C 74.8%	C 70%	✓		
X21G-01037	X2ELAN-WATER	BC 78.04%	C 68.56%	C 75.8%	B 85%	✗		Endangered IUCN red data species <i>Chiloglanis bifurcus</i> endemic to area. Reaches identified as priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPA) (Driver et al. 2011).
	X2ELAN-DOORN							
X21G-01016	X2SWAR-KINDE	BC 78.20%	Not sampled	BC 81.2%	C 70%	?	B	Reaches exceeded the set category indicating that an improved target is possible with proper management. Recommended that this reach be managed at Category B
X21J-01013	X2ELAN-HEMLO	C 75.96%	C 66.52%	C 73.5%	BC 80%	✗		
X21H-01060	X2NGOD-NOOIT	C 65.33%	B 83.1%	C 75.9%	B 85%	✗		Endangered IUCN red data species <i>Chiloglanis bifurcus</i> endemic to area. Reaches identified as priority freshwater environment for fish conservation and is listed as a fish sanctuary in the National Freshwater Ecosystem Priority Areas (NFEPA) (Driver et al. 2011).
X21K-01035	X2ELAN-ROODE	BC 78.16%	C 69.3%	C 74.9%	B 85%	✗		
	X2ELAN-GOEDG							
X21K-00997	X2ELAN-EHOEK	B 82.36%	C 71.38%	C 76.6%	C 70%	?	B	Reaches exceeded the set category in 2012 indicating that an improved target is possible with proper management. Recommended that

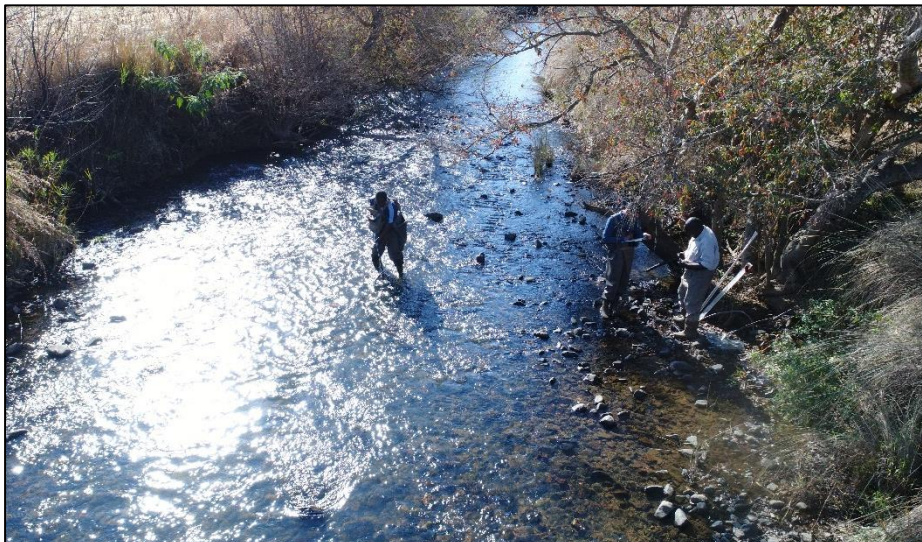
Reach Code	Site Code	Integrated Ecosatus 2012	Integrated Ecosatus 2017	TEC	Target Met ?	Suggested Target	Comments
							this reach be managed at Category B

There are a number of impacting activities in these stretches of river, with further assessments needed to identify and act on non-compliance. Based on the above-mentioned it is recommended that more frequent biomonitoring be conducted in the Elands River Catchment. It would appear that the industrial activities of the Paper Mill at Ngodwana have a serious impact on the water quality and the biological component. Therefore the owners of the Paper Mill should act responsible and the IUCMA should endorse on this water licence that regular bi-annual biomonitoring should be conducted as part of their compliance. These results should be made available to the IUCMA and MTPA to assess and identify changes in the Ecosatus downstream of the above-mentioned industry.

It is therefore recommended that this catchment should be managed at an Ecological Category B (85%). As the TEC's are not met for most of the SQ reaches within this river system it is suggested that the catchment management be reviewed and before any additional water use licenses be issued a comprehensive Reserve Determination must be conducted. In addition, the TEC's for all the other SQ Reaches (not EWR) derived from the PES-EIS desktop assessment with low confidence level, need to be reviewed and revised based on sound scientific data.

7. ACKNOWLEDGEMENTS

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APPENDIX A

Section A: Fish Species List

In this appendix all fish species are listed in alphabetical order, the amount of fish collected within a reach is indicated, expected species of the reach were not indicated

Section B: Summary of Fish Survey Data

List of reaches surveyed during 2017. The number of fish species and individuals, the time sampled, the Catch Per Unit Effort and FRAI value determined, are indicated.

Crocodile River Mainstem							
Reach Code	Site Code	Spp No.	No of Individuals	EF (min)	CPUE	FRAI	
						%	Category
X21A-00930	X2CROC-VERLO	1	2	19	0.11	77.7	C
	X2CROC-VALYS	2	24	24	1	79.8	B/C
X21B-00962	X2CROC-DONKE	4	47	32	0.68	78.6	B/C
	X2CROC-GOEGD	5	62	46	1.35	79.0	B/C
X21D-00938	X2CROC-DOORN	7	66	29	2.28	78.6	B/C
	X2CROC-RIETV	5	139	50	2.78	82.6	B
X21E-00943	X2CROC-POPLA	5	93	43	2.16	79.8	B/C
	X2CROC-MONTR	6	144	49	2.94	81.7	B/C
X22B-0888	X2CROC-RIVUL	5	152	49	3.1	79.5	B/C
X22C-00946	X2CROC-STRKS	8	62	29	2.14	82.5	B
X22J-00958	X2CROC-KAMAG	11	144	31	4.65	81.6	B/C
X22K-01018	X2CROC-N4ROA	9	108	54	2	79.7	B/C
X24C-01033	X2CROC-KAAPM	7	59	32	1.84	77.3	C
X24D-00994	X2CROC-MALEL	12	119	59	2.02	78.3	B/C
X24F-00953	X2CROC-MARO2	9	142	43	3.3	76.9	C
X24H-00880	X2CROC-MYAMB	9	101	48	2.1	76.0	C
X24H-00934	X2CROC-NKONG	7	126	40	3.15	75.2	C

Crocodile River Tributaries							
Reach Code	Site Code	Spp No.	No of Individuals	EF (min)	CPUE	FRAI	
						%	Category
X21B-00898	X2LUNS-VERLO	1	5	17	0.29	80.9	B/C
X21B-00925	X2LUNS-UITWA	5	87	35	2.49	77.5	C
Not on reach	X2KARE-WILGE	1	42	12	3.5	78.8	B/C
X21C-00859	X2ALEX-RIETF	3	71	22	3.23	83.0	B
X21D-00957	X2BUFF-SOMER	6	424	45	9.42	85.7	B
X22A-00913	X2HOUT-SUDWA	5	48	26	1.85	77.0	C
X22C-00990	X2VISS-ALKMA	4	13	19	0.68	74.5	C
X22C-01004	X2GLAD-HERMA	4	69	18	3.83	73.8	C
X22F-00977	X2NELS-R40BR	5	56	26	2.15	74.3	C
X22H-00836	X2WITR-VALLE	3	24	19	1.26	67.2	C

Elands River and Tributaries							
Reach Code	Site Code	Spp No.	No of Individuals	EF (min)	CPUE	FRAI	
						%	Category
X21F-01046	X2ELAN-DEGOE	1	1	36	0.03	64.1	C
X21G-01037	X2ELAN-WATER	3	41	46	0.89	68.1	C
	X2ELAN-DOORN	8	66	44	1.5	82.1	B
X21J-01013	X2ELAN-HEMLO	6	155	56	2.77	77.2	C
X21K-01035	X2ELAN-ROODE	7	91	27	3.37	80.0	B/C
	X2ELAN-GOEDE	7	131	44	2.98	81.6	B/C
X21K-00997	X2ELAN-LINDE	5	67	28	2.39	80.0	B/C
X21F-01100	X2LEEU-GELUK	3	15	21	0.71	78.0	C
X21G-01016	X2SWAR-KINDE	3	60	28	2.14	75.9	C
X21H-01060	X2NGOD-NOOIT	6	194	53	3.66	82.6	B

Kaap River and Tributaries							
Reach Code	Site Code	Spp No.	No of Individuals	EF (min)	CPUE	FRAI	
						%	Category
X23G-01057	X2KAAP-HONEY	6	136	23	5.91	71.2	C
X23B-01052	X2NOOR-RIVER	6	98	24	4.08	74.7	C
X23C-01098	X2SUID-DAISY	7	96	28	3.43	76.7	C
X23E-01154	X2QUEE-HILVE	7	169	22	7.68	77.8	C

Section C: Illustration of Fish Species Collected

Illustrations of fish species from the Atlas of Southern African Freshwater Species - SAIAB (Scott et al., 2004) recorded at all the sampling sites.

FAMILY MORMYRIDAE - SNOUTFISHES

Marcusenius pongolensis

(previously - *macrolepidotus*)

Bulldog



Petrocephalus catostoma (wesselsi)

Southern churchill



FAMILY ANGUILLIDAE - FRESH WATER EELS

Anguilla marmorata

Giant mottled eel



FAMILY CYPRINIDAE - BARBS, YELLOWFISH, LABEOS

Mesobola brevianalis

River sardine



Opsaridium peringueyi










Southern barred minnow




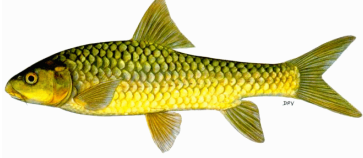








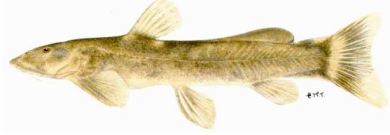




Enteromius (Barbus) anoplus

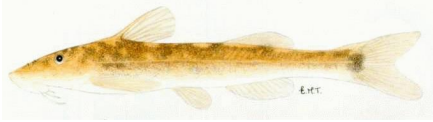
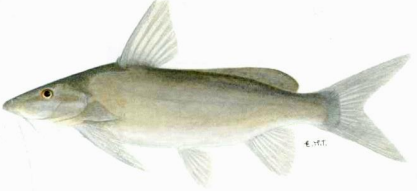



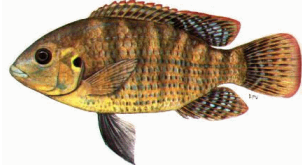

Chubbyhead barb



<p><i>Enteromius (Barbus) annectens</i></p> <p>Broadstriped barb</p>	
<p><i>Enteromius (Barbus) brevipinnis</i></p> <p>Shortfin barb</p>	
<p><i>Enteromius (Barbus) unitaeniatus</i></p> <p>Longbeard barb</p>	
<p><i>Enteromius (Barbus) viviparus</i></p> <p>Bow stripe barb</p>	
<p><i>Enteromius (Barbus) toppini</i></p> <p>East coast barb</p>	
<p><i>Enteromius (Barbus) radiatus</i></p> <p>Beira barb</p>	
<p><i>Enteromius (Barbus) trimaculatus</i></p> <p>Three spot barb</p>	
<p><i>Enteromius (Barbus) eutaenia</i></p> <p>Orange fin barb</p>	
<p><i>Enteromius crocodilensis (Barbus argenteus)</i></p> <p>Rose fin barb</p>	

<p><i>Enteromius (Barbus) paludinosus</i></p> <p>Straight fin barb</p>	
<p><i>Enteromius (Barbus) afrohamiltoni</i></p> <p>Plump barb</p>	
<p><i>Labeobarbus polylepis</i></p> <p>Bushveld small scale yellowfish</p>	
<p><i>Labeobarbus marequensis</i></p> <p>Lowveld large scale yellowfish</p>	
<p><i>Varicorhinus nelspruitensis</i></p> <p>Incomati chisel mouth</p>	
<p><i>Labeo cylindricus</i></p> <p>Red eye labeo</p>	
<p><i>Labeo molybdinus</i></p> <p>Leadon labeo</p>	
<p><i>Labeo rosae</i></p> <p>Rednose labeo</p>	
<p>FAMILY CHARACIDAE - CHARACINS</p>	

<p><i>Micralestes acutidens</i></p> <p>Silver robber</p>	
<p><i>Hydrocynus vittatus</i></p> <p>Tigerfish</p>	
<p>FAMILY AMPHILIIDAE - MOUNTAIN CATFISHES</p>	
<p><i>Amphilius uranoscopus</i></p> <p>Common or stargazer mountain catfish</p>	
<p>FAMILY SCHILBEIDAE - BUTTER CATFISHES</p>	
<p><i>Schilbe intermedius</i></p> <p>Silver catfish or Butter barbel</p>	
<p>FAMILY CLARIIDAE - AIR-BREATHING CATFISHES</p>	
<p><i>Clarias gariepinus</i></p> <p>Sharptooth catfish</p>	
<p>FAMILY MOCHOKIDAE - SQUEAKERS, SUCKERMOUTH CATLETS</p>	
<p><i>Chiloglanis anoterus</i></p> <p>Pennant-tailed suckermouth or rock catlet</p>	
<p><i>Chiloglanis paratus</i></p> <p>Sawfin suckermouth or rock catlet</p>	

<p><i>Chiloglanis swierstrai</i></p> <p>Lowveld suckermouth or rock catlet</p>	
<p><i>Synodontis zambezensis</i></p> <p>Brown squeaker</p>	
<p>FAMILY SALMONIDAE - TROUTS</p>	
<p><i>Oncorhynchus mykiss</i></p> <p>Rainbow trout</p>	
<p>FAMILY CENTRARCHIDAE - BASSES AND SUNFISHES</p>	
<p><i>Micropterus salmoides</i></p> <p>Largemouth bass</p>	
<p>FAMILY CICHLIDAE - CICHLIDS</p>	
<p><i>Pseudocrenilabrus philander</i></p> <p>Southern mouth brooder</p>	
<p><i>Tilapia sparrmanii</i></p> <p>Banded tilapia</p>	
<p><i>Coptodon rendalli</i></p> <p>Red breast tilapia</p>	

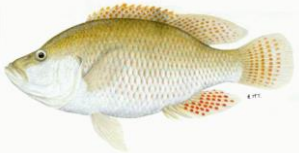
Oreochromis mossambicus

Mozambique tilapia



Serranochromis meridianus

Lowveld tilapia



FAMILY GOBIIDAE - GOBIES

Glossogobius giuris

Tank goby



Glossogobius callidus

River goby



APPENDIX B

SASS5 RESULTS

The SS indicates the total SASS5 score, ASPT the average score per taxon, %AB the percentage air breathers, % ST the percentage sensitive taxa, and the FBI presents a broad indication of organic pollution.

Crocodile River Mainstem							
Reach Code	Site Code	SS	No. of Families	ASPT	%AB	%ST	FBI
X21A-00930	X2CROC-VERLO	137	22	6.2	19	43	4.5
	X2CROC-VALYS	220	35	6.3	11	23	5.1
X21B-00962	X2CROC-DONKE	219	33	6.6	12	42	4.6
	X2CROC-GOEGD	220	31	7.1	7	65	4.2
X21D-00938	X2CROC-DOORN	180	27	6.7	23	31	4.7
	X2CROC-RIETV	159	25	6.4	18	34	4.9
X21E-00943	X2CROC-POPLA	154	26	5.9	5	19	5.3
	X2CROC-MONTR	168	27	6.2	17	39	4.0
X22B-0888	X2CROC-RIVUL	176	27	6.5	20	37	4.2
X22C-00946	X2CROC-STRKS	167	28	6.0	4	29	4.9
X22J-00958	X2CROC-KAMAG	128	23	5.6	9	15	4.9
X22K-01018	X2CROC-N4ROA	170	28	6.1	6	32	3.9
X24C-01033	X2CROC-KAAPM	185	34	5.4	8	13	4.7
X24D-00994	X2CROC-MALEL	146	29	5.0	18	24	5.1
X24F-00953	X2CROC-MARO2	132	28	4.7	29	29	5.4
X24H-00880	X2CROC-MYAMB	160	29	5.5	29	21	5.2
X24H-00934	X2CROC-NKONG	136	27	5.0	57	6	3.6

Crocodile River Tributaries							
Reach Code	Site Code	SS	No. of Families	ASPT	%AB	%ST	FBI
X21B-00898	X2LUNS-VERLO	154	25	6.2	5	49	4.0
X21B-00925	X2LUNS-UITWA	185	27	6.9	5	50	4.6
Not on reach	X2KARE-WILGE	189	31	6.1	26	40	4.9
X21C-00859	X2ALEX-RIETF	157	25	6.3	28	40	3.3
X21D-00957	X2BUFF-SOMER	191	30	6.4	23	49	4.3
X22A-00913	X2HOUT-SUDWA	200	28	7.1	3	48	4.7
X22C-00990	X2VISS-ALKMA	202	30	6.7	16	43	4.2
X22C-01004	X2GLAD-HERMA	118	19	6.2	29	24	3.9
X22F-00977	X2NELS-R40BR	189	30	6.3	10	63	4.5
X22H-00836	X2WITR-VALLE	133	28	4.8	42	38	5.6

Elands River and Tributaries							
	Site Code	SS	No. of Families	ASPT	%AB	%ST	FBI
X21F-01046	X2ELAN-DEGOE	236	37	6.4	18	50	4.7
X21G-01037	X2ELAN-WATER	172	28	6.1	10	32	3.9
	X2ELAN-DOORN	218	34	6.4	16	31	4.6
X21J-01013	X2ELAN-HEMLO	171	28	6.8	7	34	5.2
X21K-01035	X2ELAN-ROODE	181	27	6.7	11	34	4.6
	X2ELAN-GOEDE	204	32	6.4	12	41	4.7
X21K-00997	X2ELAN-LINDE	208	34	6.1	13	42	4.7
X21F-01100	X2LEEU-GELUK	127	25	5.1	11	21	7.1
X21G-01016	X2SWAR-KINDE	198	33	6.0	6	60	4.3
X21H-01060	X2NGOD-NOOIT	176	28	6.3	1	45	4.6

Kaat River and Tributaries							
Reach Code	Site Code	SS	No. of Families	ASPT	%AB	%ST	FBI
X23G-01057	X2KAAP-HONEY	223	30	7.4	7	38	4.9
X23B-01052	X2NOOR-RIVER	210	30	7.0	7.0	38	4.1
X23C-01098	X2SUID-DAISY	181	30	6.0	6.1	30	5.4
X23E-01154	X2QUEE-HILVE	173	28	6.2	7.6	57	4.0

APPENDIX C

List of plant species recorded at VEGRAI sites

Name	Exotic	Marginal	Non Marginal	Sites found
<i>Acacia meamsii</i>	X		X	EWR 2,X2ELAN-DEGOE,EWR ER 1
<i>Ageratum conyzoides</i>	X		X	EWR 3,EWR 3
<i>Argemone mexicana</i>	X		X	X2CROC-KAAPM
<i>Biancaea decapetala</i>	X		X	EWR 3
<i>Canna indica</i>	X		X	X2CROC-KAAPM
<i>Eucalyptus grandis</i>	X		X	EWR 1,EWR ER 1
<i>Gleditschia triacanthos</i>	X		X	EWR 2,EWR 3
<i>Eichhornia crassipes</i>	X	X		EWR 4,X2CROC-KAAPM,EWR 5
<i>Lantana camara</i>	X		X	EWR 3,EWR 4,X2CROC-KAAPM,EWR 5
<i>Melia azedarach</i>	X	X	X	EWR 3,EWR 4,X2CROC-KAAPM
<i>Morus nigra</i>	X		X	EWR 2,EWR 3,EWR ER 1
<i>Oenothera rosea</i>	X		X	X2ELAN-DEGOE
<i>Pennisetum clandestinum</i>	X	X		X2ELAN-DEGOE
<i>Phragmites australis</i>	X	X		EWR 2,EWR 4,X2CROC-KAAPM,EWR 5,EWR ER EWR 1
<i>Physalis peruviana</i>	X		X	EWR 3
<i>Plantago major</i>	X	X		EWR 2
<i>Populus alba</i>	X		X	EWR 3
<i>Psidium guajava</i>	X		X	EWR 3
<i>Saccharum officinarum</i>	X		X	EWR 3
<i>Sesbania punicea</i>	X		X	EWR 3,X2CROC-KAAPM,EWR ER 1
<i>Salix babylonica</i>	X		X	X2ELAN-DEGOE
<i>Solanum mauritium</i>	X		X	EWR 2 ,EWR 3
<i>Verbena tenuisecta</i>	X		X	X2ELAN-DEGOE,EWR ER 1
<i>Acacia ataxacantha</i>			X	EWR 3
<i>Acacia caffera</i>			X	EWR 2,EWR 3
<i>Acacia karoo</i>			X	EWR ER 1
<i>Acacia sieberiana</i>			X	EWR 4,X2CROC-KAAPM,EWR 5
<i>Albezia versicolor</i>			X	X2CROC-KAAPM
<i>Alloterosis semialata.</i>			X	EWR 1
<i>Aloe arborescense</i>			X	EWR 3
<i>Aloe petricola</i>			X	EWR 3
<i>Artemisia afra</i>			X	EWR 2
<i>Arundinella nepalensis</i>		X		EWR 2
<i>Bauhenia galpinii.</i>			X	EWR 3,X2CROC-KAAPM,EWR 5
<i>Berula erecta</i>		X		EWR 4,EWR 5
<i>Breonadia salicina</i>			X	EWR 3,EWR 3,X2CROC-KAAPM,EWR 5
<i>Bridelia micrantha</i>			X	EWR 3
<i>Celtus africana</i>			X	EWR 3
<i>Cliffortia linearifolia</i>		X	X	EWR 1,EWR 2,EWR 3,EWR ER 1
<i>Combretum erythrophyllum</i>		X	X	EWR 2,EWR 3,EWR 4
<i>Commelina diffusa</i>			X	X2CROC-KAAPM
<i>Crinum bulbispermum</i>			X	EWR 3,X2ELAN-DEGOE,EWR ER 1
<i>Cyclosorus interruptus</i>		X		EWR 3
<i>Cynodon dactylon</i>		X	X	EWR 4,X2CROC-KAAPM,EWR 5,X2ELAN-DEGOE
<i>Cyperus marginatus</i>		X		EWR 2,EWR 3
<i>Dalbergia amata</i>			X	EWR 3
<i>Dias continifolia</i>			X	EWR 2
<i>Dichrostachys cinerea</i>			X	EWR 4,EWR 5
<i>Dietes iridioides</i>			X	EWR 3
<i>Diospyros lyciodes</i>		X	X	EWR 2,EWR 3
<i>Diospyros mespiliformis</i>			X	X2CROC-KAAPM,EWR 5
<i>Englerophytum magalismontanum</i>			X	EWR 3
<i>Erica alopecurus</i>		X		EWR 1
<i>Euclea divinorum</i>			X	EWR 3,EWR 3
<i>Ficus ingens</i>			X	EWR 3
<i>Ficus sycomorus</i>			X	EWR 3,EWR 4,X2CROC-KAAPM,EWR 5
<i>Fuirena hirsute</i>		X	X	EWR 1,EWR 2,EWR 3
<i>Gerbera jamsonii</i>			X	EWR 3
<i>Gymnosporia senegalensis</i>			X	X2CROC-KAAPM
<i>Hyparrhenia tamba</i>			X	EWR 2,X2ELAN-DEGOE,EWR ER 1
<i>Imperata cylindrica</i>		X	X	EWR 2,EWR 3,X2CROC-KAAPM,EWR 5,X2ELAN-DEGOE
<i>Juncus punctorius</i>		X		X2ELAN-DEGOE
<i>Leucosidea sericea</i>			X	EWR 2

Name	Exotic	Marginal	Non Marginal	Sites found
<i>Loudetia simplex</i>			X	EWR 1
<i>Miscanthus junceus</i>		X	X	EWR 1
<i>Morrella serrata</i>		X		EWR 3
<i>Nuxia oppositifolia</i>			X	X2CROC-KAAPM
<i>Oxalis sp</i>		X		X2ELAN-DEGOE
<i>Paspalum distichum</i>		X		EWR 2,X2ELAN-DEGOE
<i>Pterocarpus angolensis</i>			X	EWR 3
<i>Phragmites mauritianus</i>			X	EWR 2,EWR 3,EWR 4
<i>Salix mucronata</i>		X		EWR 3,EWR ER 1
<i>Searsia chirindensis</i>			X	EWR 2
<i>Searsia gerrardii</i>		X		EWR 2,EWR 3,EWR ER 1
<i>Searsia leptodyctia</i>			X	X2ELAN-DEGOE
<i>Setaria megaphylla</i>			X	EWR 2,EWR 3,X2CROC-KAAPM,EWR 5
<i>Syzygium cordatum</i>			X	X2CROC-KAAPM,EWR 5
<i>Terminalia sericia</i>			X	EWR 4,X2CROC-KAAPM
<i>Trichilia emetica</i>			X	X2CROC-KAAPM,EWR 5
<i>Typha capensis</i>		X		EWR 2,X2ELAN-DEGOE
<i>Themedia triandra</i>			X	EWR 1,EWR 3,X2ELAN-DEGOE,EWR ER 1
<i>Thunbergia alata</i>			X	X2CROC-KAAPM,EWR 5
<i>Vepris lanceolata</i>			X	EWR 3
<i>Ziziphus micronata</i>		X	X	EWR 2, EWR 3,EWR 4

APPENDIX D

INVASIVE PLANT SPECIES LIST

Crocodile River Mainstem																	
Reach Code	X21A-00930	X21B-00962	X21D-00938	X21E-00943	X22B-0888	X22C-00946	X22J-00958	X22K-01018	X24C-01033	X24D-00994	X24F-00953	X24H-00880	X24H-00934				
Plant Species	X2CROC-VERLO	X2CROC-VALYS	X2CROC-DONKE	X2CROC-GOEDG	X2CROC-DOORN	X2CROC-RIETV	X2CROC-POPLA	X2CROC-MONTR	X2CROC-RWUL	X2CROC-STRKS	X2CROC-KAMAG	X2CROC-N4ROA	X2CROC-KAAPM	X2CROC-MALEL	X2CROC-MARO2	X2CROC-MYAMB	X2CROC-NKONG
ARACEAE																	
<i>Pistiastratoides</i>														2	2	2	2
ASTERACEAE																	
<i>Ageratum conyzoides</i>					3	3	3	2	2	2	2	2	2	2	2	2	1
<i>Chromolaena odorata</i>											3	2					
<i>Cirsium vulgare</i>		1															
<i>Flaveria bidentis</i>										2	2						
<i>Tagetes minuta</i>		1	3	2	2	1	2	3	2	3	2	2	3				
<i>Tithonia</i> spp.									4	3	3						
<i>Xanthium strumarium</i>												2	4	2	2	2	2
BIGNONIACEAE																	
<i>Macfadyena unguis-cati</i>									1								
<i>Tecomastans</i>										3							
BRASSICACEAE																	
<i>Nasturtium officinale</i>																	
AZOLLACEAE																	
<i>Azolla filiculoides</i>											3	3	3	2	2	2	2
BIGNONIACEAE																	
<i>Jacaranda mimosifolia</i>			1			1	3										
CONVOLULACEAE																	
<i>Ipomoea alba</i>										1	1	3					
EUPHORBIACEAE																	
<i>Euphorbia heterophylla</i>								1									
<i>Ricinus communis</i>								1	1	4	2	2	3				
FABACEAE																	
<i>Acacia mearnsii</i>		2	1	3													
<i>Bauhinia variegata</i>					2												
<i>Caesalpinia decapetala</i>											3	2					
<i>Gleditsia triacanthos</i>						4	4	4									
<i>Senna didymobotrya</i>								3	3	4	2	3					
<i>Senna pendula</i>									1	2							
<i>Senna septemtrionalis</i>		2	1			3	2										
<i>Sesbania bispinosa</i>											2		3				
<i>Sesbania punicea</i>			3			2	1										
HYDROCHARITACEAE																	
<i>Lagarosiphon major</i>																	
LILIACEAE																	
<i>Lilium formosanum</i>																	
MELIACEAE																	
<i>Melia azedarach</i>				2	2	1	1	2	4	2	2	2					
MORACEAE																	
<i>Morus alba</i>					2	1	1	1	3	2	2						
MYRTACEAE																	
<i>Callistemon viminalis</i>								2									
<i>Eucalyptus</i> spp.				2				3									
<i>Psidium guajava</i>		1			2	2	3	2	2	2	1						
OLEACEAE																	
<i>Ligustrum</i> sp.				2													
PAPAVERACEAE																	
<i>Argemone</i> spp.									1	2		3					
PINACEAE																	
<i>Pinus</i> spp.		3															
POACEAE																	
<i>Arundonax</i>									2	2	2	2					
<i>Bambusa balcooa</i>								1									
<i>Pennisetum purpureum</i>								1	2	2	1	1					
PONTEDERIACEAE																	
<i>Eichhornia crassipes</i>										3	3	3	2	2	2	2	2
PROTEACEAE																	
<i>Grevillea robusta</i>									2								
SALICACEAE																	
<i>Populus</i> spp.						2											
SAPINDACEAE																	
<i>Cardiospermum grandiflorum</i>									4	3	3	3	3				
ROSACEAE																	
<i>Rubus</i> spp.																	

SOLANACEAE														
<i>Datura ferox</i>						3								1
<i>Solanum incanum</i>			3					2	2					
<i>Solanum mauritianum</i>			3	2	1	3	2	2	3	2	2	2		
VERBENACEAE														
<i>Duranta erecta</i>														
<i>Lantana camara</i>						4	2	3	4	3	2	2		
<i>Verbena bonariensis</i>			2	2					1	2	1	1		

The presence of plants in the riparian zone are rated from 1 – 5, with 1 scarce and 5 estimated as dominant

Elands River and Tributaries							
Reach Code	X21F-01046	X21G-01037		X21J-01013	X21K-01035		X21K-00997
Plant Species	X2ELAN-DEGOE	X2ELAN-WATER	X2ELAN-DOORN	X2ELAN-HEMILO	X2ELAN-ROODE	X2ELAN-GOEDE	X2ELAN-EHOEK
ASTERACEAE							
<i>Ageratum conyzoides</i>				2	2	2	3
<i>Chromolaena odorata</i>							
<i>Cirsium vulgare</i>							
<i>Flaveria bidentis</i>							
<i>Tagetes minuta</i>			2	2	2	4	
<i>Tithonia</i> spp.				2	3	2	2
<i>Xanthium strumarium</i>							
BIGNONIACEAE							
<i>Macfadyena unguis-cati</i>							
<i>Tecomastans</i>					1		
BRASSICACEAE							
<i>Nasturtium officinale</i>							
AZOLLACEAE							
<i>Azolla filiculoides</i>							
BIGNONIACEAE							
<i>Jacaranda mimosifolia</i>						3	
CASUARINACEAE							
<i>Casuarina equisetifolia</i>		3	4				
CONVOLULACEAE							
<i>Ipomoea alba</i>							
EUPHORBIACEAE							
<i>Euphorbia heterophylla</i>							
<i>Ricinus communis</i>							
FABACEAE							
<i>Acacia meamsii</i>	3	4	2				
<i>Acacia melanoxylon</i>						1	
<i>Bauhinia variegata</i>			1				
<i>Caesalpinia decapetala</i>							
<i>Gleditsia triacanthos</i>							
<i>Senna didymobotrya</i>							
<i>Senna pendula</i>							
<i>Senna septemtrionalis</i>			2				
<i>Sesbaniabispinosa</i>							
<i>Sesbaniapunicea</i>			3	2			
HYDROCHARITACEAE							
<i>Lagarosiphon major</i>							
LILIACEAE							
<i>Lilium formosanum</i>		1					
MELIACEAE							
<i>Melia azedarach</i>				2	3	3	3
MORACEAE							
<i>Morus alba</i>				2	2	2	2
MYRTACEAE							
<i>Callistemon viminalis</i>		2					
<i>Eucalyptus</i> spp.		2	2	2	2	4	3

Elands River and Tributaries							
Reach Code	X21F-01046	X21G-01037		X21J-01013	X21K-01035		X21K-00997
Plant Species	X2ELAN-DEGOE	X2ELAN-WATER	X2ELAN-DOORN	X2ELAN-HEMLO	X2ELAN-ROODE	X2ELAN-GOEDE	X2ELAN-EHOEK
<i>Psidium guajava</i>				1			
OLEACEAE							
<i>Ligustrum</i> sp.					1		
PAPAVERACEAE							
<i>Argemone</i> spp.						3	
PINACEAE							
<i>Pinus</i> spp.							
POACEAE							
<i>Arundonax</i>					2	2	3
<i>Bambusa balcooa</i>							
<i>Pennisetum purpureum</i>			2	2			
PONTEDERIACEAE							
<i>Eichhornia crassipes</i>							
PROTEACEAE							
<i>Grevillea robusta</i>							
SALICACEAE							
<i>Populus</i> spp.						3	
SAPINDACEAE							
<i>Cardiospermum grandiflorum</i>				3	2	2	3
ROSACEAE							
<i>Rubus</i> spp.							
SOLANACEAE							
<i>Datura ferox</i>						2	
<i>Solanum incanum</i>			2				
<i>Solanum mauritianum</i>			3	2	3	3	
VERBENACEAE							
<i>Duranta erecta</i>							
<i>Lantana camara</i>				2	3	2	2
<i>Verbena bonariensis</i>			2				2

Crocodile River Tributaries, Elands River Tributaries and Kaap River and Tributaries

Reach Code	X21B-00898	X21B-00925	Not on Reach	X21C-00859	X21D-00957	X21H-01060	X21F-01100	X21G-01016	X22A-00913	X22C-00990	X22C-01004	X22F-00977	X22H-00836	X23E-01154	X23C-01098	X23B-01052	X23G-01057
Plant Species	X2LUNS-VERLO	X2LUNS-JITWA	X2KARE-WILGE	X2ALEX-RIETF	X2BUFF-SOMER	X2NGOW-NOOIT	X2LEEU-GELUK	X3SWAR-KINDE	X2HOUT-SUDWA	X2VISS-ALKMA	X2GLAD-HERMA	X2NELS-R40BR	X2WITR-VALLE	X2QUEE-HILVE	X2SUID-DAISY	X2NOOR-RIVER	X2KAAP-HONEY
ASTERACEAE																	
<i>Ageratum conyzoides</i>								3		2		3	3		3	2	
<i>Chromolepna odorata</i>														2			3
<i>Cirsium vulgare</i>		2															
<i>Flaveria bidentis</i>																	
<i>Tagetes minuta</i>		3						2		2					2	2	2
<i>Tithonia</i> spp.																2	2
<i>Xanthium strumarium</i>																	
BIGNONIACEAE																	
<i>Macfadyena unguis-cati</i>																	
<i>Tecomastans</i>										1		3			2		
BRASSICACEAE																	
<i>Nasturtium officinale</i>							3										
AZOLLACEAE																	
<i>Azolla filiculoides</i>																	
BIGNONIACEAE																	
<i>Jacaranda mimosifolia</i>					2				3	2				3			
CONVOLULACEAE																	
<i>Ipomoea alba</i>																	
EUPHORBIACEAE																	
<i>Euphorbia heterophylla</i>																	
<i>Ricinus communis</i>					1							2					2
FABACEAE																	
<i>Acacia mearnsii</i>		2	1	1			3	2									
<i>Bauhinia variegata</i>																	
<i>Caesalpinia decapetala</i>												4				4	3
<i>Gleditsia triacanthos</i>																	
<i>Senna didymobotrya</i>												3					2
<i>Senna pendula</i>																	
<i>Senna septentrionalis</i>				3					3					3	2	3	
<i>Sesbaniabispinosa</i>														2			
<i>Sesbaniapunicea</i>																	
HYDROCHARITACEAE																	
<i>Lagarosiphon major</i>		3															
LILIACEAE																	
<i>Lilium formosanum</i>																	
MELIACEAE																	
<i>Melia azedarach</i>										4		3			3	4	4
MORACEAE																	
<i>Morus alba</i>				1					3			2			2		
MYRTACEAE																	
<i>Callistemon viminalis</i>																	
<i>Eucalyptus</i> spp.		3					3										
<i>Psidium guajava</i>														2			2
OLEACEAE																	
<i>Ligustrum</i> sp.															4		
PAPAVERACEAE																	
<i>Argemone</i> spp.																	
PINACEAE																	
<i>Pinus</i> spp.																	
POACEAE																	
<i>Arundodonax</i>																	4
<i>Bambusabalcooa</i>																	
<i>Pennisetum purpureum</i>																	

Crocodile River Tributaries, Elands River Tributaries and Kaap River and Tributaries

Reach Code	X21B-00898	X21B-00925	Not on Reach	X21C-00859	X21D-00957	X21H-01060	X21F-01100	X21G-01016	X22A-00913	X22C-00990	X22C-01004	X22F-00977	X22H-00836	X23E-01154	X23C-01098	X23B-01052	X23G-01057
Plant Species	X2LUNS-VERLO	X2LUNS-JITWA	X2KARE-WILGE	X2ALEX-RIETF	X2BUFF-SOMER	X2NGOW-NOOIT	X2LEEU-GELUK	X3SWAR-KINDE	X2HOUT-SUDWA	X2VISS-ALKMA	X2GLAD-HERMA	X2NELS-R40BR	X2WITR-VALLE	X2QUEE-HILVE	X2SUID-DAISY	X2NOOR-RIVER	X2KAAP-HONEY
PONTEDERIACEAE																	
<i>Eichhorniacrassipes</i>													4		4		
PROTEACEAE																	
<i>Grevillea robusta</i>																	
SALICACEAE																	
<i>Populus</i> spp.																	
SAPINDACEAE																	
<i>Cardiospermum grandiflorum</i>												3		2	2		3
ROSACEAE																	
<i>Rubus</i> spp.																	
SOLANACEAE																	
<i>Datura ferox</i>																	
<i>Solanum incanum</i>		3															
<i>Solanum mauritianum</i>		2		2	2	2			2	2							
VERBENACEAE																	
<i>Durantaerecta</i>																	
<i>Lantana camara</i>					2				4	5		3	3	3	3		
<i>Verbena bonariensis</i>			2			2		2									

APPENDIX E

PROBLEMS IDENTIFIED

Crocodile River Mainstem	
Reach Code	Impacts Noted
X21A-00930	X2CROC-VERLO
X21B-00962	X2CROC-DONKE
X21B-00962	X2CROC-GOEDG
X21D-00938	X2CROC-DOORN
X21E-00943	X2CROC-RIETV
X21E-00943	X2CROC-POPLA
X21E-00943	X2CROC-MONTR
X22B-00888	X2CROC-RIVUL
X22C-00946	X2CROC-STRKS
X22J-00958	X2CROC-KAMAG
X22K-01018	X2CROC-N4ROA
X24C-01033	X2CROC-KAAPM
X24D-00994	X2CROC-MALEL
X24F-00953	X2CROC-MAR02
X24H-00880	X2CROC-MYAMB
X24H-00934	X2CROC-NKONG
	Stream bank trampling
	Removal of riparian vegetation
	Loose soil graded onto bridge
	Presence of exotic fish
	Invasive plant species
	Presence of exotic snails
	Presence of invasive crayfish
	Pine infestation on mountain slopes
	Bank scouring
	Cultivation in riparian zone
	Domestic waste in stream and riparian zone
	Poor road drainage
	Sand mining in river and riparian zone
	Excessive algal growth
	High sand deposition

Crocodile River Tributaries

Reach Code	X21B-00898	X21B-00925	Not on Reach	X21C-00859	X21D-00957	X22A-00913	X22C-00990	X22C-01004	X22F-00977	X22H-00836
Impacts Noted	X2LUNS-VERLO	X2LUNS-UITWA	X2KARE-WILGE	X2ALEX-RIETF	X2BUFF-SOMER	X2HOUT-SUDWA	X2VISS-ALKMA	X2GLAD-HERMA	X2NELS-R40BR	X2WITR-VALLE
Stream bank trampling		x		x						
Removal of riparian vegetation	x									
Loose soil graded onto bridge		x								
High quantities of silt in pools			x	x	x	x	x			
Presence of exotic fish										x
Invasive plant species		x	x	x	x	x	x		x	x
Bank scouring			x	x		x	x			
Stream crossing creates upstream impoundment				x			x			
Stream crossing physical barrier during low flows				x						
Cultivation in riparian zone					x ¹					
Commercial trees planted in riparian zone		x								
Domestic waste in stream and riparian zone		x				x	x		x	
Poor road drainage		x		x			x			x
Over abstraction										x

¹Agricultural activities on land upstream from the site within riparian zone (reduced filtering capacity) upstream and crops are irrigated (abstraction and return flow).

Elands River and Tributaries

Reach Code	X21F-01046	X21G-01037		X21J-01013	X21K-01035		X21K-00997	X21F-01100	X21G001016	X21H-01060
Impacts Noted	X2ELAN-DEGOE	X2ELAN-WATER	X2ELAN-DOORN	X2ELAN-HEMLO	X2ELAN-ROODE	X2ELAN-GOEDE	X2ELAN-EHOEK	X2LEEU-GELUK	X3SWAR-KINDE	X2NGOD-NOOIT
Stream bank trampling										
Removal of riparian vegetation							x			
Loose soil graded onto bridge										
Poor road drainage						x	x		x	x
Presence of exotic fish	x									
Presence of introduced indigenous fish										x
Invasive plant species	x	x	x	x	x	x	x		x	x
Pine infestation on mountain slopes									x	
Bank scouring	x						x		x	
Cultivation in riparian zone										
Commercial trees in riparian zone					x					
Domestic waste in stream and riparian zone		x	x	x	x	x	x	x		

Kaap River and Tributaries

Reach Code	X23E-01154	X23C-01098	X23B-01052	X23G-01057
Impacts Noted	X2QUEE-HILVE	X2SUID-DAISY	X2NOOR-RIVER	X2KAAP-HONEY
Stream bank trampling				
Removal of riparian vegetation				
Loose soil graded onto bridge				
High quantities of silt in pools	x	x		
Presence of exotic fish				
Invasive plant species	x	x	x	x
Bank scouring				
Stream crossing creates upstream impoundment				
Stream crossing physical barrier during low flows				
Cultivation in riparian zone				
Commercial trees planted in riparian zone				
Domestic waste in stream and riparian zone	x	x	x	x
Poor road drainage	x			
Over abstraction				

SUMMARY OF NEGATIVE IMPACTS

IMPACT RECORDED	ESTABLISHED EFFECTS			Physical
	Biological	Chemical	Hydrological	
Stream bank trampling	Biotic community indirectly affected by chemical, hydrological and physical changes.	Phosphates and other pollutants bind to soil particles, entering the stream without vegetal filtration.	Stream bank erosion during high flows	Sedimentation and stream bank stability
Removal of riparian and marginal vegetation for firebreaks	Biotic community indirectly affected by chemical, hydrological and physical changes.	Phosphates and other pollutants bind to soil particles, entering the stream without vegetal filtration.	Stream bank erosion during high flows	Sedimentation and stream bank stability
Loose soil graded onto bridge	Biotic community indirectly affected by chemical, and physical changes.	Phosphates and other pollutants bind to soil particles, entering the stream without vegetal filtration.		Sedimentation, especially during run-off
Poor road drainage	Biotic community indirectly affected by chemical, and physical changes.	Phosphates and other pollutants bind to soil particles, entering the stream without vegetal filtration.	Run-off water collects on roads and drain towards rivers during rainfall events instead of slowly filtering through vegetated soil prior to entering the river. Rapid flow increases below poorly drained roads.	Sedimentation, especially during run-off
Exotic fish	Predation (Buria et al. 2007), competition, parasites, trophic cascades			
Exotic snails				
Invasive plant species	Potential of some species altering the microbial functions and arthropod community (Kuebbing et al. 2014)	Altering chemical characteristics of water (Chamier et al. 2012)	High water using species (Calder & Dye2001)	Stream bank stability
Pine infested mountain slopes ²	Replaces indigenous vegetation and fauna species dependant on them.		High water using species (Calder & Dye2001)	Soil stability influence after uncontrolled fires, increasing erosion rates.
Bank scouring	Biotic community indirectly affected by physical changes to instream habitat.		Stream bank erosion during high flows	Sedimentation and stream bank stability
Cultivation in riparian zone	Indirect effect on biological community.	Filtering capacity of riparian zone in terms of sediment and chemical pollutant inputs reduced.		Ecological functioning of riparian zones ignored and disrupted
Domestic waste	Plastic ends up in world's oceans and are especially problematic to marine animals (Gall & Thompson, 2015)	High potential for chemical pollutants (e.g. batteries, remaining liquid in canisters, etc.).		

²Currently impacts are negligible, but increased infestations increase the cost of control and the risk of uncontrolled fires and subsequent damage to soil stability on steep slopes.

APPENDIX F

SITE ACCESS ARRANGEMENTS

The list that follows provides information such as contact details necessary to access sites.

Site	Farm	Arrangements Required
X2LUNS-VERLO X2CROC-VERLO	VerlorenVlei Nature Reserve	Contact Reserve Manager NohlanhlaRosemary Mdladla. Tel: +27 13 254 0799 Mobile: +27 83 608 6883 E-mail: nrmdladla@gmail.com
X2CROC-VALYS	Valyspruit	At the site, drive up to farmhouse and ask permission at the house. Oudekraal Trout Farm downstream from road – fenced – currently no contact details.
X2KARE-WILGE	Highlands Golf & Trout Estate	Controlled security gate. No entry without permission. Mark Gibbons. Mobile: +27 83 456 6717 E-mail: matt@highlandgate.org.za .
X2CROC-GOEDG	Goedehoop	Open access
X2CROC-DOORN	Doornhoek	Property entered through two locked gates downstream from Kwena Dam. Two private farms. First Owner: Alwyn Mobile: +27 82 324 2258 If he is not available his manager Duppie Mobile: +27 82 447 2533 Second Owner: Tony North Currently no contact details available No entry without permission.
X2CROC-DONKE	Spoelklippies Farm	Contact Vaughn (+27 83 450 2846) or David (+27 83 625 9648) to access property. Stop at staff houses and speak to Anna or Solomon to open the locked gate to gain access to the site. They will only open the gates with permission from Vaughn or David.
X2LUNS-UITWA	Uitwaak	Contact Jan Nel (+27 83 417 5431) to let him know we are working on his farm. Phone to get permission. Climb fence to access site at bridge.
X2ALEX-RIETF	Rietfontein	Farm owner Maarten Coetzee (+27 83 390 5428). Phone to get permission.
X2BUFF-SOMER	Indabusha Eco Lodge	Contact Carolina Brits (+27 83 443 0827). Owners Andre Watson and Steve Brits. Phone to get permission.
X2CROC-RIETV	Rietvlei	Open access
X2CROC-POPLA	Poplar Creek Farms	Farm Manager: Dawie van Rensburg (+27 83 680 1023). Phone to get permission. Enter controlled gate to access property.
X2CROC-MONTR	Montrose	Manager: Albert (+27 82 563 6831). Phone to get permission. Enter controlled gate to access property.
X2CROC-RIVUL	Rivulet	Open access
X2ELAN-HEMLO	Hemlock	Open access

Site	Farm	Arrangements Required
X2NGOD-NOOIT	Sappi Forests	Phone Peta Hardy (+27 13 734 4551 or +27 83 661 7026) for access through Sappi land. Phone to get permission. Phone MthobisiSoko (+27607213459) for access to the site on community land. Phone to get permission.
X2ELAN-ROODE	Sappi Pulp & Paper	Phone Mia Smith (+27 13 734 6090 or +27823291193). Phone to get permission.
X2ELAN-DEGOE	Goedehoop Farm, Portion 352a	Phone to get permission. Phone Wessel Maré (+27 82 494 7330) for permission to sample.
X2LEEU-GELUK	Geluk	Open access
X2ELAN-WATER	Waterval Boven	Open access
X2ELAN-DOORN	Zongororo Lodge	Phone to get permission. Phone Elsa Venter (+27 78 577 2745). E-mail: elsa@zongororo.co.za
X2ELAN-GOEDG	Goedgeluk	Open access
X2SWAR-KINDE	Ntsinini	Phone to get permission. Phone Mike (+27 72 666 4400) to access property through locked gate. If Mike is not available, enter Ntsinini across the road and ask for old lady Jenny for permission and access.
X2ELAN-EHOEK	Elandshoek	Open access
X2HOUT-SUDWA		Controlled access. Gate guard just allowed us in.
X2CROC-STRKS	Ronde Geluk at Sterkspruit turn-off	Phone to get permission. Controlled access. Phone Robbie (+27 82 445 2162) or Vic (+27 82 376 2759) for access. Robbie works for MTPA.
X2VISS-ALKMA	Alkmaar	Open access
X2GLAD-HERMA	Hermansburg	Open access
X2CROC-N4ROA	Below N4 before Gorge	Open access
X2CROC-KAMAG	Crocodile Valley Farms	Controlled gates. Phone +27 13 753 8000 for permission and access
X2NELS-R40BR	Below R40	Open access
X2WITR-VALLE		Phone to get permission. Wynand land-owner. Phone Gert (+27 76 792 1025) or Vincent Ndlovu (+27 82 225 1175) for permission, to open gate and gain access.
X2CROC-KAAPM	Kaapmuiden	Open access
X2KAAP-HONEY	Honeybird	Open access
X2NOOR-RIVER	Noord Kaap	Open access
X2SUID-DAISY	SuidKaap	Open access
X2QUEE-HILVE	Queens	Open access
X2CROC-MALEL	Kruger National Park	Controlled access. Contact Robin Peterson (+27 72 968 0882)
X2CROC-MYAMB	Kruger National Park	Controlled access. Contact Robin Peterson (+27 72 968 0882)
X2CROC-MARO2	Kruger National Park	Controlled access. Contact Robin Peterson (+27 72 968 0882)
X2CROC-NKONG	Kruger National Park	Controlled access. Contact Robin Peterson (+27 72 968 0882)

APPENDIX G

IN SITU WATER QUALITY

Crocodile River Mainstem							
Site Code	WQ No.	Date	Time	Temp	pH	EC	WC
X2CROC-VERLO	2	17/07	14:10	11.8	6.6		>120
X2CROC-VALYS	3	18/07	09:00	8.4	7.9		>120
X2CROC-DONKE	7	19/07	12:25	9.7	8.3	148	>120
X2CROC-GOEGD	5	18/07	15:30	14.3	8.5	186	>120
X2CROC-DOORN	6	19/07	10:10	³			42
X2CROC-RIETV	11	20/07	12:56	12.7	8.3	177	100
X2CROC-POPLA	12	20/07	14:56	14.3	8.3	189	105
X2CROC-MONTR	13	21/07	09:00	11.7	8.2	173	>120
X2CROC-RIVUL	14	21/07	11:45	12.8	8.4	426	>120
X2CROC-STRKS	26	27/07	08:25	14.5	8.4	406	82
X2CROC-KAMAG	30	28/07	13:05	15.8	8.3	402	102
X2CROC-N4ROA	29	28/07	08:15	15.6	8.2	452	>120
X2CROC-KAAPM	33	31/07	13:50	16.1	8.5	476	>120
X2CROC-MALEL	38	02/08	09:20	17.4	8.6	617	>120
X2CROC-MARO2	40	02/08	15:30	22.1	8.9	797	>120
X2CROC-MYAMB	39	02/08	13:00	22.9	9.0	801	>120
X2CROC-NKONG	41	03/08	10:45	20.7	8.9	962	>120

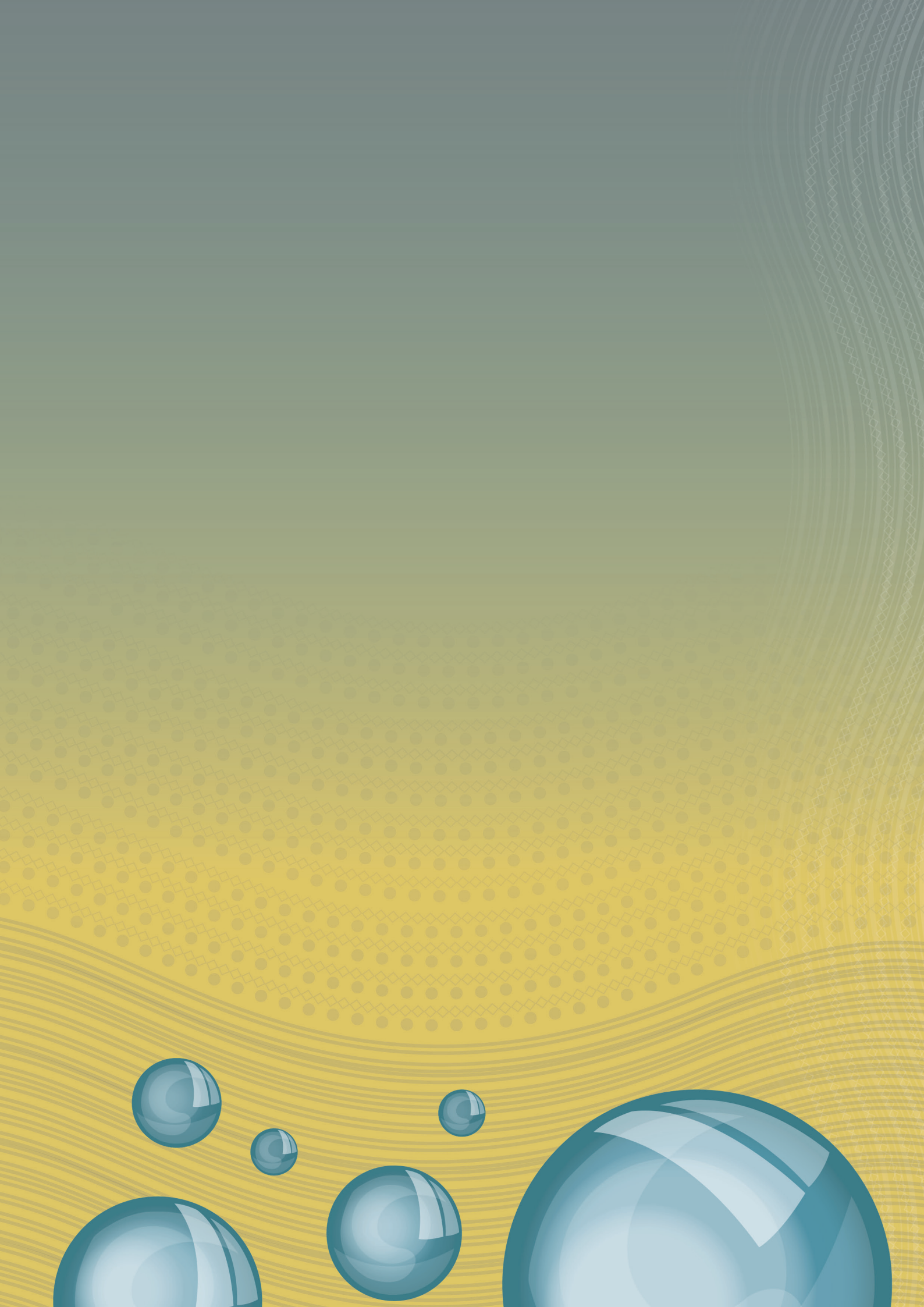
Crocodile River Tributaries							
Site Code	WQ No.	Date	Time	Temp	pH	EC	WC
X2LUNS-VERLO	1	17/07	10:50	8.6	7.3		>120
X2LUNS-UITWA	8	19/07	13:43	12.4	8.2	128	>120
X2KARE-WILGE	4	18/07	11:30	9.0	8.5	180	>120
X2ALEX-RIETF	9	20/07	08:45	10.4	8.0	206	>120
X2BUFF-SOMER	10	20/07	11:12	13.7	8.1		>120
X2HOUT-SUDWA	25	26/07	15:05	15.1	8.6	144	>120
X2VISS-ALKMA	27	27/07					>120
X2GLAD-HERMA	28	27/07	12:00	12.8	8.0	164	>120
X2NELS-R40BR	31	31/07	09:55	12.7	8.3	158	>120
X2WITR-VALLE	32	31/07	12:25	14.4	7.9	679	>120

³ The team members with the multi-parameter Water Quality Tester was late, so in situ variables were not measured at the first site.

Elands River and Tributaries							
Site Code	WQ No.	Date	Time	Temp	pH	EC	WC
X2ELAN-DEGOE	18	25/07	10:11	9.2	8.3	164	>120
X2ELAN-WATER	20	25/07	12:45	12.3	8.8	229	>120
X2ELAN-DOORN	21	25/07	14:55	12.5	9.1	249	>120
X2ELAN-HEMLO	15	24/07	09:50				>120
X2ELAN-ROODE	17	26/07	10:25	14.8	8.0	986	>120
X2ELAN-GOEDG	22	26/07	09:25	13.4	8.4	900	>120
X2ELAN-EHOEK	24	26/07	14:10	15.5	8.6	868	>120
X2LEEU-GELUK	19	25/07	11:10	12.3	9.0	375	>120
X2SWAR-KINDE	23	26/07	11:48	10.4	8.3	163	>120
X2NGOD-NOOIT	16	24/07	12:10				>120

Kaap River and Tributaries							
Site Code	WQ No.	Date	Time	Temp	pH	EC	WC
X2KAAP-HONEY	34	31/07	15:45	15.9	8.3	877	>120
X2NOOR-RIVER	35	01/08	08:20	13.7	8.2	239	>120
X2SUID-DAIRY	36	01/08	09:55	13.6	8.2	203	>120
X2QUEE-HILVE	37	01/08	12:25	14.7	8.6	256	>120







INKOMATI-USUTHU

CATCHMENT MANAGEMENT AGENCY

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The MAXSA Building,
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Mbombela, 1200

Postal address

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Mbombela, 1200

Tel: 013 753 9000

Fax: 013 753 2786