ECOSTATUS OF THE KOMATI RIVER CATCHMENT, INKOMATI RIVER SYSTEM

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INKOMATI USUTHU CATCHMENT MANAGEMENT AGENCY

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List of Abbreviations

DWS - RQIS	=	Department Water and Sanitation - Resource Quality Information Services
FRAI	=	Fish Response Assessment Index
GPS	=	Global Positioning System
m a.s.l.	=	metres above sea level
KNP	=	Kruger National Park
MIRAI	=	Macro-invertebrate Response Assessment Index
PES	=	Present Ecological State
RHP	=	River Health Programme
SASS5	=	South African Scoring System, Version 5
SQ	=	Subquatenary
SQR	=	Subquatenary River

1. INTRODUCTION

Aquatic ecosystems all over the world are severely stressed by an ever increasing demand for water for 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. It is crucial that we recognise the fact that a water resource can be exploited to such an extent that the ecosystem breaks down and a river loses its resilience and ability to sustain its quantity and quality of water. An understanding of its natural structure and function and also its responses to development and exploitation are therefore essential to conserve it in a state where it can maintain its natural biodiversity.

Water resource management approaches that focus on physical and chemical water quality and not aspects such as aquatic habitats and ecological integrity are inadequate to protect aquatic ecosystems. Many deficiencies in the management of the aquatic ecosystem have arisen due to the use of these chemical and physical aspects as the sole yardstick of environmental health.

A world-wide trend since the 1990'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. 1981).

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.

The Inkomati – Usuthu Catchment Management Agency (IUCMA) appointed the Mpumalanga Parks and Tourism Agency (MTPA – Scientific Services: Aquatic Systems) as service provider to conduct biomonitoring within the Komati River catchment on the 2014/2015 budget to determine the Present Ecological Status of this river system. Biomonitoring in the Komati River was conducted during 2014.

Monitoring for specific projects have been carried out in the past in portions of the Komati Catchment, but this was the first attempt on a catchment scale from the source to its confluence with the Crocodile River. During this 2014 survey fifty nine (59) sites were sampled in the Komati River and its tributaries, including the Klein Komati, Teespruit, Mtsoli, Seekoeispruit, Lomati, Malolotja, Phophonyane rivers (Figure 1). Existing 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) and Macro Invertebrate Response Assessment Index (MIRAI) models. These sites were sampled from June 2014 to September 2014. The habitats of the upper reaches above the 1000 m elevation were mostly high velocities over cobbles, the middle reaches 400 – 1000 m elevation were medium to high velocities over boulders, and the lower reaches below 400 m elevation were mostly low velocities over gravel and sand.

1.1 Objectives of the Survey

The objective of this study is to determine the current status (2014) of the Komati 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), the Fish Response Assessment Index (FRAI) and Riparian and Habitat Assessment Method (RHAM). This study will provide useful ecological information through an aquatic assessment and the determination of the present ecological status of the associated aquatic habitat of the Komati River and trends in aquatic health over time, in order to inform management interventions required to address systemic and point specific impacts.

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. 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 descents 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 km^2 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 m^3s^{-1} to

Figure 1: Map of the Inkomati Basin.

200 m^3s^{-1}, corresponding to about 3,600 million m^3 per year, to which South Africa contributes 82%, Swaziland about 13% and Mozambique about 4%.

There are a large number of dams in the basin which can be classified as large and most of them are located 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 Inkomati 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. 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. The health of the river system as a whole is also threatened by loss and degradation of habitats, in particular due to sedimentation and eutrophication, flow modification and the introduction of alien invasive species. In addition to these threats, the system is also threatened by extensive coal mining across the head waters with resultant risk of pollution by 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 Mesosoic period followed by Cretaceous basins east of the Lebombo.

The flow regime of the Inkomati River is characterized as torrential with high flows during the wet season, from November to March, and relative low flows in the dry season, from April to October.

The fish fauna is dominated by Zambezian elements and is characterized by relative high endemicity with many restricted range species. The Inkomati support an estimated 56 species of fish (16% of the regional total), 75 species of Odonata (28% of the regional total) have been recorded to date, 202 of the selected aquatic plants (39% of the regional total), and 24 Moluscs (21% of the regional total) (Darwall et al*.,* 2009).

Komati River

The Komati River catchment originates near Breyten (Vaalwaterspruit) on the Highveld before flowing into Nooitgedacht Dam near Carolina, onwards into Vygeboom Dam near Badplaas before entering Swaziland. In Swaziland it flows through the Maguga Dam and then back into South Africa again before finally flowing into Mozambique near Komatipoort with the confluence of the Crocodile River.

The Komati River catchment is ecologically severely stressed due to the water demands imposed on this catchment. In this catchment ESKOM and agriculture are the major water users. There are also various abstraction weirs that affect the aquatic ecosystem and are creating serious obstructions to fish migrations. Dams are also known to change the quality of the water when released back into the river system. Return flows from irrigation mobilizes a number of chemicals such as pesticides, fertilizers and salts that can affect the quality of water in this system. Point sources along the river discharge water of various qualities into the river system, not knowing what the effect may be on the ecosystem. Alien invasive fish species introduced into the numerous dams have entered the rivers and modify habitat or predate on indigenous species.

Although the ecological status of some sections in the Komati River is still in a relative good condition, the lower Komati River is in a very poor condition. Rapid flow changes and reductions, poor water quality, excessive impoundments by weirs causing deficiency in available riffle areas and the absence of fish ways are the major perturbations contributing towards the poor state of the river.

The Komati Basin Water Authority (KOBWA) is a bi-national company between the Governments of the Kingdom of Swaziland and the Republic of South (the Parties). KOBWA was established in 1993 through the treaty on the Development and Utilization of the Water Resources of the Komati River Basin, signed between Swaziland and South Africa in 1992. The main purpose for KOBWA was to implement Phase 1 of the Komati River Basin Development Project. The project comprises the design, construction, operation and maintenance of the Driekoppies Dam in South Africa and Maguga Dam in Swaziland.

The specific Bi-National agreements covering the Komati Basin are the Joint Water Commission Treaty covering all watercourses shared by South African and Swaziland and the Treaty on the Development and Utilization of the Water Resources of the Komati River Basin and the “Komati Basin Development Treaty”. The above-mentioned treaty states that the environmental aspects of the Komati Basin Water Project should be managed as to not result in the degrading of the existing environment and also that the parties take all reasonable measures to ensure the protection of the existing quality of the environment.

The SADC revised protocol has been adopted by all the SADC countries. It provides policy framework for Water Course States to manage shared water courses and possesses various provisions dealing with environmental water requirements. The most important of the SADC protocol is the INCOMAPUTO Agreement on Water Sharing signed at the World Summit on Sustainable Development in August 2002. Apart from reflecting the principle of equitable and responsible utilization for economic and social benefit, it also ensures protection of the environment.

2. REACH AND SITE DESCRIPTION

A brief description of each river and reach follows (Table 1). The main features of each reach is discussed, which includes the length, general location, elevation range, aquatic ecoregion (Kleynhans et al. 2008), vegetation type (Mucina & Rutherford 2006), and the sites sampled within each reach during 2014 (Figure 2). Up- and downstream photos of the sampling points are included at the discussion of each site.

2.1. Komati River

The Komati River mainstem has been divided into 31 SQ reaches (16 of these SQ reaches were surveyed and 15 sites were extrapolated) with the starting point at the town of Breyton at an elevation of 1,800 m a.s.l. running in a general easterly direction through Swaziland towards the westerly border Mozambique at the town of Komatipoort (118 m a.s.l.). The Komati River ends at its confluence with the Crocodile River, where after the river is referred to as the Inkomati River or Rio Inkomati as referred to in Mozambique.

The total length of the 31 reaches covers a length of 413.76 km of river. Three major impoundments, the Nooitgedacht Dam, Vygeboom Dam and Maguga Dam, are located in the Komati River mainstem.

2.2. Komati Tributaries

For the purpose of this study all Komati River tributaries are grouped together which consisted of 37 SQ reaches and 6 additional sites that have not been allocated on its SQ reaches. In total 43 monitoring sites were done on tributaries of the Komati River which cover a total length of 1109.99 km. The largest of the tributaries is the Lomati River in which 8 biomonitoring sites were surveyed. It is also within this tributary where the Driekoppies Dam is located.

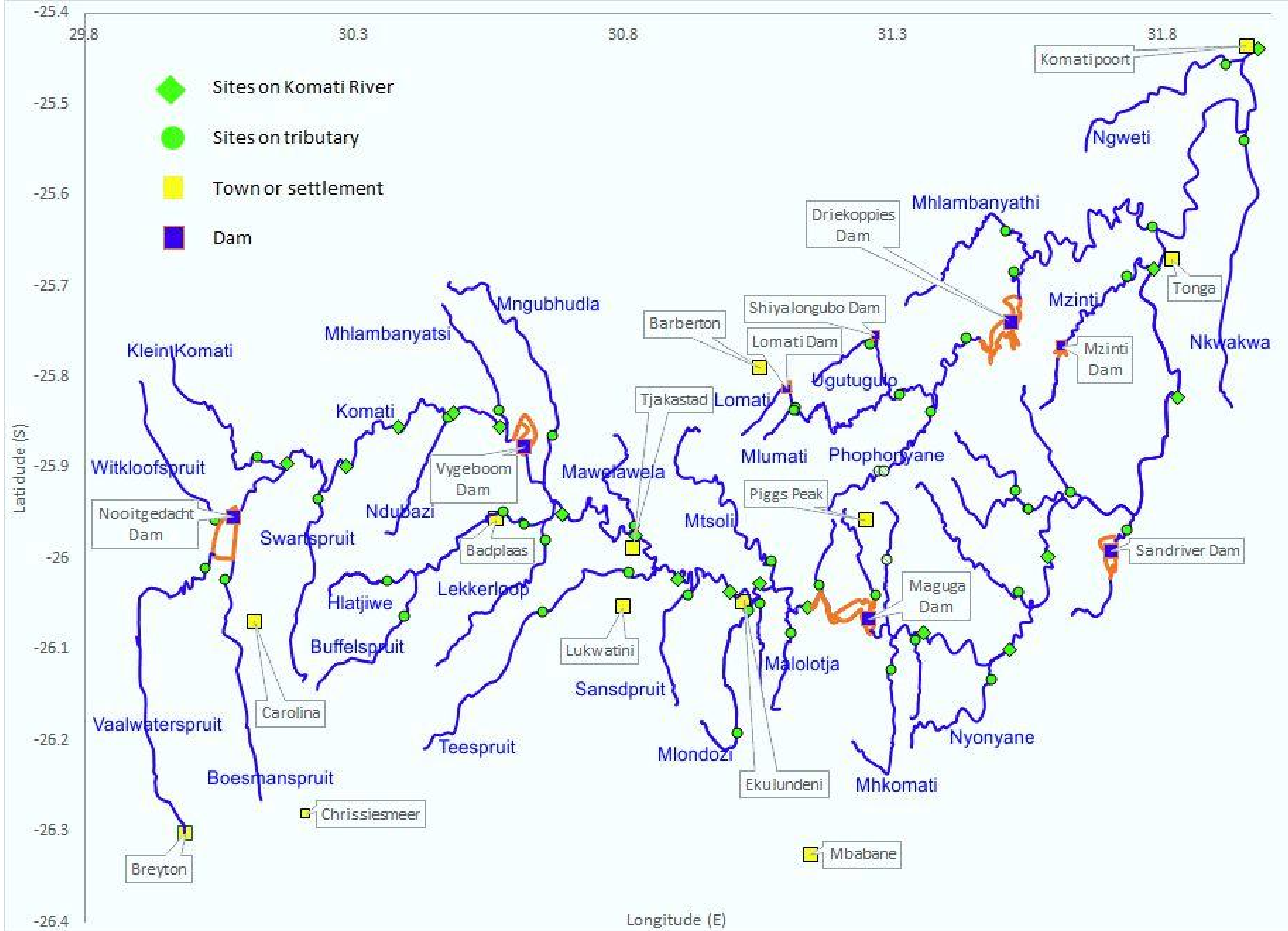

Figure 2: Map of Komati Catchment indicating all biomonitoring points

Table 1: List of reaches and sites visited within each reach

Site Code	Reach Code	Farm Name	River	Aquatic Ecoregion Lev I	Aquatic Ecoregion Lev II	Geomorp. Zone	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss) Lat (S)	GPS Co-ordinates (dd.sssss) Long (E)
X1VAAL-BOESM	X11A-01248	Boesmanspruit 9 IT	Vaalwaterspruit	11. Highveld	11.04	Lower Foothills	1,538	-26.00713	30.02756
X1BOES-ROODE	X11B-01272	Roodepoort 6 IT	Boesmanspruit				1,562	-26.02357	30.06092
X1WITK-WITKL	X11C-01147	Witkloof 403 JT	Witkloofspruit			Transitional	1,541	-25.96086	30.04052
X1KKOM-WELGE	X11D-01129	Welgevonden 412 JT	Klein Komati	10. Northern Escarpment Mountains	10.03	Upper Foothills	1,514	-25.88793	30.12033
X1KOMA-MOEDI	X11D-01196	Vlakfontein 418 JT	Komati			Lower Foothills	1,471	-25.89598	30.17625
X1SWAR-HEBRO	X11E-01237	Doornkop 420 JT	Swartspruit	11. Highveld	11.04		1,432	-25.92519	30.23756
X1KOMA-WATER	X11F-01163	Waterval 424 JT	Komati	10. Northern Escarpment Mountains	10.03		1,371	-25.89828	30.28450
X1KOMA-GEVON	X11G-01142	Gemsbokhoek 397JT					1,236	-25.85512	30.38235
X1NDUB-SAPPI	X11G-01188	Ndubazi Ranch 413 JT	Ndubazi				1,165	-25.84470	30.47466
X1KOMA-LEKKE	X11H-01140	Ndubazi Ranch 413 JT & Ranch 616 JT	Komati			Lower Foothills	1,144	-25.83430	30.49547
X1KOMA-GROOT		Grootkop 617 JT				Upper Foothills	1,100	-25.85494	30.57146
X1GLAD-VYGEB	X11K-01194	Vygeboom 619 JT	Gladdespruit			Upper Foothills	1,026	-25.86514	30.66661
X1KOMA-VYGEB	X11K-01227	Winkelhaak 723 JT	Komati			Lower Foothills	929	-25.94631	30.68474
X1BUFF-DOORN	X12A-01305	Doornkloof 23 IT	Buffelspruit	11. Highveld	11.04	Upper Foothills	1,370	-26.06264	30.39378
X1HLAT-RIETF	X12B-01246	Rietfontein 19 IT	Hlatjiwe	10. Northern Escarpment Mountains	10.03		1,382	-26.02361	30.36111
X1SEEK-DOORN	X12D-01235	Doornpoort 724 JT	Seekoeispruit				1,043	-25.94773	30.57494
X1SEEK-WINKE		Winkelhaak 723 JT				Lower Foothills	965	-25.96139	30.61846
X1TEES-WELVE	X12E-01287	Welverdiend 174 IT	Teespruit			Upper Foothills	1,138	-26.05785	30.65012
X1TEES-HEUNI		Heuningklip 154 IT					868	-26.01573	30.80877
X1KOMA-TJAKA	X12G-01200	Tjakastad 730 JT	Komati			Lower Foothills	838	-25.97453	30.82221
X1KOMA-HOOGE	X12H-01258	Hooggenoeg 162 IT	Komati			Lower Foothills	739	-26.03632	30.99806
X1KOMA-KOMAT	X12H-01296	Laaggenoeg 158 IT	Komati			Lower Foothills	798	-26.02341	30.90073
X1SAND-KORTB	X12H-01318	Laaggenoeg 158 IT	Sandspruit			Upper Foothills	798	-26.03510	30.92432
X1MTSO-DIEPG	X12J-01202	Songimvelo 600 JU	Mtsoli			Upper Foothills	734	-26.00281	31.07402
X1KOMA-HILLC	X12K-01316	Nooitgezien 3 IU Kranskop 10 IU	Komati			Lower Foothills	702	-26.02966	31.05550
X1MHLA-KRANS	X12K-01332	Kranskop 10 IU	Mhlangampepa			Transitional	733	-26.04997	31.05354
X1MLON-KRANS	X12K-01333	Kranskop 10 IU				Upper Foothills	740	-26.05772	31.03248
X1MALO-MALOL	X13A-01337	Swaziland	Malolotja	4. North Eastern Highlands	4.05	Upper Foothills	815	-26.08253	31.10888
X1KOMA-MALOL	X13A-01324	Swaziland	Komati			Lower Foothills	643	-26.05399	31.14151
X1NKOM-MALOL	X13A-01255	Swaziland	Nkomazana			Upper Foothills	641	-26.02851	31.16358
X1MKHO-MAGUG	X13B-01276	Swaziland	Mkhomazana			Transitional	652	-26.03989	31.26615
X1MBUY-MKHOM	X13C-01364	Swaziland	Mbuyane	3. Lowveld	3.07	Upper Foothills	632	-26.12210	31.29630
X1KOMA-MELET	X13D-01323	Swaziland	Komati			Upper Foothills	432	-26.08214	31.35515
X1NYON-NYONY	X13E-01389	Swaziland	Nyonyane				359	-26.13236	31.48093
X1KOMA-BHALE	X13E-01346	Swaziland	Komati			Lower Foothills	310	-26.09980	31.51587
X1MZIM-MANSE	X13F-01252	Swaziland	Mzimnene				331	-26.04071	31.52635

Site Code	Reach Code	Farm Name	River	Aquatic Ecoregion		Geomorp. Zone	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	
				Lev I	Lev II			Lat (S)	Long (E)
X1KOMA-IFR03	X13G-01282	Swaziland	Komati				283	-25.99827	31.58609
X1MBUL-MPOFU	X13G-01216	Swaziland	Mbulatana			Upper Foothills	320	-25.92469	31.52623
X1MPOF-MPOFU	X13G-01259	Swaziland	Mphofu			Lower Foothills	291	-25.93154	31.58150
X1KOMA-NYATS	X13J-01210	Fig Tree 503 JU	Komati		3.06	Lowland River	239	-25.82188	31.82616
X1KOMA-IFR04	X13J-01130	Tonga 475 JU	Komati		3.07	Lower Foothills	199	-25.68168	31.78295
X1MZIN-MASHU	X13J-01141	Mahushe Shongwe NR	Mzinti				255	-25.69248	31.73264
X1NKWA-COOPE	X13K-01068	Coopersdal 423 JU	Nkwakwa	12. Lebombo Uplands	12.01		139	-25.53515	31.95017
X1KOMA-LEBOM	X13L-00995	Lebombo 186 JU	Komati	12. Lebombo Uplands	12.01		113	-25.43901	31.97341
X1NGWE-KOMAT	X13L-01000	Komatipoort Townlands 182 JU	Ngweti	3. Lowveld	3.06		151	-25.45656	31.91683
X1LOMA-HIGHL	X14A-01173	De Bilt 372 JU	Lomati	4. North Eastern Highlands	4.05	Transitional	1,049	-25.83233	31.11699
X1UGUT-ZEIST	X14B-01166	Duursede 361 JT	Ugutugulo			Upper Foothills	1,007	-25.76321	31.24677
X1PHOP-MAGUT	X14C-01203	Swaziland	Phophonyane	3. Lowveld	3.07	Lower Foothills	438	-25.83217	31.36920
X1LOMA-HLELE	X14D-01174	Swaziland	Lomati			Upper Foothills	495	-25.81894	31.31144
X1LOMA-MBONG	X14E-01151	Swaziland	Lomati				333	-25.75736	31.43655
X1MHLA-RUSOO	X14F-01085	Rusoord 261 JU	Mhlambanyatsi			Upper Foothills	334	-25.63447	31.50451
X1LOMA-SCHOE	X14G-01128	Schoemansdal 581 JU	Lomati			Lower Foothills	279	-25.68629	31.52879
X1LOMA-LEKKE	X14H-01066	Lekkerdraai 464 JU	Lomati			Lower Foothills	181	-25.63518	31.77914
X1MHLA-GROOT	Not allocated	Grootkop 617 JT	Mhlambanyatsi	10. Northern Escarpment Mountains	10.03	Transitional	1,134	-25.83626	30.56834
X1LEKK-VERGE	Not allocated	Vergelegen 726 JT	Lekkerloop			Upper Foothills	965	-25.97977	30.65400
X1MAWE-TJAKA	Not allocated	Tjakastad 730 JT	Mawelawela				866	-25.96386	30.82030
X1UNSP-BMINE	Not allocated	Swaziland	Mlondozi			Mountain Stream	1,142	-26.19211	31.01138
X1MELE-MELET	Not allocated	Swaziland	Melete	3. Lowveld	3.07	Transitional	454	-26.08883	31.33933
X1MLUM-WELGE	Not allocated	De Bilt 372 JU	Mlumati	4. North Eastern Highlands	4.05		1,049	-25.83743	31.11370

3. METHODS

The general approach used for this study was based on the rapid appraisal methods recommended by the Department of Water Affairs and Forestry in their guidelines for Resource Directed Measures for the Protection of Water Resources. 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. 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 provide 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. The purpose of this study is to use resident aquatic biota to characterize the existence and severity of impairments in the Komati River and to attempt to identify any sources and causes of impairment related to the catchment.

Aquatic bio-monitoring is an essential component of ecological risk assessment and aims to measure present biological conditions and trends in the aquatic ecosystem. It attempts to relate the observed variation to changes in available habitat, as dictated by physical system drivers of the system such as water quality, geomorphology, and hydrology (Figure 3 and 4) (Kleynhans & Louw, 2008). Several of the aquatic species and taxa that have been recorded in the Komati River are considered highly sensitive to changes in the above-mentioned physical drivers and are expected to respond rapidly to any changes.

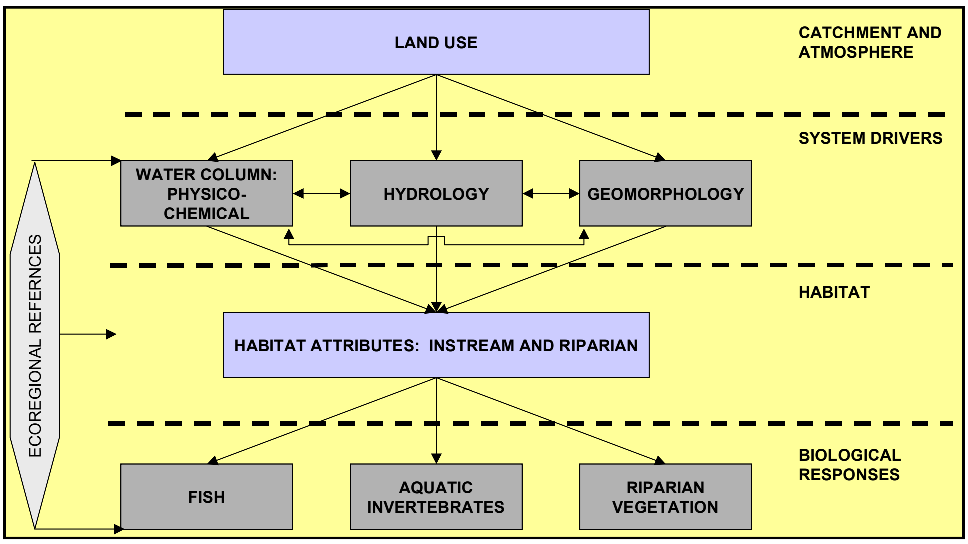

Figure 3: A simplified integration of influence of land use on physical driver determinants, habitats and the associated biological responses.

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 et al. 1981). This is because fish are "top of the food chain", relatively long-lived and mostly highly mobile. Assemblages include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). They tend to integrate effects of lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health.

Reference condition for fish species in the Komati River was based largely on Gaigher 1969, Skelton 2001, Jubb 1967, National River Health surveys (2004 surveys), the former Transvaal Directorate of Nature Conservation Database and own experience in the river. Species most likely to have occurred at each site was listed under the expected for each site. The presence, absence or abundance of taxa in comparison to the expected reference condition was largely based on previously available data. The PESEIS Front End Model was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2013, In prep; DWA, 2014). A list of fish species collected during the 2014 biomonitoring, as well as photos of the fish species recorded at sampling sites (Scott et al., 2004) and additional distribution map of fish species are attached in the Appendix.

3.1.1. Sampling

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 fact that the flow of direct electric current (DC) in water causes an anode reaction (galvanotaxis) in fish. The anode reaction in fish (pulling fish towards anode) is explained by the fact that fish orientate and move in the direction of ions. Under the influence of the electrical current fish are stunned and drawn towards the anode. The effectiveness of electro fishing is dependent on the electric current (Amperes) and not necessarily the voltage. The current should be strong enough to create an effectively large zone of fishing. However, it should allow fish to swim freely towards landing gear. If the voltage is higher than critical around the anode, fish will tend to fall in a state of nervous shock and may sail out or drop to the bottom. Apart from the critical electric parameters to be considered, the 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. All fish species were identified and anomalies and general age structure were recorded. Sampling effort per site was kept to about 30 minutes.

3.1.2. Analysis

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) 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.

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. The PESEIS Front End Model was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2013, In prep; DWA, 2014). Data compilation was done according to models that were developed to determine the Ecostatus (Kleynhans, 2008). The River Data Integration Application (RIVDINT) which was developed in a project between RQS and MTPA (Kleynhans, 2013, In prep.) and was also utilised during the data compilation and analysis process.

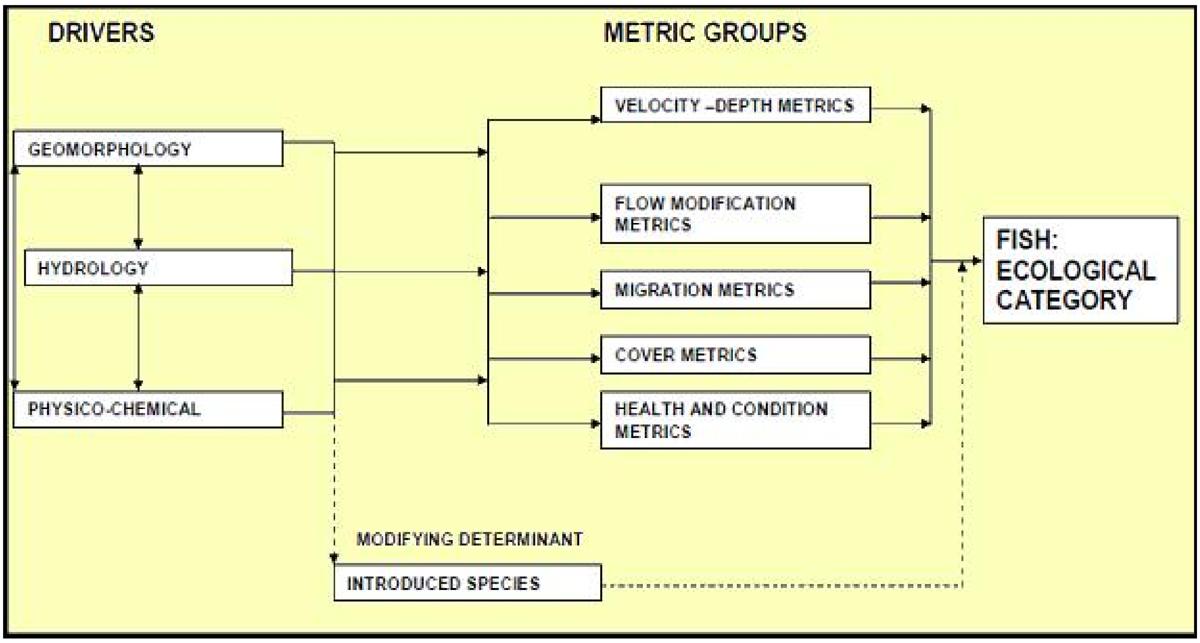

Figure 4: The relationship between ecological drivers, fish metric groups and Ecological Category

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 and 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 and Dickens 2000) and aquatic macro-invertebrate communities offer a good reflection of the prevailing flow regime and water quality in a river.

Aquatic macro invertebrates are important processors of transported organic matter in rivers and serve a vital function in purifying the water in a river. Aquatic macro-invertebrates also provide a valuable food source for larger animals within and even outside the system (Skorozjewski & de Moor 1999, O' Keeffe and Dickens 2000, Weber et al 2004, Allan 1995). In order to continue functioning optimally, species in a river system require regular inputs of nutrients and sediments, as well as flowing water. A specific river system supports a particular assemblage of species forming functional communities within reaches. These communities are adapted to the prevailing flow conditions that control temperature, sediment transport and nutrient flows. A decrease or increase in flow, sediment transport or nutrient loads will lead to changes in community structures through loss of certain species and increases in others, as well as providing conditions for a range of new or otherwise scarce species to flourish.

The four major components of a stream system that determine productivity for aquatic organisms are the flow regime, physical habitat structure (e.g., channel form and substrate distribution), water quality (e.g., temperature, dissolved oxygen), and energy inputs from the watershed (e.g., nutrients and organic matter) (Milhous and Bartholow, 2004). Distribution of an aquatic macro invertebrate population is ultimately set by the physical-chemical tolerance of the individuals in the population to an array of environmental factors. The distribution pattern resulting from habitat selection by a given aquatic macro invertebrate species reflects the optimal overlap between habit (mode of existence) and physical environmental conditions that comprise the habitat.

3.2.1. Sampling

Aquatic invertebrates were collected using a standard net and taxa were identified to at least family level according to the SASS5 sampling technique (Dickens and Graham, 2001). Taxa collected from streams were analysed according to the standard SASS technique. Chutter (1998) developed the SASS protocol as an indicator of water quality. It has since become clear that SASS gives an indication of more than mere water quality, but rather a general indication of the present state of the invertebrate community. Sampling should preferably be concentrated during the low flow periods to represent "End of Wet", "Dry" or "End of Dry" season.

3.2.2. Analysis

The interpretation of values can differ significantly for different eco-regions in the country (Davies & Day, 1998). Dallas (2007) used available SASS-5 Score and ASPT values for each eco-region in South Africa to generate biological bands that could be used as a guideline for interpreting the values obtained during the present study. 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 also used to interpret the Ecological Condition of the macro invertebrate for the sites. The MIRAI is a rule-based model recently developed by DWAF (Thirion, 2008). It integrates the ecological requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions.

3.3. Chemical and Physical Water Quality Measurements

At each biomonitoring site in situ water measurements were recorded in 1.5 ℓ samples, collected in treated plastic bottles, for analysis at WaterLab. Results for water quality constituents were measured at the sites on the Komati River and was compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

System variables, quality indicators, nutrients, indicator organisms, inorganic salts and toxicity was analysed:

- Water temperature (˚C) should not be allowed to vary from background average; daily water temperature considered normal for a specific site and time of day by >2°C or >10% (DWAF 1996).
- The pH should not vary from the range of background pH values for a specific site and time of day by >0.5 of a pH unit, or by >5% (DWAF 1996).
- Saturation (%) levels should be measured by a 06h00 sample or lowest instantaneous concentration recorded in a 24-hour period (DWAF 1996).
- Total Dissolved Solids (TDS) (mg/ℓ) concentrations should not be changed by >15%from the normal cycles of the water body under unimpacted conditions at any time of the year, and the amplitude and frequency of natural cycles must remain unchanged.

- Inorganic Nitrogen (mg/ℓ) Calculated by adding individual concentrations of ammonia (NH_3 + NH_4) + nitrite (NO_2). NH_4 not analysed by laboratory.
- Copper (Cu) depends on water hardness (mg $CaCO_3$/ℓ), which is not analysed by the Water Laboratory. Target Water Quality Range for soft (<60) water is 0.0003 mg/ℓ; medium water (60 – 119) is 0.0008 mg/ℓ; hard water (120 – 180) is 0.0012 mg/ℓ; and very hard water (>180) is 0.0014 mg/ℓ.
- Iron concentration should not be allowed to vary by >10% of background dissolved Fe concentration for a particular site at a specific time (DWAF 1996).

3.4. Present Ecological Status

The Present Ecological Status (PES) of the river is expressed in terms of various components that are drivers (physic-chemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the Ecostatus.

(a) The PES per SQR is assessed according to 5 metrics that represents a very broad qualitative assessment of both the instream and riparian components of a river

(b) Only the main PES categories (A to E) were used for interpretation (Table 2). It is not considered realistic to distinguish boundary categories (A/B etc.) on a desktop level as the boundaries between categories are essentially fussy within the A to F delineation and that there exist a probability that the SQR may be a member of any of the two neighbouring categories.

(c) Individual metric ratings should be considered when considering the condition of the instream of riparian PES. Depending on the purpose of the assessment and the EI (Ecological Intolerance rating) and ES (Ecological Sensitive rating), it may be necessary that the instream and riparian integrity be determined according to the IHI (Index of Habitat Integrity) (Kleynhans & Louw, 2008).

The scale used for river health describes five different states of health, from an A class (natural) to an E class (unacceptable). The results of applying the biological and habitat indices during a river survey provide the contexts 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 2: Present Ecological State of the River Classification

Class	Ecological State of River	Description
A	Natural	No measurable modification
B	Good	Largely unmodified
C	Fair	Moderately modified
D	Poor	Largely modified
E	Unacceptable	Seriously/critically modified

3.5. Assumptions and Limitations

3.5.1. Reach scale

The sub-quaternary (SQ) reaches that were delineated for the PES/EIS&ES were based on a large scale (1:500 000), so the reaches did not necessarily co-incide with ecological boundaries that are relevant at a smaller scale. For example, the SQ reach for the Teespruit (X12E-01287) crosses two Level I aquatic ecoregions (Kleynhans et al. 2005), and three vegetation types (Mucina & Rutherford 2006), so ecological characteristics within the SQ are likely to differ significantly along its length. This means that features such as stream order, physical-chemical similarity, tributary junctions or physical barriers (e.g. waterfalls) are not considered. The large scale further results in a mismatch between the digitised channel and the actual channel when the rivers from the 1:500 000 digitised map is overlaid onto Google Earth, which stands out when zooming to a smaller scale (Figure 5).

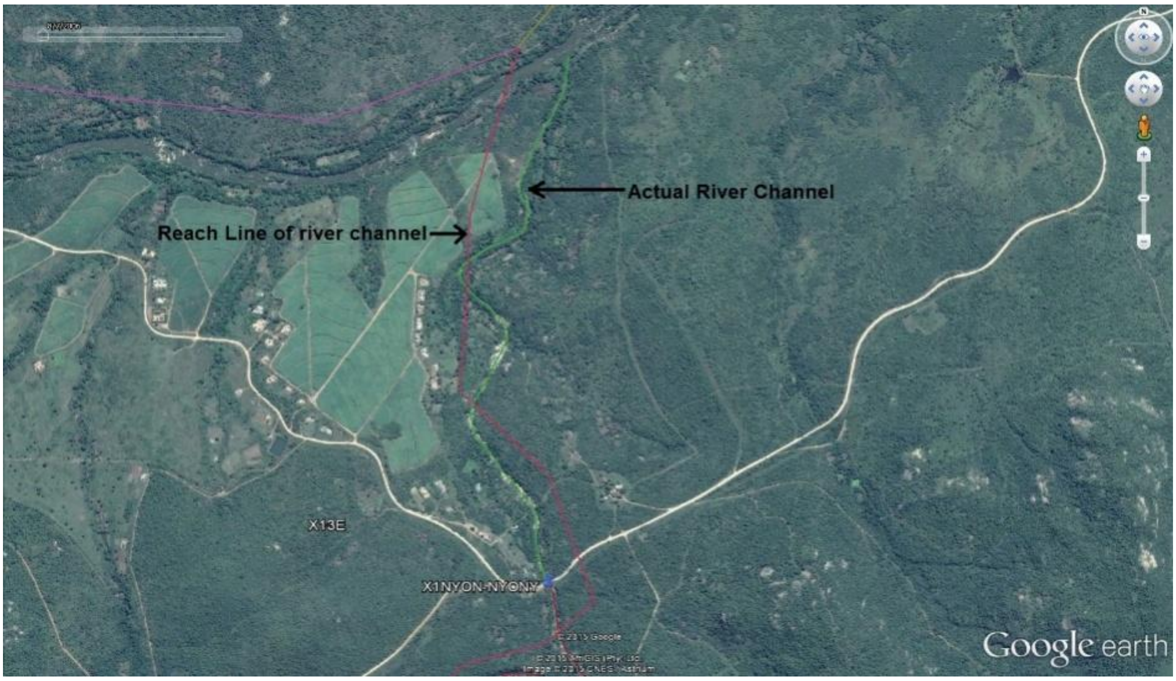

Figure 5. A copy of Google Earth indicating the accuracy of reach length provided using the Nyonyane River as an example.

3.5.2. Fish and invertebrate taxa expected for reaches

The fish and invertebrate taxa expected within each reach (SQ) were based on the available data sets, combined with expert opinion. There are several streams, especially tributaries, for which no data were available. Seasonal movements and distribution of fish species and/or SASS taxa within these reaches are also not well known. The only reliable data that exists are therefore from sampled sites. The PES for fish and aquatic invertebrates was based on the difference between the observed and expected (natural) composition of taxa, yet few records are available on the expected composition of taxa, particularly for smaller tributaries, many of which have no historical records. The PES results should therefore be interpreted with caution.

3.5.3. Limited Sampling

Spatial and temporal variations, and natural and anthropogenic influences are not incorporated into this assessment. Several data sets which incorporate seasonality and changes over time are required to understand current conditions. At some of the sites the only sampling data available is those collected during the winter of 2014. For example, comparing to available data collected in 1966/67 (Matthew 1968), taxa previously recorded in abundance on the Komati River was absent at several of the sites in 2014. When these changes took place or whether it's a seasonal variation is not clear because of limited data.

Natural variation in SASS results between seasons in stream and rivers is projected based on expert knowledge, but has not been verified with actual data. Caution is therefore needed when interpreting biomonitoring data while continuous monitoring will assist in broadening the data base and providing for more meaningful interpretation.

4. RESULTS

Bio-monitoring results summarised for each reach in the Komati River and its tributaries are indicated in Table 2. Sites in each reach and present state are indicated. The bio-indicators used were the Macro-invertebrate Response Assessment Index (MIRAI) and the Fish Response Assessment Index (FRAI). Using these two indicators the Instream Ecological Category was determined. Another bio-indicator, VEGRAI - indicator of riparian vegetation - was derived from the PES-EIS to determine the total Ecostatus of the reach.

Table 1: Present Ecological State of the River Classification.

Class	Ecological State of River	Description
A	Natural	No measurable modification
B	Good	Largely unmodified
C	Fair	Moderately modified
D	Poor	Largely modified
E	Unacceptable	Seriously/critically modified

The scale used for river health describes five different states of health, from an A class (natural) to an E class (unacceptable). The results of applying the biological and habitat indices during a river survey provide the contexts 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 3: Biomonitoring results summarised for each reach in the Komati River and its tributaries.

Reach Code	Site Code	River	Bio-Indicators		Instream Ecological Category	Bio-Indicators	Ecostatus
			FRAI	MIRAI		VEGRAI	
X11A-01248	X1VAAL-BOESM	Vaalwaterspruit	BC	B	BC	B	B
X11B-01272	X1BOES-ROODE	Boesmanspruit	D	CD	D	CD	CD
X11C-01147	X1WITK-WITKL	Witkloofspruit	C	C	C	C	C
X11D-01129	X1KKOM-WELGE	Klein Komati	C	B	BC	C	C
X11D-01196	X1KOMA-MOEDI	Komati	C	AB	BC	BC	BC
X11E-01237	X1SWAR-HEBRO	Swartspruit	C	C	C	B	C
X11F-01163	X1KOMA-WATER	Komati	BC	BC	BC	B	B
X11G-01142	X1KOMA-GEVON	Komati	C	BC	C	B	BC
X11G-01188	X1NDUB-SAPPI	Ndubazi	C	C	C	C	C
X11H-01140	X1KOMA-LEKKE X1KOMA-GROOT	Komati	C	C	C	CD	C
X11K-01194	X1GLAD-VYGEB	Gladdespruit	C	C	C	D	C
X11K-01227	X1KOMA-VYGEB	Komati	C	C	C	B	C
X12A-01305	X1BUFF-DOORN	Buffelspruit	C	BC	C	D	C
X12B-01246	X1HLAT-RIETF	Hlatjiwe	C	C	C	D	C
X12D-01235	X1SEEK-DOORN X1SEEK-WINKE	Seekoeispruit	C	C	C	D	C
X12E-01287	X1TEES-WELVE X1TEES-HEUNI	Teespruit	C	C	C	C	C
X12G-01200	X1KOMA-TJAKA	Komati	C	C	C	CD	C
X12H-01258	X1KOMA-HOOGE	Komati	B	B	B	B	B
X12H-01296	X1KOMA-KOMAT	Komati	BC	B	B	B	B
X12H-01318	X1SAND-KORTB	Sandspruit	C	B	B	C	C
X12J-01202	X1MTSO-DIEPG	Mtsoli	C	B	BC	C	C
X12K-01316	X1KOMA-HILLC	Komati	C	C	C	BC	C
X12K-01332	X1MHLA-KRANS	Mhlangampepa	C	C	C	B	BC

Reach Code	Site Code	River	Bio-Indicators		Instream Ecological Category	Bio-Indicators	Ecostatus
			FRAI	MIRAI		VEGRAI	
X12K-01333	X1MLON-KRANS	Mlondozi	C	D	CD	C	C
X13A-01337	X1MALO-MALOL	Malolotja	A	A	A	A	A
X13A-01324	X1KOMA-MALOL	Komati	B	C	BC	B	BC
X13A-01255	X1NKOM-MALOL	Nkomazana	D	CD	CD	CD	CD
X13B-01276	X1MKHO-MAGUG	Mkhomazana	C	C	C	C	C
X13C-01364	X1MBUY-MKHOM	Mbuyani	D	D	D	C	C
X13D-01323	X1KOMA-MELET	Komati	C	C	C	C	C
X13E-01389	X1NYON-NYONY	Nyonyane	C	D	C	C	C
X13E-01346	X1KOMA-BHALE	Komati	C	D	CD	C	C
X13F-01252	X1MZIM-MANSE	Mzimnene	C	D	C	D	CD
X13G-01282	X1KOMA-IFR03	Komati	C	C	C	C	C
X13G-01216	X1MBUL-MPOFU	Mbulatana	B	C	C	C	C
X13G-01259	X1MPOF-MPOFU	Mphofu	AB	D	C	CD	C
X13J-01210	X1KOMA-NYATS	Komati	C	C	C	D	C
X13J-01130	X1KOMA-IFR04	Komati	C	C	C	CD	C
X13J-01141	X1MZIN-MASHU	Mzinti	C	C	C	C	C
X13K-01068	X1NKWA-COOPE	Nkwakwa	C	D	D	D	D
X13L-00995	X1KOMA-LEBOM	Komati	C	C	C	C	C
X13L-01000	X1NGWE-KOMAT	Ngweti	C	CD	CD	D	D
X14A-01173	X1LOMA-HIGHL	Lomati	C	C	C	C	C
X14B-01166	X1UGUT-ZEIST	Ugutugulo	C	C	C	C	C
X14C-01203	X1PHOP-MAGUT	Phophonyane	C	C	C	C	C
X14D-01174	X1LOMA-HLELE	Lomati	B	C	BC	BC	BC
X14E-01151	X1LOMA-MBONG	Lomati	B	C	BC	C	C
X14F-01085	X1MHLA-RUSOO	Mhlambanyatsi	C	C	C	C	C
X14G-01128	X1LOMA-SCHOE	Lomati	C	C	C	CD	C
X14H-01066	X1LOMA-LEKKE	Lomati	C	C	C	D	CD
Not allocated	X1MHLA-GROOT	Mhlambanyatsi	C	C	C		
Not allocated	X1LEKK-VERGE	Lekkerloop	C	B	BC		
Not allocated	X1MAWE-TJAKA	Mawelawela	C	C	C		
Not allocated	X1UNSP-BMINE	Mlondozi	D	C	CD		
Not allocated	X1MELE-MELET	Melete	C	D	CD		
Not allocated	X1MLUM-WELGE	Mlumati	C	C	C		

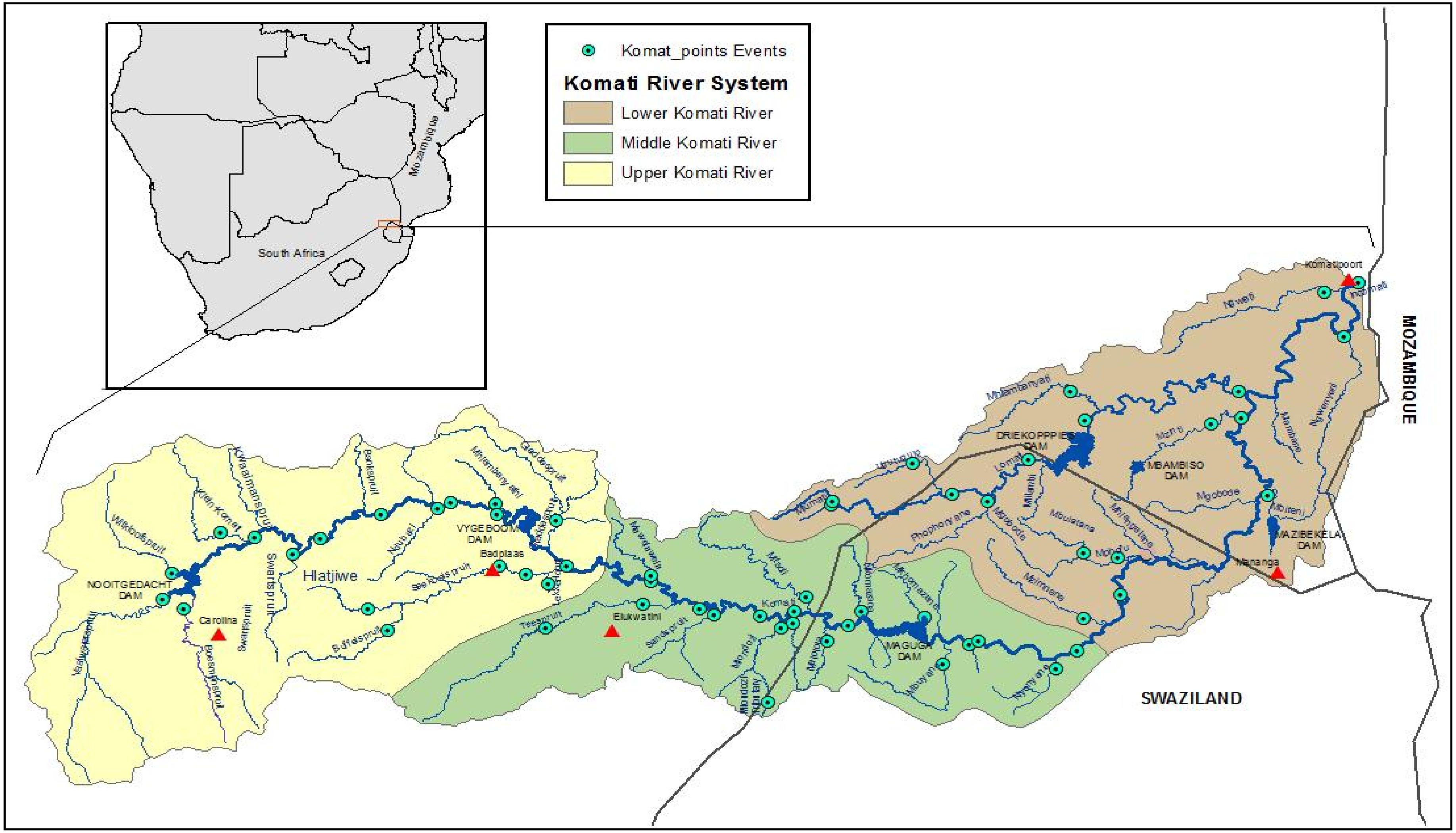

Figure 6: Map of the Komati River System indicating all biomonitoring points.

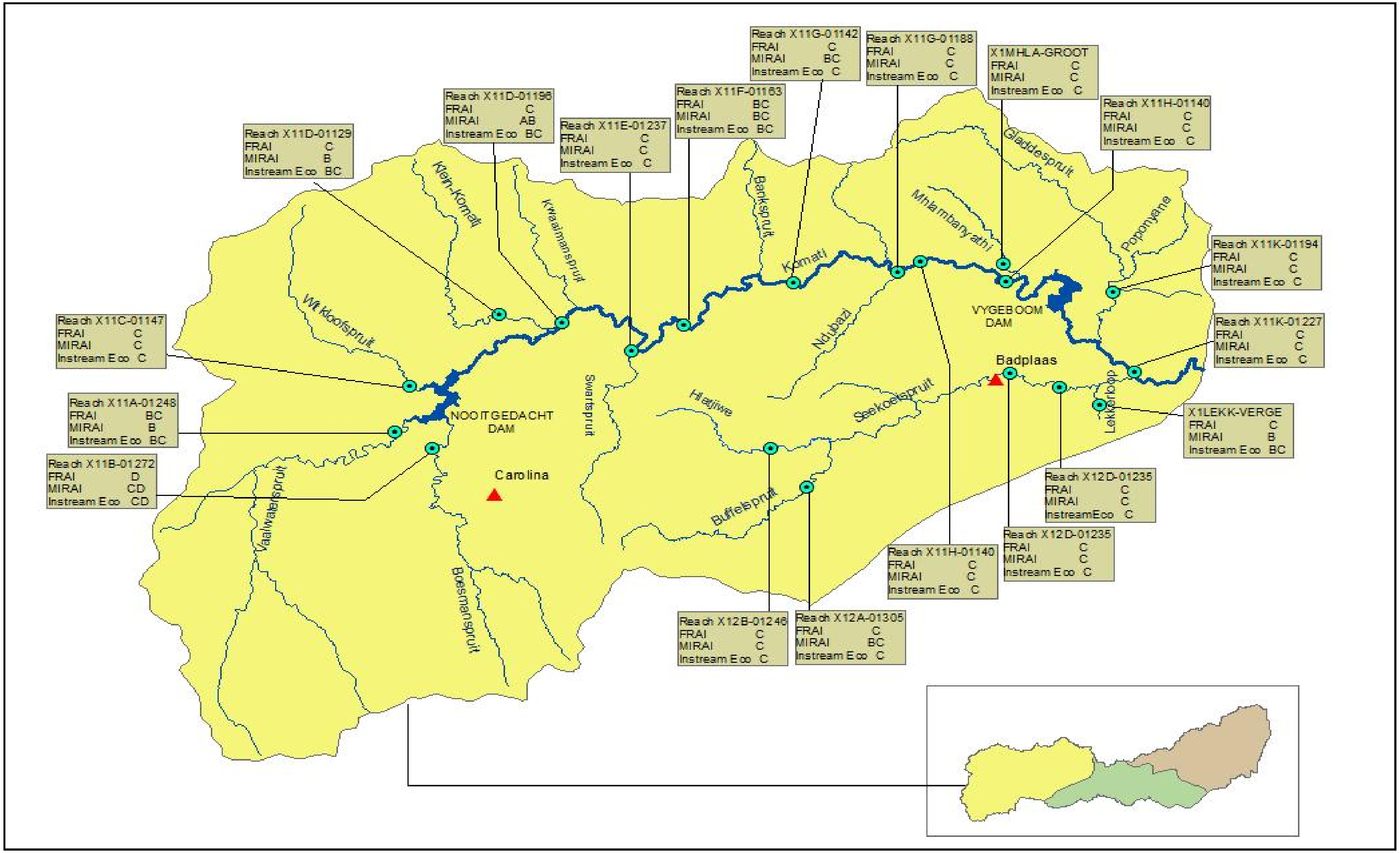

Figure 7: Map of the upper Komati River System indicating all biomonitoring points.

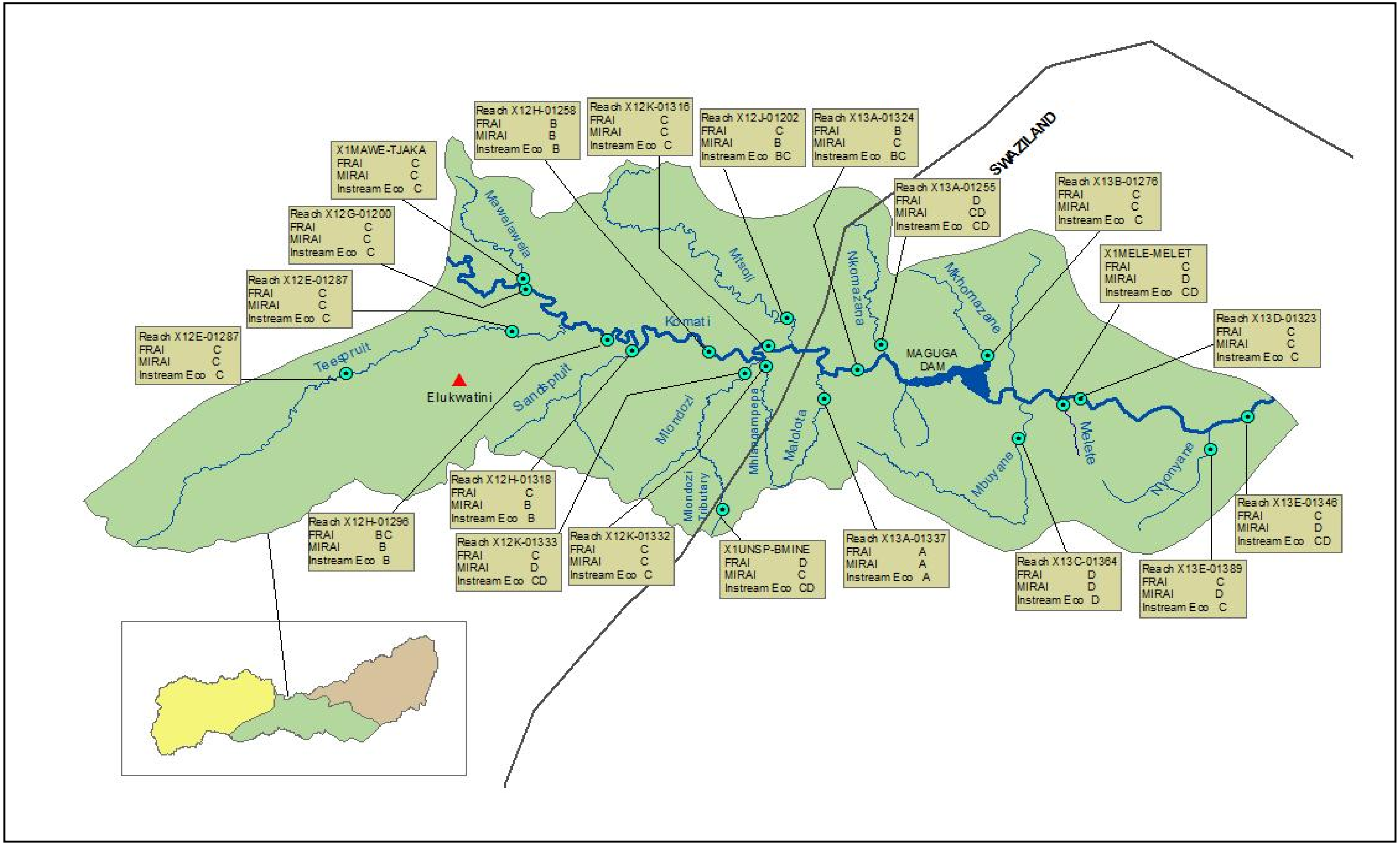

Figure 8: Map of the middle Komati River System indicating all biomonitoring points.

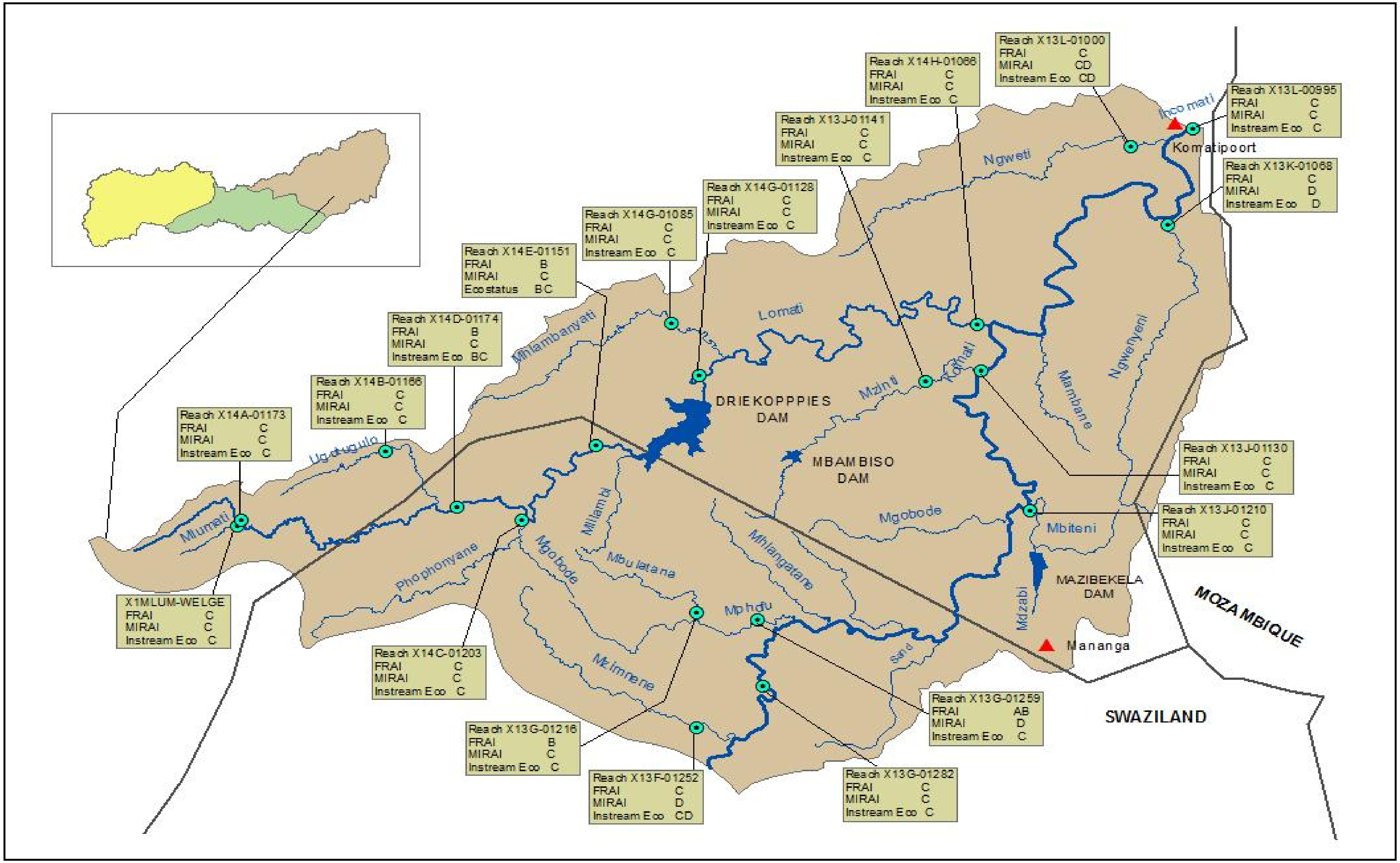

Figure 9: Map of the lower Komati River System indicating all biomonitoring points.

Komati River Mainstem Reaches

SQ REACH NUMBER X11D-01196

SQ Reach Code (downstream -->)	Site Code	River	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11D-01196	X1KOMA-MOEDI	Komati	1,471	S -25.89598 E 30.17625	C 69.5%	AB 89.3%	BC 79.4%	BC	BC 80%	BC 79.7%	4.5

General description

Reach X11D-01196: Komati

The site (X1KOMA-MOEDI) on the Komati River is located downstream from the Nooitgedacht Dam as well as its confluence with the Klein Komati River (Figure 10 & 11). The sampling point is located at an elevation of 1,471 m a.s.l., and the reach (X11D-01196) length is 4.5 km. Geomorphologically the site is categorised as a lower foothills zone.

In terms of vegetation types, the site is located in the KaNgwane Montane Grassland, and in the Northern Mountain Escarpment aquatic ecoregion. Land-use in the upper catchment includes livestock grazing, crop irrigation, coal mines, towns, numerous small dams and of course the large Nooitgedacht Dam and the impact of controlled water releases.

Fish

The aquatic habitat surveyed at this site consisted of mainly very shallow riffles and long stretches of pools. At this biomonitoring site all off the fish velocity depth classes were present: fast shallow (moderate), fast deep (sparse), slow shallow (rare) and slow deep (abundant). Fish cover present rated from sparse to moderate with the slow deep habitats having moderate overhanging vegetation, undercut banks and root wads, but sparse substrate mainly consisting of fine siltation. In the fast shallow habitats the fish cover rated moderate with moderate undercut banks and root wads and moderate submerged aquatic macrophytes. No overhanging vegetation was present. The substrate in the fast shallow habitats were moderate consisting of embedded pebbles resulting in loss of interstitial spaces causing a loss of available fish habitat. This reach was sampled for the first time and no historical records are available (DWA, 2014). The fish assemblage recorded at the site consisted of only two species of an expected ten species for this reach. The reophilic species *Chiloglanis pretoriae* and *Amphilius uranoscopus* were collected in the fast fish velocity habitats. No sampling were conducted in the deep habitats due to inaccessibility.

The CPUE (catch per unit effort) calculated for this site is 0.2 (15 individuals; 69 minutes) indicating a very low abundance. The reason for the low abundance of fish and species collected can be related to river regulation as a result of uncontrolled releases from the dam disturbing the natural water temperature regime. River regulation furthermore causes increased sedimentation and a loss of available fish habitat.

A Fish Response Index (FRAI) score of 69.5% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first monitoring on record was 1966 in the vicinity of the X1KOMA-MOEDI site (± 5.6 km downstream), in a different reach. Only Ephemeroptera (mayflies) were recorded during the 1966 survey. SASS data for the site is available for June, July and August 1994, May 1995, November 2012, July 2013 and this monitoring in July 2014. All the families recorded in 1966, with the exception of Oligoneuriidae, were present during the 2014 sampling event. Taxa recorded in later years absent from the 1994 – 1995 samples included the following:

- Corixidae since 2012;
- Planorbinae since 2013;
- Philopotamidae since 2013;
- Psephenidae for the first time in 2014, and;
- Unionidae for the first time in 2014.

The functional feeding group of the families Planorbinae and Psephenidae is scrapers, and Philopotamidae and Unionidae filtering collectors. Corixidae are either predators or micro-piercers. Increases in filtering collectors are generally associated with rivers downstream from impoundments, where there is an increase in fine particles from the standing waters(Gullan & Cranston 2010). Scrapers increase with increased periphyton development, which is associated with enhanced light inputs and high nutrient entry (Gullan & Cranston 2010). High amounts of aquatic macrophytes were noted in the river, which further supports availability of light and nutrients with altered flow regimes, and more than likely the appearance of Corixidae.

During the 2014 survey, taxa preferring fast, moderate and slow flowing waters were dominant. Taxa associated with stagnant water were also present, but not abundant. Taxa associated with the cobble biotope dominated, with taxa rated with preferences to high water quality dominant and abundant.

The taxa at the site in the different biotopes sampled in 2014 was above the average of the ecoregion for all the biotopes sampled. Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-MOEDI site on the Komati River was rated as natural to slightly impaired (A/B-class).

Chemical and Physical Water Quality

Table 4. Results for water quality constituents measured at the site (X1KOMA-MOEDI) on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**04**			
Sampling Date	**08 July 2014**			
Sampling Time	**12h20**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**10.7**			
pH	**7.8**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**12.8**			
Saturation (%)	**130.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**21.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**142.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**12**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**9**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**8**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.334**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**8**		<2,000	

* = Not measured by Laboratory NA = Not available

The percentage saturated oxygen was elevated (130.4%), but readings at 06h00 in the morning over different seasons are required to meaningfully interpret this result. Water quality results fell within expected ranges (Table 4).

On Site Impacts Recorded

- Willow trees (*Salix babylonica*) are located in the riparian zone up- and downstream from the sampling point. Henderson (1991) found *S. babylonica* to be "the most widespread woody riverine invader in the grasslands of South Africa". The author further suggested that "alien willows pose a potential threat to the conservation of indigenous riparian species and may alter the hydrology of the watercourses they invade".

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (79.4%) suggesting a slightly to moderately impaired habitat.

KOMATI

Site Code	X1KOMA-MOEDI	**Reach**	X11D-01196
Longitude	-25.89598° S	**Quaternary Catchment**	X11D
Latitude	30.17625° E	**Elevation**	1,471 m a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.0015	**Geomorphological Zone**	Lower Foothills

Figure 10. Upstream view of the site on the Komati River, X1KOMA-MOEDI (08 July 2014, G Diedericks).

Figure 11. Downstream view of the site on the Komati River, X1KOMA-MOEDI (08 July 2014, G Diedericks).

SQ REACH NUMBER X11F-01163

SQ Reach Code (downstream -->)	Site Code	River	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11F-01163	X1KOMA-WATER	Komati	1,371	S -25.89828 E 30.28450	BC 81.2%	BC 80.4%	BC 80.8%	B	B 85%	B 82.7%	20.8

General description

Reach X11F-01163: Komati

This site on the Komati River is located approximately 23 km downstream from the X1KOMA-MOEDI, on the farm Waterval in the Komati Gorge Reserve (Figure 12 & 13). The sampling point is at an elevation of 1,371 m a.s.l, and the reach length is 20.8 km. Geomorphologically the site is categorised as upper foothills stream. The site located in the KaNgwane Montane Grassland vegetation type, and within the Northern Mountain Escarpment aquatic ecoregion. Land-use in the upper catchment includes livestock grazing, crop irrigation, coal mines, towns, the Nooitgedacht Dam and numerous smaller dams. Other impacts included the danger of alien species Rainbow trout (*Oncorhynchus mykiss*) escaping from holding ponds into the river.

Fish

The aquatic site sampled is situated within Komati Gorge consisting primarily of fast deep rapids. At this site is a river crossing that creates a backwater pool immediately downstream from the crossing. The fish velocity depth classes present were fast shallow (moderate), fast deep (very abundant), slow shallow (moderate) and slow deep (moderate). The fish cover present consisted largely of substrate with rocks and boulders. No overhanging vegetation and undercut banks and root wads were observed.

During previous surveys six of an expected ten species were recorded (DWA, 2014). During the present survey the fish assemblage of six species were recorded, of which only *Amphilius uranoscopus*, *Barbus argenteus* and *Chiloglanis pretoriae* were collected historically and at present. Three flow dependant species, *Chiloglanis pretoriae*, *Labeobarbus polylepis* and *Barbus argenteus*, were the most abundant species collected. *Labeobarbus polylepis* is a cool water species and expected to be abundant in the area. It occurs in deep pools and flowing waters of permanent rivers (Skelton, 2001). This part of the river is considered of importance in providing suitable spawning sites for this species. In a 2006 survey conducted by JS Engelbrecht and F Roux, *Anguilla mossambica* was recorded indicating that this species has been able to negotiate the Vygeboom Dam downstream of this reach. Since then the Maguga Dam has been constructed in the Komati River increasing the migratory barriers for *Anguilla mossambica*. During the present survey no eels were recorded indicating a decline in abundance of the species that can possibly be attributed to the increase in the migrational obstructions in the river.

The CPUE (catch per unit effort) calculated for this site is 0.7 (34 individuals; 49 minutes) indicating a very low abundance. Although a relative high diversity of fish species were collected, the abundance of fish collected was low. The relative deep, fast flowing habitat with large boulders made it difficult to sample the site.

A Fish Response Index (FRAI) score of 81.2 % was calculated for this reach based on all available information, placing this reach in an ecological Class BC (slightly to moderately impaired with moderate diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with moderate, fast and slow flow dominated, with taxa preferring stagnant water also present, but at low abundances. The highest abundance and diversity of taxa was in the cobbles biotope, followed by vegetation and gravel/sand/mud. The taxa diversity in the stones and gravel/sand/mud biotope was higher in the river than the averages for the ecoregion. Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-WATER site on the Komati River was rated as slightly-moderately impaired (B/C-class).

Chemical and Physical Water Quality

Table 5. Results for water quality constituents measured at the X1KOMA-WATER site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**06**			
Sampling Date	**08 July 2014**			
Sampling Time	**16h55**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**11.5**			
pH	**8.1**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.2**			
Saturation (%)	**113.5**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**20.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**135.9**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			

Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**12**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**7**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.324**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**7**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results measured and analysed fell within expected ranges (Table 5).

On Site Impacts Recorded

- Very sparse and low infestation of the riparian zone with exotic tree species, and;
- Off-channel dams stocked with exotic trout.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (80.8%) suggesting a slightly to moderately impaired habitat.

KOMATI

Site Code	X1KOMA-WATER	**Reach**	X11F-01163
Longitude	-25.89828° S	**Quaternary Catchment**	X11F
Latitude	30.28450° E	**Elevation**	1,371 m a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.0051	**Geomorphological Zone**	Upper Foothills

Figure 12. Upstream view of the site on the Komati River, X1KOMA-WATER (08 July 2014, G Diedericks).

Figure 13. Downstream view of the site on the Komati River, X1KOMA-WATER (08 July 2014, G Diedericks).

SQ REACH NUMBER X11G-01142

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11G-01142	X1KOMA-GEVON	Komati	1,236	S -25.85512 E 30.38235	C 75.8%	BC 78.1%	C 77%	BC	B 85%	BC 80.4%	16.27

General description

Reach X11G-01142: Komati

This site on the Komati River is located approximately 17 km downstream from the X1KOMA-WATER site, on the farm Gemsbokhoek, upstream from a flower farm and nursery (Figure 14 & 15). The sampling point is at an elevation of 1,236 m a.s.l, and the reach length is 16.3 km. Geomorphologically the site is categorised as upper foothill stream. The site located in the KaNgwane Montane Grassland vegetation type, and within the Northern Mountain Escarpment aquatic ecoregion. Land-use in the upper catchment includes livestock grazing, crop irrigation, coal mines, towns, the Nooitgedacht Dam and numerous smaller dams.

Fish

This biomonitoring site is characteristic of an upper foothill stream with a steep gradient and fast flowing river with abundant fast fish velocity depth classes (fast shallow and fast deep abundant). Both the slow deep habitats (slow deep and slow shallow) rated sparse. The fish cover present rated mostly absent for overhanging vegetation, but moderate in the fast shallow fish velocity depth class created by reeds in the riparian zone. Undercut banks and root wads were not recorded. The substrate was sparse in the slow fish velocity habitat types, while moderate to abundant in the fast habitat types (rocks and pebbles).

Six of the expected ten species for this reach was recorded during the fish assemblage. The flow dependent species collected were *Amphilius uranoscopus*, *Barbus argenteus, Chiloglanis pretoriae* and *Labeobarbus marequensis*. Only the flow dependant *Chiloglanis pretoriae* was collected in relative abundance. Both of the Cichlid species, *Tilapia sparrmanii* and *Pseudocrenilabrus philander* collected in low abundance and both these species were infected with the digenean parasite commonly known as “black spot”. The reason for the low abundance and occurrence of parasites can be attributed to the fact that the available fish habitat is sub-optimal for these species.

The CPUE (catch per unit effort) calculated for this site is 0.94 (55 individuals; 58 minutes) indicating a low abundance. Although a relative high diversity of fish species were collected, the abundance of fish collected was low.

A Fish Response Index (FRAI) score of 75.8% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with fast and moderate flow hydraulic biotopes dominated, with taxa associated with slow and stagnant flow velocities also present, but at low abundances. The highest abundance and diversity of taxa was in the cobbles biotope, followed by vegetation and gravel/sand/mud. The taxa diversity in all biotopes was higher for the site than the averages for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-WATER site on the Komati River was rated as slightly-moderately impaired (B/C-class).

Chemical and Physical Water Quality

Table 6. Results for water quality constituents measured at the X1KOMA-GEVON site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**09**			
Sampling Date	**09 July 2014**			
Sampling Time	**16h20**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**10.0**			
pH	**8.2**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**9.7**			
Saturation (%)	**96.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**18.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**120.9**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**12**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**7**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	

Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.283**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**6**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results measured and analysed fell within expected ranges (Table 6).

On Site Impacts Recorded

- Very sparse and low infestation of the riparian zone with exotic tree species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (77%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-GEVON	**Reach**	X11G-01142
Longitude	-25.85512° S	**Quaternary Catchment**	X11G
Latitude	30.38235° E	**Elevation**	1,236 m a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.005	**Geomorphological Zone**	Upper Foothills

Figure 14. Upstream view of the site on the Komati River, X1KOMA-GEVON (09 July 2014, G Diedericks).

Figure 15. Downstream view of the site on the Komati River, X1KOMA-GEVON (09 July 2014, G Diedericks).

SQ REACH NUMBER X11H-01140

<table>
<tr><th>SQ Reach Code (downstream-->)</th><th>Site Code</th><th>River</th><th>Elevation (m a.s.l.)</th><th>GPS Co-ordinates (dd.sssss)</th><th>FRAI</th><th>MIRAI</th><th>Instream Ecological Category</th><th>PES Category</th><th>Riparian PES</th><th>Ecostatus</th><th>Length km</th></tr>
<tr><td rowspan="4">X11H-01140</td><td rowspan="2">X1KOMA-LEKKE</td><td rowspan="4">Komati</td><td rowspan="2">1,144</td><td>S -25.83430</td><td rowspan="4">C
69.3%</td><td rowspan="4">C
69.3%</td><td rowspan="4">C
69.3%</td><td rowspan="4">C</td><td rowspan="4">CD
60%</td><td rowspan="4">C
65.5%</td><td rowspan="4">33.41</td></tr>
<tr><td>E 30.49547</td></tr>
<tr><td rowspan="2">X1KOMA-GROOT</td><td rowspan="2">1,100</td><td>S -25.85494</td></tr>
<tr><td>E 30.57146</td></tr>
</table>

General description

Reach X11H-01140: Komati

The X1KOMA-LEKKE site on the Komati River is located approximately 2.2 km downstream from its confluence with the Dubai River (Figure 16 & 17), and the X1KOMA-GROOT site a further 10.2 km downstream (Figure 18 & 19) . The X1KOMA-LEKKE site is located on Sappi forestry boundary, between the farms Ndubazi Ranch and Racebaan, and the X1KOMA-GROOT site on the farm Grootkop, upstream from Vygeboom Dam. The one sampling point is at an elevation of 1,144 m a.s.l. and the other at 1,100 m a.s.l. The reach length is 33.4 km. Geomorphologically both sites fall within the lower foothills zone. The sites are located in the KaNgwane Montane Grassland vegetation type, and within the Northern Mountain Escarpment aquatic ecoregion. Land-use in the upper catchment includes livestock grazing, commercial forestry, trout farms, crop irrigation, coal mines, towns, the Nooitgedacht Dam and numerous smaller dams. There are extensive agricultural activities between the X1KOMA-LEKKE and X1KOMA-GROOT sampling points.

Fish

This reach can be seen as transitional zone between and upper and a lower foot hill stream with an increase in slower habitat and decrease in fast habitat. The aquatic habitat surveyed at the upstream site (X1KOMA-LEKKE) consisted of mainly riffles and runs and the fish velocity depth classes present were predominantly fast habitat types with fast shallow (very abundant), fast deep (abundant), slow shallow (sparse) and slow deep (rare). The downstream site (X1KOMA-GROOT) consisted of deep water pools with infrequent riffles and runs. The fish velocity depth classes included abundant fast shallow and fast deep habitats, with the slow shallow (sparse) and slow deep (moderate). At both sites the overhanging vegetation rated moderate to abundant with no undercut banks and root wads observed. For both sites the substratum rating for the slow velocity depth classes was sparse. For the fast fish velocity depth classes the substrate ranged from moderate to abundant comprising of rocks and cobbles. At the X1KOMA-GROOT site signs of sedimentation were noted that could affect fish habitat availability.

The fish assemblage recorded during the present survey at site X1KOMA-LEKKE consisted of three species and at site X1KOMA-GROOT four species. In total five of the twelve expected species were recorded for this reach, comprising of *Amphilius uranoscopus*, *Chiloglanis pretoriae*, *Labeobarbus marequensis*, *Pseudocrenilabrus philander* and *Tilapia sparrmanii* with *C. pretoriae* the most abundant species. This reach is a transitional zone for the two species *Labeobarbus polylepis and Labeobarbus marequensis.* During this survey only *Labeobarbus marequensis* was collected.

All of the *A. uranoscopus* was covered with white spots. The 'white spots' on the *A. uranoscopus*, previously commonly referred to as the protozoan white spot or 'ich' (*Ichthyophthirius multifiliis*), has now correctly been identified as digenean larvae (metacercariae in cysts). These digeneans (trematodes) are most likely from the genus *Tetracotyle,* but identification to species level is difficult without molecular analysis. The cysts which harbour the *Tetracotyle* larvae are ellipsoidal in shape and very prominent, covering most parts of the body of the fish, including fins. The presence of parasites indicate stress related conditions due to deteriorated habitat quality. The principle applies that fish under stress conditions are more vulnerable to parasite infestations.

The CPUE (catch per unit effort) calculated for the X1KOMA -LEKKE site is 1.6 (82 individuals; 52 minutes) and for the X1KOMA-GROOT site is 0.81 (51 individuals; 63 minutes) indicating a lower abundance at the downstream site. This can be attributed to sedimentation and loss of available fish habitat.
A Fish Response Index (FRAI) scored respectively of 68.7% for X1KOMA-LEKKE and 69.9% for X1KOMA-GROOT was calculated for this reach based on all available information. An average FRAI score of 69.3% was used placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at these two sites on record. Taxa associated with fast and moderate flow hydraulic biotopes dominated, while taxa associated with slow and stagnant flow velocities were also present but at low abundance. The highest abundance and diversity of taxa at both sites was in the cobbles biotope. Taxa diversity and the presence of sensitivity taxa was less at the X1KOMA-GROOT site than at the upstream X1KOMA-LEKKE site. Sensitive taxa was dominant at both sites.

Taxa diversity in the stones biotope was greater at the upstream site (X1KOMA-LEKKE) than the average for the ecoregion, but lower at the downstream site (X1KOMA-GROOT). The sensitivity ratings for the stones biotope, however, was similar for the two sites. The vegetation biotope at the X1KOMA-GROOT site was also poorly represented compared to the X1KOMA-LEKKE site, which is reflected in the taxa diversity and abundance. Overall, sensitive taxa were present at both sites, but taxa diversity at the downstream site (X1KOMA-GROOT) was considerably less than recorded at the upstream site (X1KOMA-LEKKE).

The combined stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-LEKKE and X1KOMA-GROOT sites in reach X11H-01140 on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 7. Results for water quality constituents measured at the X1KOMA-LEKER site (No. 11) and the X1KOMA-GROOT site (No.13) on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS		SOUTH AFRICAN GUIDELINES		
			Aquatic	Livestock Use	Recreational Use
Water Sample No.	**11**	**13**			
Sampling Date	**10 July 2014**				
Sampling Time	**11h20**	**15h30**			
CONSTITUENTS					
System Variables					
Water Temperature (°C)	**9.5**	**10.7**			
pH	**8.0**	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.2**	**13.8**			
Saturation (%)	**100.4**	**139.6**	80 - 120		
Clarity (cm)	**>120**	**>120**			<100
Quality Indicators					
Electrical Conductivity (mS/m @ 25°C)	**14.0**	**14.8**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**91.0**	**96.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**	**<10**			
Nutrients					
Free Ammonia (NH_3) mg/ℓ	**<0.2**	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**	**NA**			
Ortho-Phosphate (P) mg/ℓ	**<0.05 oligo - euro**		<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	**NA**		<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms					
E coli (counts/100 mℓ)	**35**	**49**		<200	<130
Inorganic Salts					
Total Hardness (mg $CaCO_3$/ℓ)	*	*			
Sulphate (SO_4) mg/ℓ	**<5**	**<5**		<1,000	
Inorganic – Toxic					
Chloride (Cl) mg/ℓ	**<5**	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.280**	**0.286**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results were very similar between the two sites, with the exception of dissolved and saturated oxygen levels, which was considerably higher at the downstream site (X1KOMA-GROOT). Readings at 06h00 in the morning over different seasons are however required to meaningfully interpret this result. All water quality constituents measured and analysed fell within expected ranges (Table 7).

On Site Impacts Recorded

- High sediment deposition in the pool areas at the X1KOMA-GROOT sampling point; and
- Extremely high degree of exotic weed infestation of the riparian zone at the X1KOMA-GROOT sampling site.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (69.3%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-LEKKE X1KOMA-GROOT	**Reach** **Quaternary Catchment**	X11H-01140 X11H
Latitude X1KOMA-LEKKE **Longitude**	-25.83430°S 30.49547 E	**Elevation X1KOMA-LEKKE**	1,144 m a.s.l.
Latitude X1KOMA-GROOT **Longitude**	-25.85495 S 30.57146°E	**Elevation X1KOMA-GROOT**	1,100 m a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient -LEKKE **River Gradient -GROOT**	0.0050 0.0071	**Geomorphological Zone-LEKKE** **Geomorphological Zone -GROOT**	Lower Foothills Upper Foothills

Figure 16. Upstream view of the site on the Komati River, X1KOMA-LEKKE (10 July 2014, G Diedericks).

Figure 17. Downstream view of the site on the Komati River, X1KOMA-LEKKE (10 July 2014, G Diedericks).

Figure 18. Upstream view of the site on the Komati River, X1KOMA-GROOT (10 July 2014, G Diedericks).

Figure 19. Downstream view of the site on the Komati River, X1KOMA-GROOT (10 July 2014, G Diedericks).

SQ REACH NUMBER X11K-01227

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11K-01227	X1KOMA-VYGEB	Komati	929	S -25.94631 E 30.68478	C 76%	C 68.1%	C 72.1%	C	B 85%	C 77.6%	6.1

General description

Reach X11K-01227: Komati

The X1KOMA-VYGEB site on the Komati River is located approximately 12.5 km downstream from the Vygeboom Dam, 5.4 km downstream from the Komati-Gladdespruit confluence, and about 640 m upstream from where the Komati River merge with the Seekoeispruit (Figure 20 & 21). The site is located on the farm Sterkspruit, which falls within the Nkomazi Private Game Reserve. The site is on reach X11K-01227, which is listed as 6.1 km in length. The sampling point is at an elevation of 929 m a.s.l, categorised geomorphologically as a lower foothills stream. The site located in the Swaziland Sour Bushveld vegetation type (Mucina & Rutherford 2006), and within the Northern Escarpment Mountains aquatic ecoregion (Kleynhans et al. 2005). Land-use in the upper catchment includes livestock grazing, commercial forestry, game farm, crop irrigation, mining, and the impacts of stream regulation from the Vygeboom Dam.

Fish

This biomonitoring site is characteristic of a lower foothill stream with a steep gradient and fast flowing river. The fish velocity depth classes fast shallow (very abundant) and fast deep (abundant) dominated this habitat, with only sparse slow shallow habitat types and slow deep absent. The fish cover present rated moderately for overhanging vegetation and sparse for undercut banks and root wads. The substratum varied from moderate to abundant and consisted of cobbles and pebbles. This monitoring point can be regarded as an optimum habitat for flow dependant species with abundant habitat availability during high flow periods.

The fish assemblage recorded at the site consisted of only nine species of an expected 18 species. The assemblage was dominated by the two flow dependant species, *Chiloglanis pretoriae* and *Labeobarbus marequensis*. *Amphilius uranoscopus* and *Labeo molybdinus*, are other flow dependant species collected in low abundance. Two of the three expected *Chiloglanis* species were collected namely *Chiloglanis pretoriae* and *Chiloglanis paratus*. The absence of *Chiloglanis swierstrai* can be related to the absence of sandy runs. Three Cichlid species were collected namely, *Oreochromis mossambicus, Pseudocrenilabrus philander and Tilapia sparrmanii.* This monitoring site is impacted by flow regulation from the Vygeboom Dam impacting on the available fish habitat therefore impacting on the fish species diversity and abundance. Flow releases from large impoundments have a detrimental impact downstream on the fish habitat as well as the chemico-physical properties of the river. The disrupted water temperature regime further impact on unsynchronised breeding behaviour of fish species.

The CPUE (catch per unit effort) calculated for this site is 2.8 (116 individuals; 42 minutes) indicating a relative high abundance.

A Fish Response Index (FRAI) score of 76.0% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Matthew (1968) carried out a survey for Ephemeroptera during 1966 and 1967 at the R38 bridge below Vygeboom Dam. The Vygeboom Dam's construction was completed in 1972. Ephemeroptera families recorded by J. Matthew during his surveys in 1966 and 1967 included Tricorythidae and Prosopistomatidae, both absent at the downstream site in 2014.

Taxa associated with fast and moderate flow hydraulic biotopes dominated, with taxa associated with slow and stagnant flow velocities also present, but at lower abundances. The highest abundance and diversity of taxa was in the cobbles biotope. The diversity and abundance in the vegetation and gravel/sand/mud was lower than the average for the ecoregion. Taxa diversity in the stones biotope was higher than the average for the ecoregion, with a high number of sensitive taxa. The diversity for the site overall was less than average, but sensitive taxa still dominate.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-VYGEB site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 8. Results for water quality constituents measured at the X1KOMA-VYGEB site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**16**			
Sampling Date	**15 July 2014**			
Sampling Time	**09h50**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**11.6**			
pH	**7.4**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.0**			
Saturation (%)	**104.9**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**15.8**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**102.7**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		

Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**4**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**12**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.076**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**4**		<2,000	

* = Not measured by Laboratory NA = Not available

Sulphate levels increased compared to upstream sites, however, water quality results measured and analysed for all constituents fell within expected ranges (Table 8).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (72.1%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-VYGEB	**Reach**	X11K-01227
Longitude	-25.94631° S	**Quaternary Catchment**	X11K
Latitude	30.68478° E	**Elevation**	929 m a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0044	**Geomorphological Zone**	Lower Foothills

Figure 20. Upstream view of the site on the Komati River, X1KOMA-VYGEB (15 July 2014, G Diedericks).

Figure 21. Downstream view of the site on the Komati River, X1KOMA-VYGEB (15 July 2014, G Diedericks).

SQ REACH NUMBER X12G-01200

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12G-01200	X1KOMA-TJAKA	Komati	838	S -25.97453 E 30.82221	C 73.6%	C 71.1%	C 72.4%	C	CD 60%	C 67.1%	35.48

General description

Reach X12G-01200: Komati

The X1KOMA-TJAKA site on the Komati River is located at Tjakastad, downstream from the rivers' confluence with the Mawelawela (Figure 22 & 23). The sampling site is located on the farm Tjakastad. The site is on reach X12G-01200, which is listed as 35.5 km in length. The sampling point is at an elevation of 838 m.a.s.l, categorised geomorphologically as a lower foothill stream. The site located in the Swaziland Sour Bushveld vegetation type (Mucina & Rutherford 2006), and within the Northern Escarpment Mountains aquatic ecoregion (Kleynhans et al. 2005). Land-use in the upper catchment includes livestock grazing, villages, commercial forestry, game farm, crop irrigation, mining, and the Vygeboom Dam.

Fish

The aquatic site sampled is situated close by Tjakastad characterised by a main channel that consist of rapids, riffles and runs, and a side channel consisting of runs. No slow fish velocity depth classes (slow deep and slow shallow) were recorded. The fast fish velocity depth classes recorded at the site were abundant fast shallow and moderate fast deep classes. Except for sparse overhanging vegetation in the fast shallow habitat, the only other fish cover present was abundant substrate varying from boulders to gravel.

The fish assemblage consisted of only seven of an expected 18 fish species for this site. Historically 13 species of fish were recorded for this reach(DWA, 2014). Flow dependant species collected during the survey includes *Amphilius uranoscopus, Barbus unitaeniatus, Chiloglanis pretoriae, Chiloglanis paratus*, *Labeo molybdinus and Labeobarbus marequensis* collected in high abundance (119 individuals). Although *Labeobarbus marequensis* is a flow dependant species with a high (4.3) flow-depth preference for fast deep and fast shallow fish velocity depth classes, this species is moderately intolerant (3.1) to reduced flow conditions, have a very high (4.5) preference to substrate and is moderately tolerant to modified water quality (2.1). Their presence and high abundance as recorded at this monitoring site can be explained based on these intolerant ratings. Of special interest is the eel, *Anguilla mossambica* which was collected. 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.

The CPUE (catch per unit effort) calculated for this site is 3.04 (149 individuals; 49 minutes) indicating a high abundance of fish collected. It was only *Labeobarbus marequensis* that is a more tolerant species that occurred in high abundance (119 individuals) therefore reflecting a skewed abundance of species. A low species diversity was recorded. The low diversity and low abundance of most species can be attributed to a lack of available fish habitat. Due to the nearby Tjakastad, the influence of illegal netting was evident which may also contribute to the low abundance of species recorded at the site.

A Fish Response Index (FRAI) score of 73.6% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Previous surveys other than 2014 on record carried out at this site was during February, May and August 2012, and May and July 2013.

Most of the taxa recorded during previous surveys were also present in 2014, but there were several exceptions of which some of the sensitive taxa included Tricorythidae, Aeshnidae, Naucoridae, Elmidae and Psephenidae. The family Machadorythidae was abundant in the gravel/sand/mud biotope. Taxa associated with moderate and slow flows were dominant, but the taxa associated with fast and moderate flows were less than the average for the ecoregion. Taxa diversity in the stones biotope was higher than the average for the ecoregion, but with less sensitive taxa. The vegetation biotope had a relative high diversity with sensitive taxa also present. The diversity for the site overall was above average, but in terms of sensitive taxa it was below.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-TJAKA site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 9. Results for water quality constituents measured at the X1KOMA-TJAKA site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**15**			
Sampling Date	**14 July 2014**			
Sampling Time	**15h10**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**11.8**			
pH	**7.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.0**			
Saturation (%)	**105.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				

Electrical Conductivity (mS/m @ 25°C)	**17.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**114.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**7**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.079**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**4**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results measured and analysed for all constituents fell within expected ranges (Table 9).

On Site Impacts Recorded

- Cars are washed at the edge of the river, with hydrocarbons, soaps and other pollutants directly entering the river;
- High quantities of domestic waste in the stream and riparian zone, and;
- The Veg City in Tjakastad supplies the community with gill-nets which are used to fish in the river.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (72.4%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-TJAKA	**Reach**	X12G-01200
Longitude	-25.97453° S	**Quaternary Catchment**	X12G
Latitude	30.82221° E	**Elevation**	838 m a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0022	**Geomorphological Zone**	Lower Foothills

Figure 22. Upstream view of the site on the Komati River, X1KOMA-TJAKA (14 July 2014, G Diedericks).

Figure 23. Downstream view of the site on the Komati River, X1KOMA-TJAKA (14 July 2014, G Diedericks).

SQ REACH NUMBER X12H-01296

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12H-01296	X1KOMA-KOMAT	Komati	798	S -26.02341 E 30.90073	BC 81.6%	B 85.1%	B 83.4%	B	B 85%	B 84.1%	13.92

General description

Reach X12H-01296: – Komati

The X1KOMA-KOMAT site on the Komati River is located in the Songimvelo Nature Reserve (MTPA) on the farm Doornhoek (Figure 24 & 25). The site is on reach X12H-01296, which is listed as 13.9 km in length. The sampling point is at an elevation of 798 m.a.s.l, categorised geomorphologically as a lower foothill stream. The site located in the Swaziland Sour Bushveld vegetation type (Mucina & Rutherford 2006), and within the Northern Escarpment Mountains aquatic ecoregion (Kleynhans et al. 2005). Land-use in the upper catchment includes conservation, livestock grazing, villages, commercial forestry, game farms, crop irrigation, mining, and the Vygeboom Dam.

Fish

This biomonitoring site is situated in the Songimvelo Nature Reserve and therefore within protected areas. This site is characteristic of a lower foothill stream with a moderately inclined and fast flowing river. All fish velocity depth classes were present and rated as follows: fast shallow (abundant), fast deep (abundant), slow deep (moderate) and slow shallow (moderate). The aquatic habitat consisted of a large pool just downstream of the river crossing, followed by a sequence of riffles and runs. The fish cover present rated sparse to moderate for overhanging vegetation in the fast habitat types with no undercut banks and root wads present. The substrate in the slow deep habitats was dominated by large boulders creating ideal fish habitat for limnophilic species. The substrate in the fast habitat types was in abundance including rocks, cobbles and pebbles.

The fish species recorded at the site consisted of 12 species of an expected 18 species, indicating a high diversity of species and a good representation of this reach. Two *Chiloglanis* species, *C. pretoriae* and *C. paratus* were collected with *Chiloglanis paratus* the only *Chiloglanis* species moderately intolerant (3.2) to no flow conditions. The fish assemblage was dominated by the high abundance of reophilic species *Amphilius uranoscopus*, *Chiloglanis pretoriae, Labeo molybdinus and Labeobarbus marequensis* (48 individuals) which were the most abundant species. This area is important to *Labeobarbus marequensis* which provides suitable habitat for spawning and recruitment. Species belonging to the limnophilic fish assemblage collected in the pool biotope includes *Barbus trimaculatus, Barbus unitaeniatus, Barbus paludinosus, Clarias gariepinus, Pseudocrenilabrus philander, Oreochromis mossambicus and Tilapia sparrmanii.* The age class distribution reflected sub-adults and adults which is an indication that breeding function is not disrupted at present.

The CPUE (catch per unit effort) calculated for this site is 1.9 (128 individuals; 68 minutes) indicating a relative abundance and diversity of species.

A Fish Response Index (FRAI) score of 81.6% was calculated for this reach based on all available information, placing this reach in an ecological Class BC (slightly too moderately impaired with moderate diversity and abundance of species).

Invertebrates

Previous monitoring at this site (X1KOMA-KOMAT) was carried out during June, July and August 1994 and May 1995. One family that stands out from the Matthews (1968) data on Ephemeroptera and the 1990's SASS data are the presence of Tricorythidae at sites downstream from the Vygeboom Dam. Tricorythidae was absent from all sampling sites on the Komati River downstream from the Vygeboom Dam during the 2014 survey. Based on studies by Palmer & Scherman (2000), salinity tolerance of *Tricorythustinctus* (Ephemeroptera: Tricorythidae) decrease with increases in sulphates (SO_4^{2-}). Sulphate increases in natural ecosystems are generally associated with mining effluents (Dallas & Day 2004). Sulphate values were higher in the Komati River downstream from the Vygeboom Dam compared to results of sites in the Komati River upstream from Vygeboom Dam.

In 2014, taxa with preferences for moderate to slow flowing conditions were dominant, but taxa associated with fast flows and stagnant water were present. The family Machadorythidae was present at low abundance in the gravel/sand/mud biotope.

In 2014, taxa diversity and the amount of sensitive taxa in the stones biotope was higher than the average for the ecoregion. The vegetation biotope had a relative high diversity with sensitive taxa also present. Overall both the diversity and sensitivity ratings for the site exceeded the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-KOMAT site on the Komati River was rated as slightly impaired (B-class).

Chemical and Physical Water Quality

Table 10. Results for water quality constituents measured at the X1KOMA-KOMAT site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**18**			
Sampling Date	**16 July 2014**			
Sampling Time	**10h05**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**12.6**			
pH	**8.1**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)				
Saturation (%)		80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**18.4**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**119.6**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**8**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.049**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**4**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results measured and analysed for all constituents fell within expected ranges (Table 10).

On Site Impacts Recorded

- High quantities of domestic waste in the stream and riparian zone, and;
- Poor road drainage, resulting in loose soil entering the river directly during rainfall events.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class B (83.4%) suggesting a slightly impaired habitat.

KOMATI

Site Code	X1KOMA-KOMAT	**Reach**	X12H-01296
Longitude	-26.02341° S	**Quaternary Catchment**	X12H
Latitude	30.90073° E	**Elevation**	798 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0018	**Geomorphological Zone**	Lower Foothills

Figure 24. Upstream view of the site on the Komati River, X1KOMA-KOMAT (16 July 2014, G Diedericks).

Figure 25. Downstream view of the site on the Komati River, X1KOMA-KOMAT (16 July 2014, G Diedericks).

SQ REACH NUMBER X12H-01258

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12H-01258	X1KOMA-HOOGE	Komati	739	S --26.03632 E 30.99806	B 82.1%	B 83.3%	B 82.7%	B	B 85%	B 83.7%	19.09

General description

Reach X12H-01258: Komati

The X1KOMA-HOOGE site on the Komati River is located on the farm Hooggenoeg. The site is on reach X12H-01258, which is listed as 19.1 km in length (Figure 26 & 27). The reach starts at the Sandspruit-Komati confluence, and ends at the Mlondozi-Komati confluence. The sampling point (X1KOMA-HOOGE) is at an elevation of 739 m.a.s.l, categorised geomorphologically as a lower foothill stream. The site located in the Swaziland Sour Bushveld vegetation type (Mucina & Rutherford 2006), and within the Northern Escarpment Mountains aquatic ecoregion (Kleynhans et al. 2005). Land-use in the upper catchment includes conservation, livestock grazing, villages, commercial forestry, game farms, crop irrigation, mining, and the Vygeboom Dam.

Fish

This biomonitoring site is located in the Komati River below Hoogenoeg weir on Songimvelo Nature Reserve. A plunge pool directly below the weir is present, followed by rapids, riffles and runs. Marginal pools on the sides are observed. The crest height of the weir is approximately 3 m high and the absence of a fish ladder making this weir an obstruction to fish migrational movement. This obstruction have a direct impact on fish species diversity and abundance, as well as impacting on the spawning behavioural movement. The fish velocity depth classes observed were fast shallow (abundant), fast deep (very abundant) with both the slow deep habitats (slow deep and slow shallow) present, but sparse. The only fish cover present was in the form of substrate (moderate to abundant) consisting of boulders, rocks, cobbles, pebbles and gravel. No overhanging vegetation, undercut banks and root wads were recorded.

The fish assemblage recorded at the site consisted of nine of an expected 18 species for this reach. The reophilic species collected at this site includes *Amphilius uranoscopus*, *Chiloglanis pretoriae, Labeo molybdinus and Labeobarbus marequensis*. As is expected in this area *Labeobarbus marequensis* was collected in high abundance. Limnophilic species collected in the plunge pool directly below the weir includes *Barbus trimaculatus, Barbus unitaeniatus, Clarias gariepinus, Oreochromis mossambicus and Tilapia sparrmanii.* The CPUE (catch per unit effort) calculated for this site is 2.4 (136 individuals; 56 minutes) indicating a relative abundance. Although a relative high abundance of fish species were collected, the diversity of fish collected was low. 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 the weir acting as an obstruction in migrational routes.

Fish Response Index (FRAI) score of 82.1% was calculated for this reach based on all available information, placing this reach in an ecological Class B (slightly impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first for the X1KOMA-HOOGE site on record. The habitat looks very good, but flow was very strong and some of the habitat was inaccessible. Taxa with preferences for moderate to slow flowing conditions were dominant, but taxa associated with fast flows and stagnant water were also present.

Taxa diversity and the amount of sensitive taxa in the stones biotope was higher than the average for the ecoregion. A lower diversity and number of sensitive taxa than the average for the ecoregion was recorded at the X1KOMA-HOOGE site. Overall the diversity was higher but the sensitivity rating lower when compared to averages for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-HOOGE site on the Komati River was rated as slightly impaired (B-class).

Chemical and Physical Water Quality

Table 11. Results for water quality constituents measured at the X1KOMA-HOOGE site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	**Livestock Use**	**Recreational Use**
Water Sample No.	**20**			
Sampling Date	**16 July 2014**			
Sampling Time	**14h55**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**14.2**			
pH	**8.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**12.4**			
Saturation (%)	**136.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**22.1**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**143.7**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.3**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			

Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**2**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**8**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.039**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Levels of saturated oxygen was elevated. The site is downstream from a weir, which might be the reason for elevated levels, however, readings at 06h00 in the morning over different seasons are required to meaningfully interpret this result. All other water quality results measured and analysed fell within expected ranges (Table 11).

On Site Impacts Recorded

- Cattle and goats were abundant in the Songimvelo Nature Reserve.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class B (82.7%) suggesting a slightly impaired habitat.

KOMATI			
Site Code	X1KOMA-HOOGE	**Reach**	X12H-01258
Longitude	-26.03632° S	**Quaternary Catchment**	X12H
Latitude	30.99806° E	**Elevation**	739 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0050	**Geomorphological Zone**	Lower Foothills

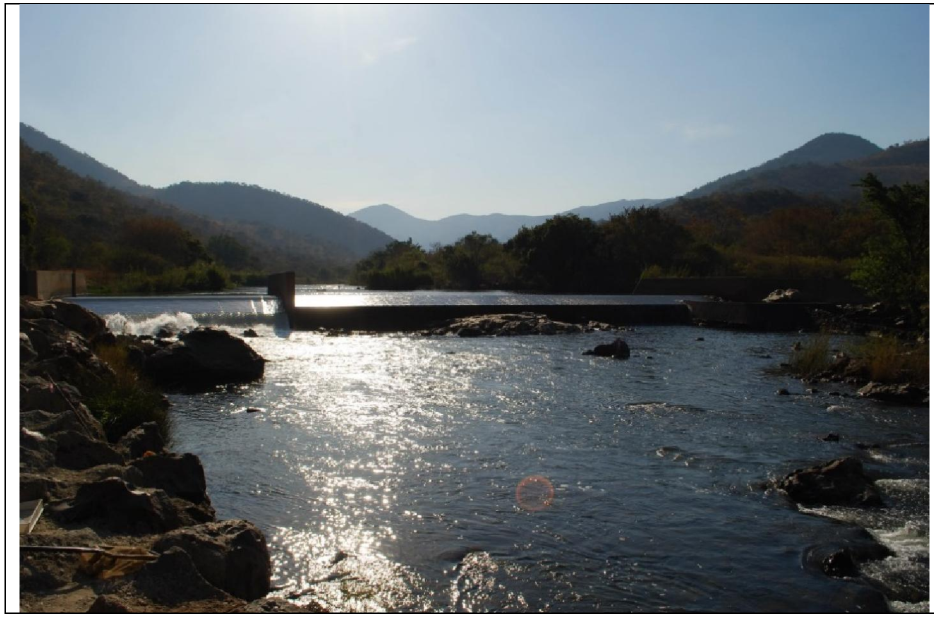

Figure 26. Upstream view of the site on the Komati River, X1KOMA-HOOGE (16 July 2014, G Diedericks).

Figure 27. Downstream view of the site on the Komati River, X1KOMA-HOOGE (16 July 2014, G Diedericks).

SQ REACH NUMBER X12K-01316

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12K-01316	X1KOMA-HILLC	Komati	702	S -26.02966 E 31.05550	C 75.3%	C 67.9%	C 71.6%	C	BC 80%	C 75.2%	6.3

General description

Reach X12K-01316: Komati

The X1KOMA-HILLC site on the Komati River is located on the boundary of the Songimvelo Nature Reserve between the farms Kranskop and Nooitgezien (Figure 28 & 29). The site is on reach X12K-01316, starting at the confluence with the Mhlangampepa and ending at the confluence with the Mtsoli, which represents 6.3 km in river length. The sampling point is at an elevation of 702 m.a.s.l., categorised geomorphologically as a lower foothill stream. The site located in the Swaziland Sour Bushveld vegetation type (Mucina & Rutherford 2006), and within the Northern Escarpment Mountains aquatic ecoregion (Kleynhans et al. 2005). Impacts and activities in this reach include settlements and small-scale farming.

Fish

The aquatic habitat surveyed at this location is a lower foothill stream. The habitat type at this site observed were rapids, riffles and runs with a side channel and isolated slow shallow habitats. The fish velocity depth classes recorded were fast shallow (abundant), fast deep (abundant), slow shallow (moderate) and slow deep absent. The fish cover present identified was moderate to abundant with abundant overhanging vegetation and sparse undercut banks and root wads in fast shallow habitats. The substrate rated moderate in the fast and abundant in the slow fish velocity depth classes. The substrate comprised mostly of boulders, rocks and cobbles. Some embeddedness of the substrate was noted as a result of sedimentation occurring within this reach.

At this site nine of the expected eighteen species were recorded. Reophilic species recorded during the survey included *Labeo molybdinus, Labeo cylindricus, Labeobarbus marequensis, Chiloglanis swierstrai* and *Chiloglanis pretoriae.* At this site three Chiloglanis species were expected namely *Chiloglanis pretoriae, Chiloglanis paratus and Chiloglanis swierstrai*. The absence of *Chiloglanis paratus* and very low abundance of *Chiloglanis swierstrai* can be related to absence of suitable habitat. Limnophilic species were collected in a side channel with isolated slow habitats namely, *Barbus paludinosus* and the three Cichlidae species *Oreochromis mossambicus*, *Pseudocrenilabrus philander and Tilapia Sparrmanii* which favours slow flowing water. The CPUE (catch per unit effort) calculated for this site is 1.4 (76 individuals; 56 minutes) indicates a relative abundance.

A Fish Response Index (FRAI) score of 75.3% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Previous monitoring at this site (X1KOMA-HILLC) was the collection of Ephemeroptera in 1966 and 1967, which is published in Matthews (1968). The only other monitoring on record is the SASS monitoring in 2014. Matthews (1968) recorded several species of Baetidae, Caenidae, Heptageniidae, Leptophlebiidae, Polymitarcidae, Prosopistomatidae and Tricorythidae. In the 2014 survey, Polymitarcidae, Prosopistomatidae and Tricorythidae were absent from the sample. Taxa with preferences for moderate, fast and slow flowing conditions were dominant, with taxa associated with stagnant water also present.

In 2014, taxa diversity was lower than the average for the ecoregion, but the dominance of sensitive taxa were similar. Overall the diversity was lower than the average for the ecoregion, and the sensitivity ratings were the same.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-KOMATsite on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 12. Results for water quality constituents measured at the X1KOMA-HILLC site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**23**			
Sampling Date	**17 July 2014**			
Sampling Time	**12h25**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**13.8**			
pH	**8.1**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.5**			
Saturation (%)	**92.2**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**23.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**153.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			

Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**8**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.039**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results measured and analysed for all constituents fell within expected ranges (Table 12).

On Site Impacts Recorded

- High quantities of sediment deposition, and;
- High infestation of the riparian zone with exotic weeds, especially *Sesbania punicea*.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (71.6%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-HILLC	**Reach**	X12K-01316
Longitude	-26.02966° S	**Quaternary Catchment**	X12K
Latitude	31.05550° E	**Elevation**	702 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0029	**Geomorphological Zone**	Lower Foothills

Figure 28. Upstream view of the site on the Komati River, X1KOMA-HILLC (17 July 2014, G Diedericks).

Figure 29. Downstream view of the site on the Komati River, X1KOMA-HILLC (17 July 2014, G Diedericks).

SQ REACH NUMBER X13A-01324

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13A-01324	X1KOMA-MALOL	Komati	643	S -26.05399 E 31.14151	B 82.1%	C 74.7%	BC 78.4%	BC	B 85%	BC 81.2%	7.6

General description

Reach X13A-01324: Komati

The X13A-01324 reach on the Komati River starts at the confluence with the Malolotja River to the Nkomazana confluence, which represents 7.6 km of river (Figure 30 & 31). The sampling site, X1KOMA-MALOL, is located in this reach upstream from the Maguga Dam, within the Malolotja Nature Reserve. The sampling point is at an elevation of 643 m.a.s.l, and is categorised geomorphologically as a lower foothill stream. The site located in the Swaziland Sour Bushveld vegetation type (Mucina & Rutherford 2006), and within the North Eastern Highlands aquatic ecoregion (Kleynhans et al. 2005).

Fish

The aquatic habitat surveyed at this location is a lower foothill stream which has characteristics associated with this transitional zone. The habitat type at this site observed were riffles, runs and slower moving longitudinal pools. The fish velocity depth classes recorded were fast shallow (very abundant), fast deep (moderate), slow shallow (rare) and slow deep absent. The fish cover present identified was sparse to moderate with moderate overhanging vegetation and sparse undercut banks and root wads. The substrate rated abundant in both the fast and slow fish velocity depth classes. The habitat diversity was primarily dominated by fast deep and fast shallow fish velocity depth classes. The instream habitat was, however, impacted by eutrophication as excessive brown algae were observed.

At this site 11 of the expected 20 species were recorded. These included the limnophilic species *Barbus unitaeniatus, Marcusenius pongolensis and Oreochromis mossambicus*, which favours slow flowing water, although during certain phases of life history stages a biotope of flowing water is required. These species are moderately tolerant to no flow conditions and modified water quality (physico-chemical), based on the intolerance ratings for each species. Reophilic species recorded during the survey included *Labeo molybdinus, Labeo cylindricus, Labeobarbus marequensis* and *Labeobarbus polylepis* with the flow sensitive species being *Amphilius uranoscopus* and *Chiloglanis pretoriae*, *Chiloglanis swierstrai* and *Chiloglanis paratus*. These species are flow dependant species with a high (4.3 to 4.6) flow-depth preference for fast deep and fast shallow fish velocity depth classes. During the survey no longfin eels (*Anguilla mossambica*) were recorded. This species is catadromous meaning that they live for many years in freshwater before they migrate down to the marine environment to breed in the ocean near Madagascar. Eel larvae metamorphose into glass eels and then become elvers before they may migrate upstream into freshwater to colonise the rivers until maturity, before they migrate back to the sea to breed again. The presence of large dams, downstream creates largely unsurpassable barriers to the migrations of this species. The absence of this species in the Komati River indicates that migration routes are no longer functional due to the presence of the Maguga Dam.

For the fish species collected the age classes reflects juveniles, sub-adults and adults, which is a clear indication that a viable population is present with breeding functions not disrupted at present. The CPUE (catch per unit effort) calculated for this site is 6.0 (204 individuals; 34 minutes) indicates a relative high abundance. A Fish Response Assessment Index (FRAI) score of 82.1% was calculated for this reach based on all available information placing this reach in an Ecological Class B, slightly impaired with a high diversity of species.

Invertebrates

The monitoring at this site in 2014 is the first on record. Taxa with preferences for moderate, fast and slow flowing conditions were dominant, with taxa associated with stagnant water also present.

Taxa diversity was higher than the average for the ecoregion, and the dominance of sensitive taxa was below average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-MALOL site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 13. Results for water quality constituents measured at the X1KOMA-MALOL site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**30**			
Sampling Date	**04 August 2014**			
Sampling Time	**15h25**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**14.3**			
pH	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**12.6**			
Saturation (%)	**139.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**20.2**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**131.3**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			

Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.3**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**0**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4)	**6**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.067**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**9**		<2,000	

* = Not measured by Laboratory NA = Not available

Saturated oxygen levels exceeded 120%, however, measurements at 06h00 in the morning over different seasons are required to meaningfully interpret the result. All other water quality results measured and analysed for the constituents fell within expected ranges (Table 13).

On Site Impacts Recorded

- Extremely high quantities of periphyton covering submerged rocks.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (78.4%) slightly to moderately impaired habitat.

KOMATI

Site Code	X1KOMA-MALOL	**Reach**	X13A-01324
Longitude	-26.05399° S	**Quaternary Catchment**	X13A
Latitude	31.14151° E	**Elevation**	643 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Higlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0044	**Geomorphological Zone**	Lower Foothills

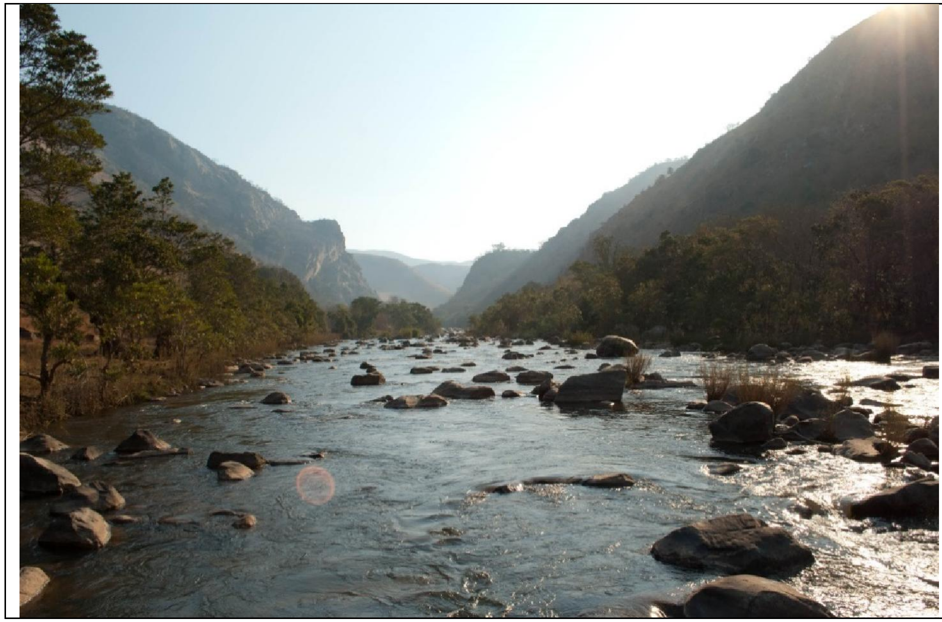

Figure 30. Upstream view of the site on the Komati River, X1KOMA-MALOL (04 August 2014, G Diedericks).

Figure 31. Downstream view of the site on the Komati River, X1KOMA-MALOL (04 August 2014, G Diedericks).

SQ REACH NUMBER X13D-01323

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13D-01323	X1KOMA- MELET	Komati	432	S-26.08214 E 31.35515	C 72.6%	C 68.9%	C 70.8%	C	C 70%	C 70.4%	23.3

General description

Reach X13D-01323: Komati

The X1KOMA-MELET site on the Komati River is located 14.1 km downstream from the Maguga Dam, and downstream from the Melete-Komati confluence (Figure 32 & 33). This reach on the Komati River, X13D-01323, starts at the confluence with the Mbuyane River ending at the confluence with the Nyonyane, representing 23.3 km in river length. The sampling point is at an elevation of 432 m.a.s.l, categorised geomorphologically as a lower foothill stream. The site is located in the Granite Lowveld vegetation type (Mucina & Rutherford 2006), and within the Lowveld aquatic ecoregion (Kleynhans et al. 2005).

Fish

This monitoring site is downstream from the Maguga Dam below a weir used for abstraction for irrigational purposes and at a transitional zone between a steep gradient river and a foothill river with a less steep gradient. Due to the large size of the Komati River at this site and the geomorphology associated downstream of a weir, it was only possible to sample two side channels. The habitat consisted of riffles and runs with a large pool downstream of the weir. The pool was not surveyed due to its depth. The fish velocity depth classes monitored included fast shallow (abundant) and fast deep (moderate). The fish velocity depth classes for slow shallow and slow deep were thus not surveyed. The fish cover observed was moderate with moderate overhanging vegetation, undercut banks and root wads and an abundant substrate in the form of rocks and boulders.

At this site thirteen of the twenty nine expected fish species were recorded. The fish species were collected at relative abundance reflecting most of the age classes present – juveniles, sub-adults and adults. This can be related to a positive breeding function at present. The sensitive reophilic species collected during the surveys includes*, Labeobarbus marequensis, Opsaridium peringueyi, Barbus eutaenia, Labeo molybdinus and Labeo cylindricus* were collected in relative abundance. The flow dependant species recorded were *Amphilius uranoscopus, Chiloglanis pretoriae, Chiloglanis emarginatus, Chiloglanis swierstrai and Chiloglanis paratus.* The presence of four Chiloglanis species is indeed significant as these species are flow dependant species with a high flow-depth preference for fast deep and fast shallow fish velocity depth classes. *Chiloglanis emarginatus* is a near threatened species which occurs only in tributaries of the Phongola and Komati-Inkomati rivers in South Africa and Swaziland. This species is threatened by water abstraction, river regulation and sedimentation.

The absence of many limnophilic species favouring slow flowing water, can be related to the absence of the slow flowing and slow deep biotopes. 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 habitat deterioration due to excessive siltation, sedimentation and flow regulation. The CPUE (catch per unit effort) for this site is 7.42 (349 individuals; 47 minutes) which indicate a high abundance of recorded species.

A Fish Response Assessment Index (FRAI) score of 72.6% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a moderate diversity of species).

Invertebrates

The survey in 2014 was the first at this site on record. Taxa with preferences for moderate and fast dominated, while taxa associated with slow flowing and stagnant conditions were also present. Taxa diversity was higher than the average for the ecoregion, but the dominance of sensitive taxa were similar. Overall the diversity was lower than the average for the ecoregion, and the sensitivity ratings were the same.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-KOMAT site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 14. Results for water quality constituents measured at the X1KOMA-MELET site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**34**			
Sampling Date	**06 August 2014**			
Sampling Time	**10h00**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**15.4**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.4**			
Saturation (%)	**93.3**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**13.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**90.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05	<0.005 = oligotrophic		

	oligo - euro	0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.3**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**120**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**7**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.066**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**7**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results measured and analysed for all constituents fell within expected ranges (Table 14).

On Site Impacts Recorded

- High quantities of sediment deposition.
- Stream regulation from Maguga Dam

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (70.8%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-MELET	**Reach**	X13D-01323
Longitude	-26.08214° S	**Quaternary Catchment**	X13D
Latitude	31.35515° E	**Elevation**	432 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0133	**Geomorphological Zone**	Upper Foothills

Figure 32. Upstream view of the site on part of a side channel below the weir in the Komati River, X1KOMA-MELET (06 August 2014, G Diedericks).

Figure 33. Downstream view of the site on part of a side channel below the weir in the Komati River, X1KOMA-MELET (06 August 2014, G Diedericks).

SQ REACH NUMBER X13E-01346

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13E-01346	X1KOMA- BHALE	Komati	310	S-26.09980 E 31.51587	C 69.6%	D 50.7%	CD 60.2%	C	C 70%	C 64.4%	12.67

General description

Reach X13E-01346: Komati

The X1KOMA-BHALE site on the Komati River in Swaziland is located upstream from the town Madlangempisi. This reach on the Komati River, X13E-01346, starts at the confluence with the Nyonyane River ending at the confluence with the Mzimnene, representing 12.7 km in river length (Figure 34 & 35). The sampling point is at an elevation of 310 m.a.s.l, categorised geomorphologically as a lower foothills stream. The site is located in the Granite Lowveld vegetation type (Mucina & Rutherford 2006), and within the Lowveld aquatic ecoregion (Kleynhans et al. 2005).

Fish

This reach is representative of the lower foothill stream, below 310 m.a.s.l, and is characterised as a low inclined, multiple channelled stream with some upstream anabranching. The substratum is dominated by sand and gravel and contains runs, large pools and limited riffles. The fish velocity depth classes recorded were slow deep (abundant), slow shallow (moderate) and fast shallow and with fast deep sparse. The fish velocity depth classes consists primarily of slow deep and slow shallow habitats. The fish cover present identified was very sparse with very sparse overhanging vegetation and undercut banks and root wads. In the fish velocity depth classes fast shallow and fast deep moderate substratum were recorded, whilst in the slow shallow and slow deep depth classes sparse substratum were observed. A well developed riparian zone of indigenous tree species was recorded.

Fish species unique to the area include *Chiloglanis emarginatus, Marcusenius pongolensis and Opsaridium peringueyi*. At this site twelve of the expected twenty five fish species were recorded during surveys in relative abundance. During the surveys the reophilic species collected include, *Opsaridium peringueyi, Barbus eutaenia, Labeobarbus marequensis, Labeo cylindricus and Micralestes acutidens.* The absence of many species can be attributed to limited available fish habitat due to excessive sedimentation recorded at this site. For most of the fish species all the age classes, juveniles, sub-adult and adult, were reflected indicating that the breeding function is functional. 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 habitat deterioration due to siltation and sedimentation. The CPUE (catch per unit effort) is 7.3 (241 individuals; 33 minutes) which indicate a relative diversity and abundance of recorded species.

A Fish Response Assessment Index (FRAI) score of 69.6% was for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with moderate diversity and abundance of species).

Invertebrates

Previous monitoring in 1966/67 occurred very close to this site (X1KOMA-BHALE). The study was on Ephemeroptera which was published in Matthews (1968). The only other monitoring on record is the SASS monitoring in 2014. Matthews (1968) recorded several species of Baetidae but also Caenidae, Heptageniidae, Leptophlebiidae, Oligoneuridae, Prosopistomatidae and Tricorythidae. In the 2014 survey, only the families Baetidae and Heptageniidae were recorded. The family Tricorythidae has not been record (in 2014) at any of the sites (eight) in the Komati River below Vygeboom Dam. The X1KOMA-BHALE site was also the first point in 2014 where the family Athyidae (freshwater shrimps) was recorded, and then all the way downstream. Taxa with preferences for moderate, fast and slow flowing conditions were dominant, with taxa associated with stagnant water also present.

In 2014, taxa diversity was lower than the average for the ecoregion, both in terms of diversity and sensitivity. The only cobble-riffle-run biotope was regularly disturbed by trucks filling with water in the river. The stones biotope had a very low number of taxa (5), and was the lowest for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-BHALE site on the Komati River was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 15. Results for water quality constituents measured at the X1KOMA-BHALE site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**36**			
Sampling Date	**06 August 2014**			
Sampling Time	**15h00**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**17.7**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.9**			
Saturation (%)	**93.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**13.7**			
Total Dissolved Solids (mg/ℓ)	**89.1**		<1,000	

[EC (mSm @ 25°C) x 6.5]				
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**440**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**6**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.081**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**7**		<2,000	

* = Not measured by Laboratory NA = Not available

The E coli counts in the river was high, but overall water quality results measured and analysed for all other constituents fell within expected ranges (Table 15).

On Site Impacts Recorded

- High quantities of sediment deposition, and;
- Water trucks use this site as a filling point, and cars and trucks use it as a wash bay.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class CD (60.2%) suggesting a moderately to largely impaired habitat.

KOMATI

Site Code	X1KOMA-BHALE	**Reach**	X13E-01346
Longitude	-26.09980 S	**Quaternary Catchment**	X13E
Latitude	31.51587° E	**Elevation**	310 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.001	**Geomorphological Zone**	Lower Foothills

Figure 34. Upstream view of the site on Komati River, X1KOMA-BHALE (06 August 2014, G Diedericks).

Figure 35. Downstream view of the site on Komati River, X1KOMA-BHALE (06 August 2014, G Diedericks).

SQ REACH NUMBER X13G-01282

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13G-01282	X1KOMA-IFR03	Komati	283	S-25.99827 E 31.58609	C 75.5%	C 66.8%	C 71.2%	C	C 70%	C 70.7%	21.86

General description

Reach X13G-01282: Komati

The X1KOMA-IFR03 site on the Komati River in Swaziland is located upstream from the Ukukuku settlement. This reach on the Komati River, X13G-01282, starts at the confluence with the Mzimnene River ending at the confluence with the Mphofu River, representing 21.9 km in river length (Figure 36 & 37). The sampling point is at an elevation of 283 m.a.s.l, categorised geomorphologically as a lower foothill stream. The site is located in the Granite Lowveld vegetation type (Mucina & Rutherford 2006), and within the Lowveld aquatic ecoregion (Kleynhans et al. 2005).

Fish

This aquatic habitat is representative of a lower foothill stream within the lowveld region characterised by riffles, runs and pools. The area surveyed was directly below a gauging weir creating downstream riffles and runs with boulders, rocks and pebbles. Further downstream multiple channels with anastomosing and anabranching were observed. The fish velocity depth classes recorded were moderate for all fish velocity depth classes - slow deep (moderate), fast shallow (moderate) and slow shallow (moderate) with fast deep (moderate). The fish cover present identified was sparse with sparse overhanging vegetation and undercut banks and root wads. The substrate rated moderate in the fast and rare in the slow fish velocity depth classes. This is due to observed sedimentation and siltation.

Twelve of the twenty six expected indigenous fish species were collected during the survey. As the sampling effort was primarily focused on the fast shallow biotope, primarily reophilic species were collected in relative abundance which included *Labeobarbus marequensis, Labeo molybdinus and Labeo cylindricus*. Flow sensitive species from the Chiloglanis family comprised of *Chiloglanis pretoriae, Chiloglanis swierstrai and Chiloglanis paratus* with a high (4.2) flow-depth preference for fast deep and fast shallow fish velocity depth classes. These species are moderately intolerant (4.2) to reduced flow conditions. All three species have a very high (4.9) preference to substrate. Two tolerant lowveld Cichlid species, *Oreochromis mossambicus and Tilapia sparrmanii* were recorded which is associated to lentic water bodies.

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 reduced available fish habitat due to siltation and sedimentation. The age classes for all the collected species were representative and included juveniles, sub-adults and adults indicating positive reproduction. The CPUE (catch per unit effort) for this site is 10.16 (366 individuals: 36 minutes). Although an increase is noted for the CPUE value for the survey, it can be explained that abundance of the non-sensitive species increased for this period.

A Fish Response Assessment Index (FRAI) score of 75.5% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a moderate diversity and relative abundance of species). The relative low ecological class (C) can be related to sediment deposition reducing available instream fish habitat.

Invertebrates

This is the first monitoring on record at this site for 2014. Taxa with preferences for moderate to slow flowing conditions were dominant, with taxa associated with stagnant water and fast flows also present.

In the stones biotope, both taxa diversity and sensitivity ratings were above the average for the ecoregion. The vegetation and gravel/sand/mud biotope had lower diversity, but similar sensitivity ratings. Overall though, the diversity and combined sensitivity for the site was above the averages for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-IFR03 site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 16. Results for water quality constituents measured at the X1KOMA-IFR03 site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**37**			
Sampling Date	**06 August 2014**			
Sampling Time	**17h20**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**17.1**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.8**			
Saturation (%)	**91.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**15.3**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**99.5**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			

Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**110**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**6**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.079**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**9**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality constituents measured in field and analysed fell within expected ranges (Table 16).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (71.2%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-IFR03	**Reach**	X13G-01282
Longitude	-25.99827 S	**Quaternary Catchment**	X13G
Latitude	31.58609° E	**Elevation**	283 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0016	**Geomorphological Zone**	Lower Foothills

Figure 36. Upstream view of the site on Komati River, X1KOMA-IFR03 (06 August 2014, G Diedericks).

Figure 37. Downstream view of the site on Komati River, X1KOMA-IFR03 (06 August 2014, G Diedericks).

SQ REACH NUMBER X13J-01210

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13J-01210	X1KOMA-NYATS	Komati	239	S-25.82188 E 31.82616	C 73.5%	C 75.1%	C 74.3%	C	D 50%	C 63.9%	3.52

General description

Reach X13J-01210: Komati

The X1KOMA-NYATS site on the Komati River in South Africa, is located 19.5 km downstream from the Swaziland-South Africa border (Figure 39 & 40). This reach on the Komati River, X13J-01210, starts at the confluence with the Mgobode River ending at the confluence with the Mbiteni River, representing 3.5 km in river length. The sampling point is at an elevation of 239 m.a.s.l, categorised geomorphologically as a lowland river. The site is located in the Granite Lowveld vegetation type (Mucina & Rutherford 2006), and within the Lowveld aquatic ecoregion (Kleynhans et al. 2005). Impacts and activities in this reach include urbanisation, weirs and agriculture as well as the presence of the alien and invasive red claw crayfish (*Cherax quadricarinatus*)(See appendix).

Fish

This reach is representative of the lower foothill stream, below 310 m.a.s.l. within the aquatic Lowveld bio-region, and is characterised by temperate fish species. It is a multiple channelled stream with an upstream plunge pool. The aquatic habitat contains riffles and runs with predominantly fast deep and with fast shallow habitats (moderate to abundant). The slow fish velocity depth classes were limited with only slow shallow habitats (sparse) observed on the fringes of the plunge pool. Instream vegetation in the form of emerging reeds (phragmites) provide sparse to moderate overhanging vegetation in the shallow habitats, providing additional fish cover. No undercut banks and root wads were recorded. The substratum consisted primarily of sand and embedded gravel with isolated rocks, providing limited habitat and cover.

The fish assemblage recorded at the site during the present survey consisted of eleven species of an expected 35 species for this reach. Surveying methods focus primarily on fast shallow and slow shallow habitats that would exclude species with a preference for fast deep and slow deep habitats. It must furthermore be kept in mind that this is a rapid appraisal of fish species occurring at a specific time and space within these habitats. During the surveys the flow dependant species collected includes*, Opsaridium peringueyi, Barbus eutaenia, Barbus trimaculatus, Labeobarbus marequensis, Labeo cylindricus, Chiloglanis swierstrai, Chiloglanis pretoriae, Chiloglanis paratus and Micralestes acutidens.* The fish abundance was dominated by *Micralestes acutidens*, followed by *Chiloglanis paratus* which is an indication of the presence of the more temperate lowveld species. Limnophilic species collected are *Oreochromis mossambicus* and *Barbus toppini. Oreochromis mossambicus* is at presently listed on the IUCN red data species list due to the high possibility of hybridization with *Oreochromis niloticus* through the introduction of this alien and invasive aquaculture species into river systems. 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 habitat deterioration due to siltation and sedimentation. Through the construction of multiple weirs large portions of the river has been transformed from a lotic habitat to a lentic habitat thus creating suitable habitat to the establishment of alien and invasive species, favouring limnophilic species. The CPUE (catch per unit effort) is 4.1 (155 individuals; 38 minutes) which indicate a high abundance of recorded species.

A Fish Response Index (FRAI) score of 73.5% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Previous monitoring on the Komati River in 1966/67 occurred on the Swaziland-South African border, 19.5 km upstream from the X1KOMA-NYATS sampling point. The study was on Ephemeroptera, which was published in Matthews (1968). The only other monitoring on record is the SASS monitoring in 2014. Matthews (1968) recorded several species of Baetidae, Caenidae, Heptageniidae, and Oligoneuridae. In the 2014 survey, one specimen each from the families Prosopistomatidae and Tricorythidae were recorded. This was the first record in the 2014 survey of Tricorythidae in the Komati River since it was last recorded upstream from the Vygeboom Dam.

Taxa with preferences for slow and moderate flow conditions dominated, but taxa associated with fast flowing and stagnant waters were also present. Taxa diversity and sensitivity ratings was higher than the average for the ecoregion in the stones and vegetation biotopes, but lower in terms of sensitivity in the gravel/sand/mud biotope. Overall, taxa diversity and sensitivity was higher than the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-NYATS site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 17. Results for water quality constituents measured at the X1KOMA-NYATS site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	56			
Sampling Date	21 August 2014			
Sampling Time	09h45			
CONSTITUENTS				

System Variables				
Water Temperature (°C)	**21.4**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.5**			
Saturation (%)	**107.8**	80 - 120		
Clarity (cm)	**69**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**43.4**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**281.5**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.5**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**96**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**13**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**50**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.056**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**42**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was fairly limited. Elevated levels of chloride, sodium and sulphates were measured, especially when compared to other measurements in the catchment. All water quality constituents measured in field and analysed fell within expected ranges (Table 17).

On Site Impacts Recorded

- Large scale sand mining is taking place approximately 260 m downstream from the Swaziland-South African border. Sand mining is an activity that needs to be licenced, and have to go through an environmental impact assessment before a licence with conditions are issued.

Figure 38. Sand mining in the Komati River and riparian banks (S -25.92630 and E 31.75807) on the South African side, 260 m from the Mananga border between South Africa and Swaziland (21 August 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (74.3%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-NYATS	**Reach**	X13J-01210
Longitude	-25.82188 S	**Quaternary Catchment**	X13J
Latitude	31.82616° E	**Elevation**	239 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.06
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0005	**Geomorphological Zone**	Lowland River

Figure 39. Upstream view of the site on Komati River, X1KOMA-NYATS (21 August 2014, G Diedericks).

Figure 40. Downstream view of the site on Komati River, X1KOMA-NYATS (21 August 2014, G Diedericks).

SQ REACH NUMBER X13J-01130

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13J-01130	X1KOMA-IFR04	Komati	199	S-25.68168 E 31.78295	C 69%	C 62.4%	C 65.7%	C	CD 60%	C 63.3%	6.93

General description

Reach X13J-01130: Komati

The X1KOMA-IFR04 site on the Komati River is located at the low-water bridge in the town of Tonga (Figure 41 & 42). This reach on the Komati River, X13J-01130, starts at the confluence with the Mzinti River ending at the confluence with the Lomati River, representing 6.9 km in river length. The sampling point is at an elevation of 199 m.a.s.l, categorised geomorphologically as a lower foothills stream. The site is located in the Granite Lowveld vegetation type (Mucina & Rutherford 2006), and within the Lowveld aquatic ecoregion (Kleynhans et al. 2005). Impacts and activities in this reach include urbanisation, weirs and agriculture as well as the presence of the alien and invasive red claw crayfish (*Cherax quadricarintus*) (See Appendix).

Fish

This reach is also representative of the lower foothill streams and the site is just downstream from Tonga weir. The site is characterised by a multi-channel river over bedrock with multiple rapids, riffles and runs. The fish velocity depth classes present at the time of the survey were slow deep (moderate), fast shallow (moderate) and fast deep (abundant) with the slow shallow absent. The fish cover present identified was sparse overhanging vegetation at only the fast shallow habitat, with no undercut banks and root wads at all the fish velocity depth classes. The substrate rated moderate consisting of bedrock, boulders, rocks, cobbles, pebbles and gravel.

The fish assemblage at this site is expected to consist of 35 indigenous fish species. The present survey consisted of only eight species. The flow dependant species collected includes*, Barbus eutaenia, Barbus trimaculatus, Labeobarbus marequensis, Labeo cylindricus* and *Chiloglanis pretoriae.* The fish abundance was dominated by *Labeo cylindricus*, followed by *Barbus eutaenia*. Limnophilic species collected are *Oreochromis mossambicus, Clarias gariepinus* and *Marcusenius pongolensis.* The endangered *Chetia brevis* has been recorded during a KOBWA survey (Kotze, 2014), but none was collected during the present survey. The reasons for this species to be listed in the Red Data List of Threatened Species are its limited distribution range and main treats to this species are alien and invasive fish, subsistence fishing and agricultural activities (Cambray & Swartz, 2007). 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 habitat deterioration due the construction of multiple weirs acting as barriers. The CPUE (catch per unit effort) is 3.0 (153 individuals; 51 minutes) which indicate a high abundance of recorded species.

A Fish Response Index (FRAI) score of 69.0% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first data on record collected at this site (X1KOMA-IFR04) was in 1966/67. The study was on the Ephemeroptera in the Inkomati Catchment, which was published in Matthews (1968). SASS monitoring of the site after 1967 on record were collected in March, May, August and October 1997, August and November 2003, July and November 2004, March 2009 and this monitoring during August 2014.

Ephemeroptera families collected by Matthews (1968) at the X1KOMA-IFR04 site included several species of Baetidae, Caenidae, Heptageniidae, Oligoneuridae, Prosopistomatidae, Machadorythidae and Tricorythidae. Of these families, only Prosopistomatidae was not recorded since 1967. Machadorythidae was not present in the 2014 sample. In previous years (2003 – 2009) it might have been encountered, but it is not listed as a SASS taxa, and was probably not recorded. According to Elouard & Gillies (1989), Machadorythidae inhabits rivers in slow to stagnant waters where the river bed in unstable. They are found partially submerged in shifting substrates among detritus of decomposing leaf packs. Slow flowing portions of the river was too deep to access during the 2014 sampling event.

Leptophlebiidae was first recorded in August 2003 and thereafter during every ensuing sampling event. Taxa with preferences for slow to stagnant water was dominant in 2014, with taxa associated with moderate to fast flowing conditions present.

In 2014, taxa diversity in the stones biotope was higher than the average for the ecoregion, both in terms of diversity and sensitivity. The vegetation and gravel/sand/mud biotopes had higher than average diversity for the ecoregion, but sensitivity was lower. Overall, taxa diversity was greater than the average for the ecoregion, but tolerant taxa were more dominant.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-IFR04 site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 18. Results for water quality constituents measured at the X1KOMA-IFR04 site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**57**			
Sampling Date	**21 August 2014**			
Sampling Time	**13h35**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**21.6**			
pH	**8.2**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.0**			
Saturation (%)	**91.6**	80 - 120		
Clarity (cm)	**98**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**60.0**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**390.0**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.5**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**44**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**19**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**86**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.031**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**69**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was fairly low. Elevated levels of chloride, sodium and sulphates were measured, especially when compared to other measurements in the catchment. All water quality constituents measured in field and analysed fell within expected ranges (Table 18).

On Site Impacts Recorded

- Washing of cars and clothes in the river, and;
- High quantities of domestic waste in the river and riparian zone.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (65.7%) suggesting a slightly to moderately impaired habitat.

KOMATI

Site Code	X1KOMA-IFR04	**Reach**	X13J-01130
Longitude	-25.68168 S	**Quaternary Catchment**	X13J
Latitude	31.78295° E	**Elevation**	199 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0021	**Geomorphological Zone**	Lower Foothills

Figure 41. Upstream view of the site on Komati River, X1KOMA-IFR04 (21 August 2014, G Diedericks).

Figure 42. Downstream view of the site on Komati River, X1KOMA-IFR04 (21 August 2014, G Diedericks).

SQ REACH NUMBER X13L-00995

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13L-00995	X1KOMA-LEBOM	Komati	113	S-25.43901 E 31.97341	C 70.1%	C 72.8%	C 71.5%	C	C 70%	C 70.8%	3.1

General description

Reach X13L-00995: Komati

The X1KOMA-LEBOM site on the Komati River is located in the Kruger National Park, upstream from the Komati River's confluence with the Crocodile River whereafter it becomes the Inkomati River entering Mozambique (Figure 43 & 44). This reach on the Komati River, X13L-00995, starts at the confluence with the Ngweti River ending at the confluence with the Crocodile River, representing 3.1 km in river length. The sampling point is at an elevation of 113 m.a.s.l, categorised geomorphologically as a lower foothills stream. The site is located in the Tshokwane-Hlane Basalt Lowveld vegetation type (Mucina & Rutherford 2006), and within the Lebombo Uplands aquatic ecoregion (Kleynhans et al. 2005). Impacts and activities in this reach include urbanisation and agriculture.

Fish

This biomonitoring site is the last monitoring site in the Komati River mainstem just before the confluence with the Crocodile River. This site is located within the boundaries of the Kruger National Park and within a protected area. Due to the presence of numerous crocodiles and hippopotamus biomonitoring is constrained due to the safety hazards. Fish biomonitoring was limited only to fast shallow, fast deep and slow shallow habitats where relative safe monitoring could be ensured. As this is the last SQ reach in the Komati River mainstem all upstream activities would reflect on this reach: large impoundments and numerous weirs, disrupted flow regulation regimes, obstruction of fish migration regime, water abstraction for sugar cane and other agricultural activities, organic enrichment through return-flows, Nkomasi urbanisation with associated non-functional sewerage systems, newly introduced alien and invasive species.

This reach is representative of a typical temperate lowveld river and is characterised by a low gradient multi-channel with multiple riffles, runs and large longitudinal pools. The fish velocity depth classes recorded were slow shallow (sparse) and the fast shallow (abundant), fast deep (abundant) with the slow deep absent. The fish cover present identified was sparse to moderate overhanging vegetation with sparse undercut banks and root wads. The substrate rated abundant consisting of bedrock, boulders, rocks, cobbles, pebbles and gravel.

The fish assemblage recorded consisted of eleven species of an expected 35 species. The assemblage was dominated by *Micralestes acutidens* with *Labeo cylindricus* also in abundance. The other flow dependant species include *Chiloglanis paratus, Labeobarbus marequensis, Hydrocynus vittatus, Brycinus imberi and Labeo congoro*. Limnophilic species recorded were *Clarias gariepinus, Glossogobius giuris, Oreochromis mossambicus and Petrocephalus wesselsi.* The CPUE (catch per unit effort) for this site is a 0.9 (41 individuals; 48 minutes) which indicates a low species abundance.

A Fish Response Index (FRAI) score of 70.1% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first data on record collected at this site (X1KOMA-LEBOM) was in 1966/67. The study was on the Ephemeroptera in the Inkomati Catchment, which was published in Matthews (1968). SASS monitoring of the site after 1967 on record were collected in July 2013 and this monitoring during August 2014.

Ephemeroptera families collected by Matthews (1968) at the X1KOMA-LEBOM site included several species of Baetidae, Caenidae, Heptageniidae, Leptophlebiidae, Oligoneuridae, Prosopistomatidae, and Tricorythidae. Of these families, Leptophlebiidae, Oligoneuridaeand Prosopistomatidae was not recorded since 1967. The family Oligoneuridae is normally associated with slight flows in spring-summer, which would explain its absence from the July 2013 and 2014 samples to some degree. Tricorythidae was absent from the 2014 sample.

Taxa with preferences for fast, slow, moderate flows and stagnant water were all well represented in the 2014 sample.

In 2014, taxa diversity and the sensitivity rating for the stones biotope was higher than the average for the ecoregion. The vegetation and gravel/sand/mud biotopes had higher than or in the latter average diversity for the ecoregion, but sensitivity was lower. Overall, taxa diversity was greater than the average for the ecoregion, and sensitive taxa were dominant.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-LEBOM site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 19. Results for water quality constituents measured at the X1KOMA-LEBOM site on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**59**			
Sampling Date	**22 August 2014**			
Sampling Time	**09h30**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**22.0**			

pH	**8.2**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.1**			
Saturation (%)	**93.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**75.4**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**490.1**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**1.3**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**50**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**31**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**104**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**<0.025**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**63**		<2,000	

* = Not measured by Laboratory NA = Not available

Elevated levels of nitrate, chloride, sodium and sulphates were measured, especially when compared to other measurements in the catchment. All water quality constituents measured in field and analysed fell within expected ranges (Table 19).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (71.5%) suggesting a moderately impaired habitat.

KOMATI

Site Code	X1KOMA-LEBOM	**Reach**	X13L-00995
Longitude	-25.43901 S	**Quaternary Catchment**	X13L
Latitude	31.97341° E	**Elevation**	113 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 5: Tshowane-Hlane Basalt Lowveld
River Gradient	0.0017	**Geomorphological Zone**	Lower Foothills

Figure 43. Upstream view of the site on Komati River, X1KOMA-LEBOM (22 August 2014, G Diedericks).

Figure 44. Downstream view of the site on Komati River, X1KOMA-LEBOM (22 August 2014, G Diedericks).

EXTRAPOLATED SQ REACHES

Due to inaccessibility (dams, gorges, no access) and absence (biotopes not present to survey) of biomonitoring sites of these relative short reaches, not all the SQ reaches could be surveyed. However, it is important to categorise these reaches as they will provide the holistic picture of the status of the Komati River mainstem. The FRAI, MIRAI and Instream Ecological Category, PES, Riparian PES and Ecostatus for these SQ reaches were derived and/or extrapolated from previous surveys and expert judgment.

SQ Reach Code (downstream-->)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11D-01219	C 65%	C 75.5%	C 71.3%	D	BC 80%	C 73.7%	17.8
X11E-01157	C 70%	B 85%	C 77.5%	C	BC 80%	BC 78.3%	12.7
X11G-01177	C 73%	C 75%	C 74%	C	C 70%	C 72.7%	2.28
X12K-01330	C 70%	C 65%	C 67.5%		B 85%	C 73.3%	0.3
X13A-01302	B 82.1	C 70%	C 74%	B	AB 90%	C 77.7%	8.7
X13B-01317	D 50%	D 50%	D 50%	D	C 70%	D 56.7%	8.57
X13B-01351	CD 60%	CD 60%	CD 60%	B	C 70%	C 63.3%	2.01
X13H-01281	C 75%	C 70%	C 72.5%	D	CD 60%	C 68.3%	4.01
X13H-01277	C 75%	C 70%	C 71.7%	D	CD 60%	C 67.3%	9.34
X13H-01280	C 75%	C 70%	C 71.7%	D	D 50%	C 63.5%	4.34
X13J-01221	C 75%	C 70%	C 72.5%	D	D 50%	C 65%	35.7
X13J-01149	C 70%	C 70%	C 70%	C	D 50%	C 63.3%	25.06
X13K-01114	C 65%	C 65%	C 65%	D	D 50%	CD 60%	5.2
X13K-01038	C 65%	C 65%	C 65%	D	D 50%	CD 60%	35.3
X13L-01027	C 65%	C 65%	C 65%	D	D 50%	CD 60%	10.7

Summary of Komati River Mainstem Indices

FRAI Categories

Figure 45 summarises the FRAI categories for 31 SQ reaches (of which 16 reaches were monitored and 15 extrapolated). It indicates that the overall FRAI for the Komati River mainstem is a Class C moderately impaired with a moderate diversity and low abundance of species. The expected trend would be for the high altitude streams close to the source of this river to be of a higher class with a gradual decrease towards the lower-lying reaches. However, in this study the upper SQ reaches are severely impacted by the deteriorating state of tributaries feeding into the mainstem. These tributaries are primarily impacted by mining activities in the upper Komati River. Fortunately, reaches located within Komati Gorge Reserve, Songimvelo Nature Reserve and Malolotja National Park improve slightly to classes BC and B indicating that the river is slightly modified with a fish assemblage status indicating a relative high diversity of species and abundance within these protected areas. Numerous dams and weirs as well as land use practices further impact on the fish community within this river. Other areas of concerns are below large impoundments, namely, Nooitgedacht, Vygeboom and Maguga dams, where stream regulation and its operating rules impacts negatively on the downstream fish assemblage. Of particular concern is the two reaches below the Maguga Dam in Swaziland where the FRAI categories decreases to a D and CD class indicating largely modified SQ reaches with low fish diversity and abundance. Downstream of these impoundments the river improves again and the C Class category is maintained throughout to its confluence with the Crocodile River.

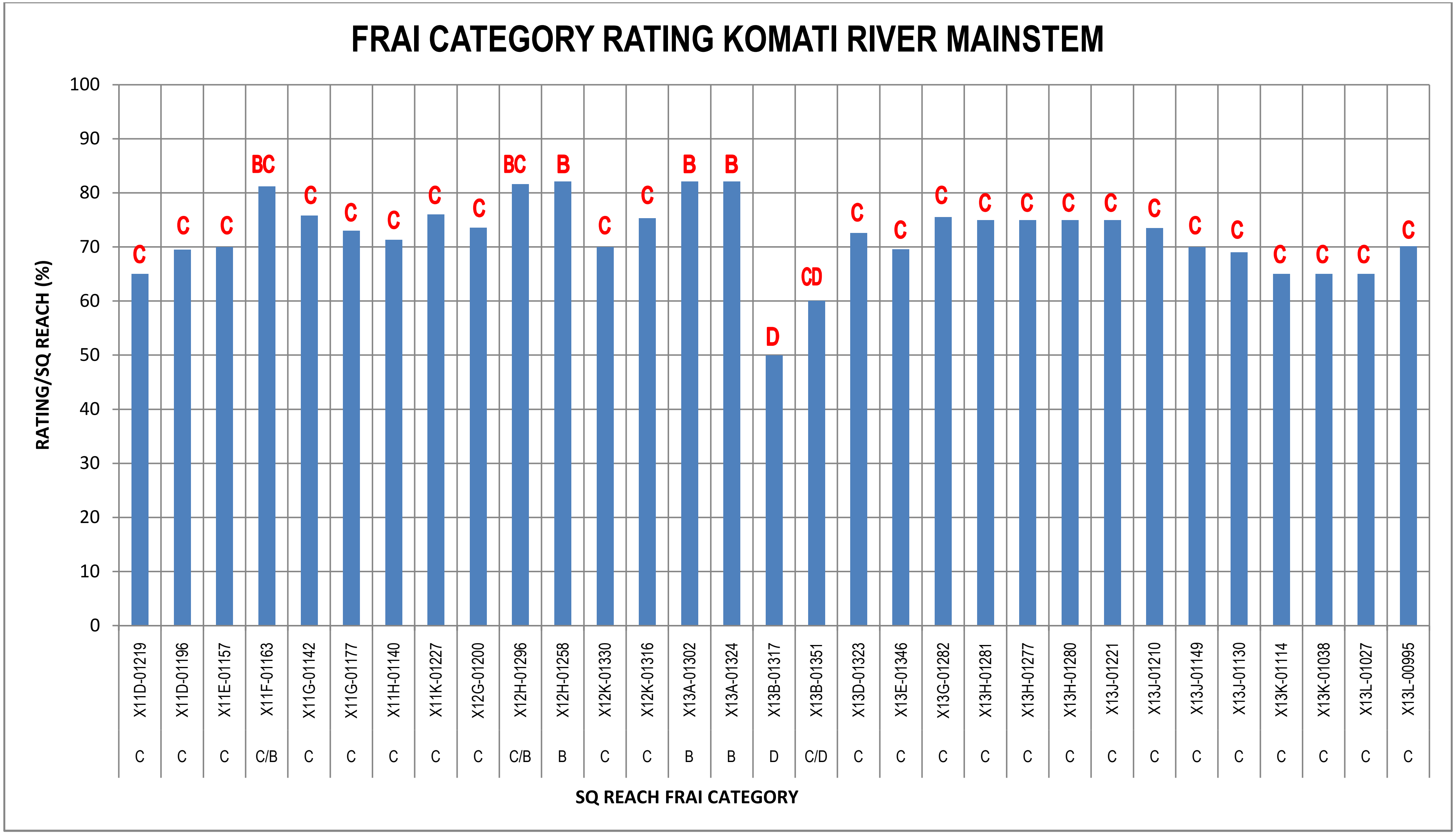

Figure 45: FRAI category for the Komati River Mainstem SQ reaches.

MIRAI Categories

Based on the aquatic invertebrate community, the Komati River is categorised as slightly impaired (AB through to BC class) in the headwaters and then gradually decreasing to a C class category in the middle and lower reaches of the Komati River. Flow regulation and impacts associated with large dams results in deterioration of the reach to a class D (severely impaired). Conditions steadily improve to moderately impaired (C-class) further downstream from the dam, until its confluence with the Crocodile River close to the town of Komatipoort near the South Africa-Mozambique border (Figure 46). The MIRAI categories for the Komati River mainstem is overall categorised as moderately impaired (C class).

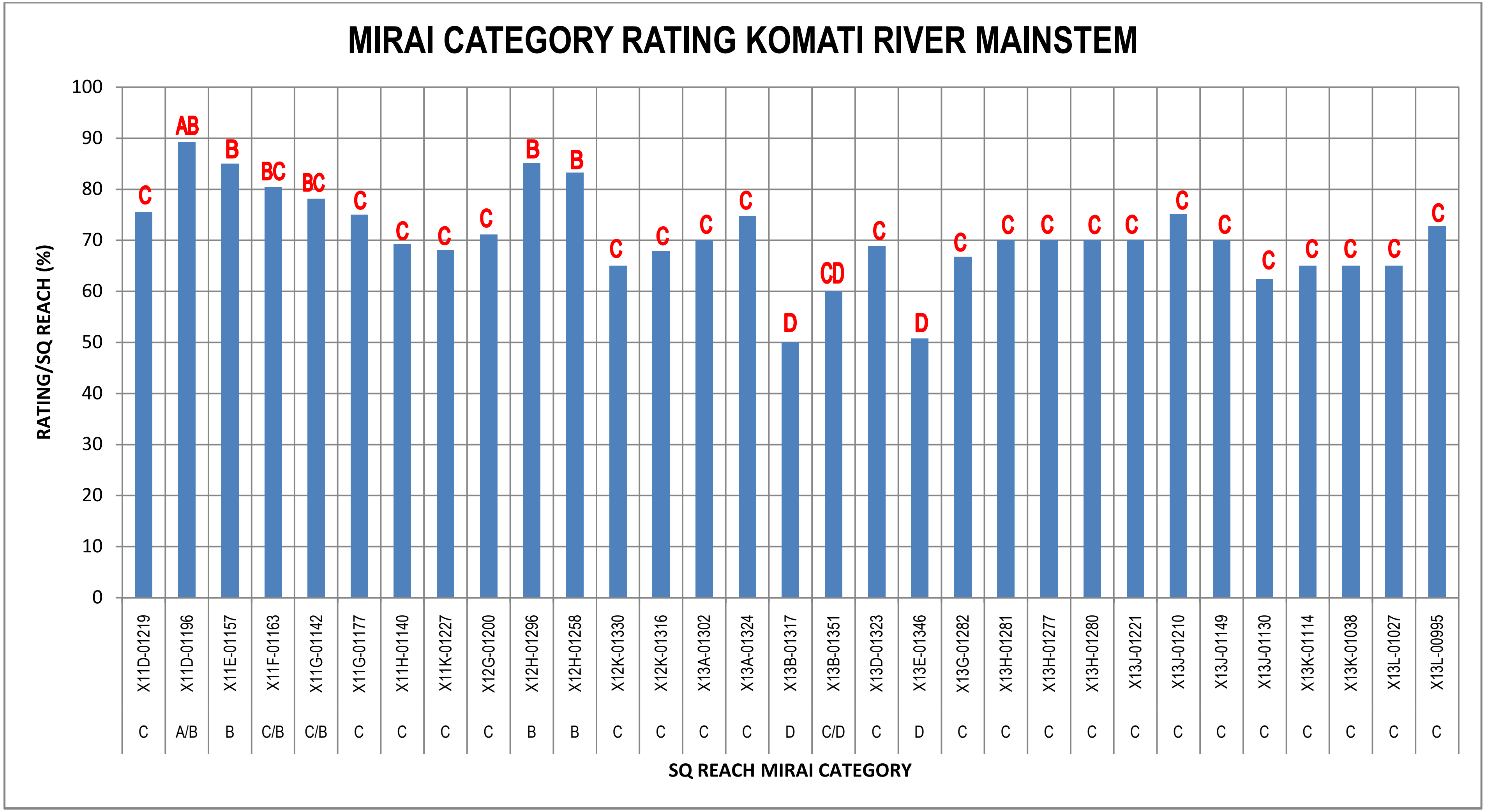

Figure 46: MIRAI category for the Komati River Mainstem SQ reaches.

Instream Ecological Category and Integrated Ecostatus rating of the Komati River Mainstem

The Instream Ecostatus Rating is derived from the fish assemblage (FRAI) and the macro-invertebrate assemblage (MIRAI). From Figure 47 it is evident that the Instream Ecological Category Rating is consistent throughout the mainstem ranging from a Class BC to a Class C. The Integrated Ecostatus Rating is derived from the fish (FRAI) and macro-invertebrates (MIRAI) assemblages and riparian index (VEGRAI) and is fairly consistent with the Instream Ecostatus Rating, Class C (Figure 48).

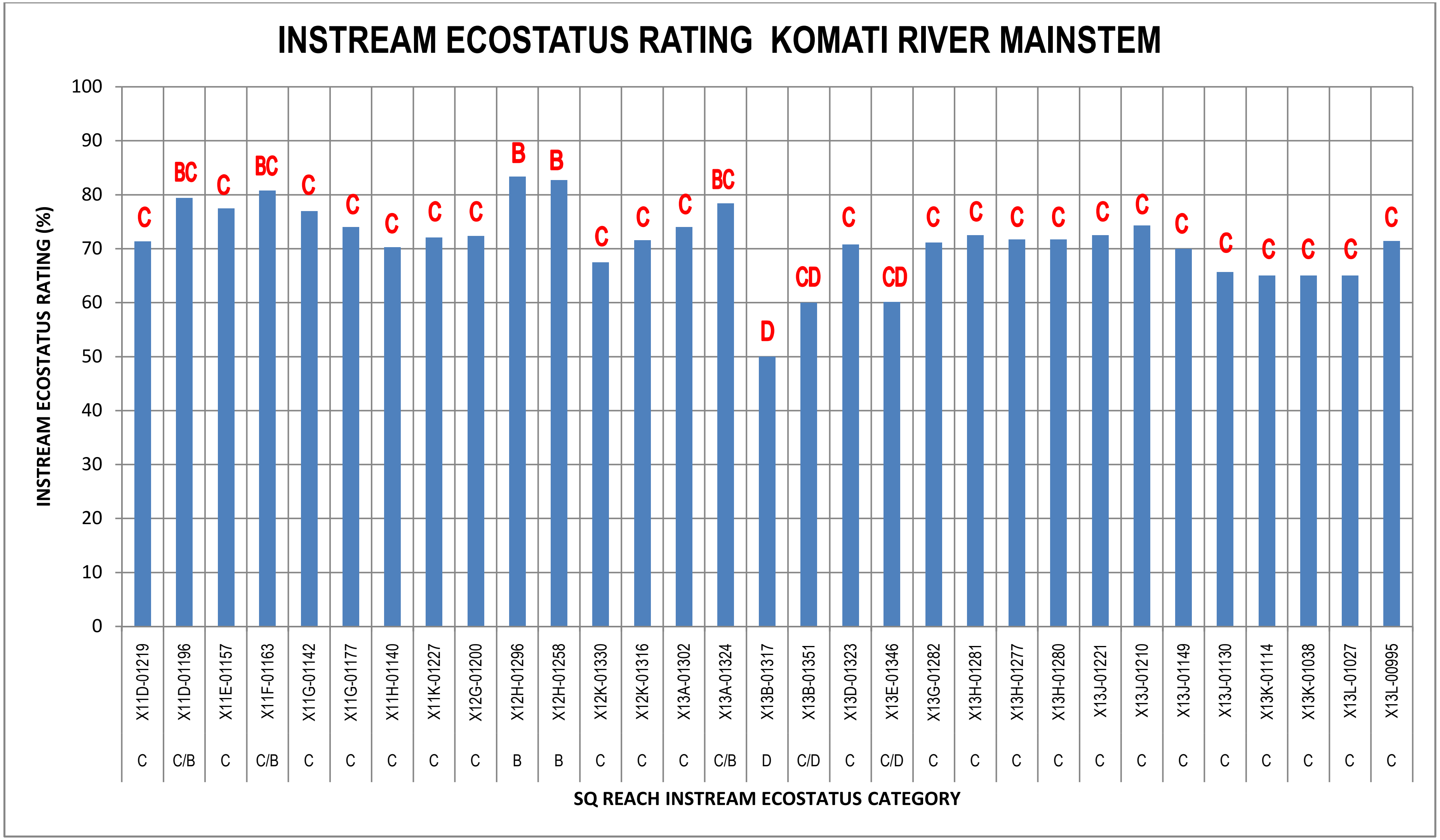

Figure 47: Instream Ecostatus rating for the Komati River Mainstem SQ reaches.

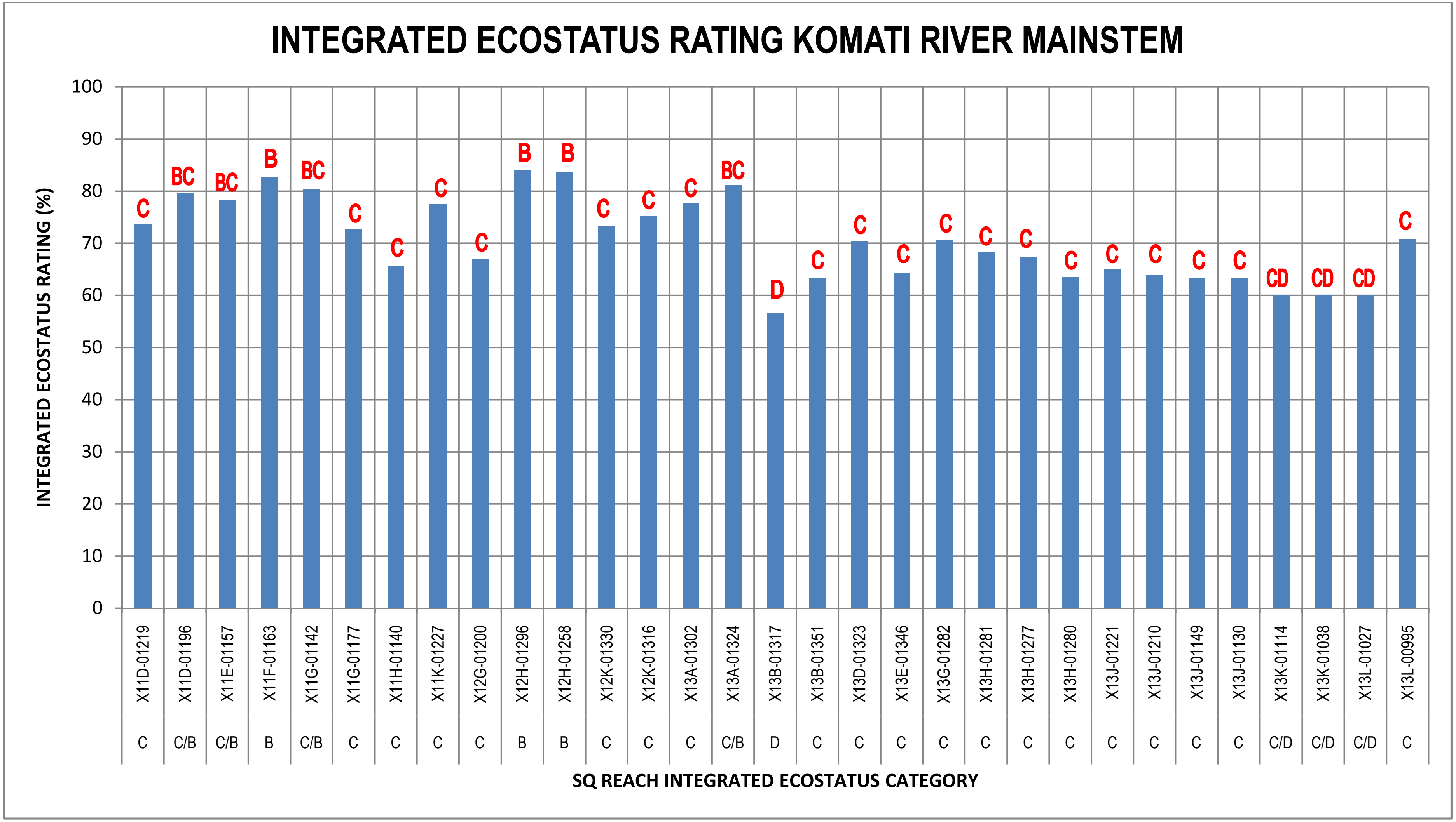

Figure 48: Integrated Ecostatus rating for the Komati River Mainstem SQ reaches.

Komati River Tributaries

SQ REACH NUMBER X11A-01248

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11A-01248	X1VAAL-BOESM	Vaalwaterspruit	1,538	S-26.00713 E 30.02756	BC 78.2%	B 82.4%	BC 80.3%	B	B 85%	B 82.3%	30.2

General description

Reach X11A-01248: Vaalwaterspruit

The Vaalwaterspruit originates in the town of Breyton at an elevation of 1,800 m.a.s.l. (Figure 49 & 50). Five reaches are recognised in the Vaalwaterspruit catchment, of which three reaches fall onto the main stream and two represents tributaries. All these reaches fall within the Highveld aquatic ecoregion. From Breyton the main stream flows for a distance of 62.3 km in a north to north-easterly direction towards the sampling point (X1VAAL-BOESM) and ultimately into the Nooitgedacht Dam. The reach (X11A-01248) length is 31.7 km, of which 3.7 km falls within the Nooitgedacht Dam. The sampling point in the reach is located at an elevation of 1,538 m.a.s.l, and is categorised geomorphologically as a lower foothills streams. Large portions of the catchment is dominated by natural vegetation, which is part of the Eastern Highveld Grasslands vegetation type. Land-use includes mainly livestock grazing, some crop irrigation, small dams and the town of Breyton (storm-water run-off and sewage treatment works). A coal mining site is located on a tributary of the Vaalwaterspruit. Impacts and activities in this reach are mainly agricultural. One site (X1VAAL-BOESM), directly next to the Nooitgedacht Nature Reserve and upstream from Nooitgedacht Dam, was sampled within this reach.

Fish

This site consisted of mainly large pools, shallow riffles and slow flowing runs. Fish sampling was done in the downstream section of the site and the fish velocity depth classes present were: fast shallow (abundant), fast deep (sparse) and slow shallow (moderate) and slow deep (absent). Overhanging vegetation present as cover rated from sparse to moderate with the fast shallow habitats having moderate overhanging vegetation with sparse undercut banks and root wads. The substrate in the fast shallow habitats was abundant consisting of boulders, rocks, cobbles and gravel. Moderate substrate cover was available as fish cover in the fast deep and slow shallow habitats. The fish assemblage recorded at the site consisted of three species of an expected seven species of indigenous fish for this reach. The reophilic species, *Chiloglanis pretoriae,* was collected in the fast fish velocity habitats. Two limnophilics, *Clarias gariepinus* and *Tilapia sparrmanii,* were collected in slow shallow habitat. *Clarias gariepinus* has not previously been collected, but is expected to be found, especially with the close proximity of the Nooitgedacht Dam where it does occur. Both *T. sparrmanii* collected was infected with a digenean parasite, commonly known as “black spot”. Many different digeneans can cause "black spot" signs on the skin of a fish, but *Neascus* is one of the most common. These metacercariae become encysted in and or under the skin of fish, and are “attacked” by the fish's immune system. This leads to a build-up of pigment cells (formed by the host), causing the characteristic black spots. Fish normally are unaffected by *Neascus* unless they become heavily infected. There is no health risk associated with eating the cooked flesh of fish infected with *Neascus*, but they may develop in humans if fish are consumed raw or undercooked.

The CPUE (catch per unit effort) calculated for this site is 0.5 (26 individuals; 52 minutes) indicating a very low abundance. The reasons for the low abundance of fish and species collected can be related to the predacious alien and invasive *Micropterus salmoides,* which is known to occur in this reach and the time of the year the sampling took place (winter).

A Fish Response Index (FRAI) score of 78.2% was calculated for this reach based on all available information, placing this reach in an ecological Class BC (Slightly to moderately impaired with low diversity and abundance of species).

Invertebrates

No historical results for this reach was available. In the 2014 sample, taxa with preferences for different velocities were relatively even, and taxa preferring fast flowing waters (>0.6 m/s) dominant. Taxa associated with the cobble biotope dominated, with the community dominated by sensitive taxa. High abundances of Ephemeroptera (Mayflies) were recorded, especially Baetidae, Caenidae, Heptageniidae, Leptophlebiidae and Tricorythidae. The family Hydropsychidae were present at high abundance.

Conditions in 2014 were rated as good.

Chemical and Physical Water Quality

Table 20. Results for water quality constituents measured at the Vaalwaterspruit site (X1VAAL-BOESM) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**07**			
Sampling Date	**09 July 2014**			
Sampling Time	**10h00**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**7.9**			
pH	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.1**			
Saturation (%)	**95.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**17.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**113.5**		<1,000	

Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**2**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**16**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**10**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.247**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**9**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results fell within an expected range (Table 20).

On-site Impacts Recorded

- General waste are dumped over the bridge into the stream and riparian zone;
- Invasive weeds in the riparian zone upstream from the monitoring site, and;
- A small degree of stream banks scouring.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (80.3%) suggesting a slightly to moderately impaired habitat.

VAALWATERSPRUIT

Site Code	X1VAAL-BOESM	**Reach**	X11A-01248
Longitude	-26.00713° S	**Quaternary Catchment**	X11A
Latitude	30.02756° E	**Elevation**	1,538 m.a.s.l.
Aquatic Ecoregion Lev I	11. Highveld	**Aquatic Ecoregion Lev II**	11.04
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 12. Eastern Highveld Grassland
River Gradient	0.0045	**Geomorphological Zone**	Lower Foothills

Figure 49. Upstream view of the Vaalwaterspruit site (X1VAAL-BOESM) upstream from the R33 provincial road (09 July 2014, G Diedericks).

Figure 50. Downstream view of the Vaalwaterspruit site (X1VAAL-BOESM) downstream from the R33 provincial road (09 July 2014, G Diedericks).

SQ REACH NUMBER X11B-01272

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11B-01272	X1BOES-ROODE	Boesmanspruit	1,562	S-26.02357 E 30.06092	D 54.1%	CD 61.9%	D 58%	C/D	CD 60%	CD 58.8%	29.12

General description

Reach X11B-01272: – Boesmanspruit

The Boesmanspruit originates less than 10 km west from Carolina at an elevation of 1,760 m.a.s.l. (Figure 51 & 52). Three reaches are currently recognised in the Boesmanspruit catchment, of which two reaches fall onto the main stream and one represents a tributary. All these reaches fall within the Highveld aquatic ecoregion. From its origin, the Boesmanspruit main stream flows for a distance of 46.5 km in a northerly direction towards the sampling point (X1BOES-ROODE) and ultimately into the Nooitgedacht Dam. The reach (X11B-01272) length is 29.5 km, of which 1.9 km falls within the Nooitgedacht Dam. The sampling point in the reach is located at an elevation of 1,551 m.a.s.l., and is categorised geomorphologically as a lower foothills streams. Large portions of the catchment is dominated by natural vegetation, which fall into the Eastern Highveld Grasslands vegetation type. Land-use is very similar to the Vaalwaterspruit catchment, which includes livestock grazing, crop irrigation, several small dams and streams draining from the town of Carolina (storm-water run-off and sewage treatment works). A coal mining site is located on a tributary of the Boesmanspruit. Impacts and activities in this reach include mining, agriculture and urbanisation. Two mines within the Boesmanspruit sub-catchment, Northern Coal and Siphethe Coal, were issued with directives in terms of section 19 of the National Water Act, 1998 (Act No. 36 of 1998) on 10 July 2012. Acid mine drainage was taking place from these two mines.There is also an ongoing decanting from Union Colliery, a subsidiary of BHP Billiton (Pty) Ltd.

Fish

This biomonitoring site is on the largest tributary feeding Nooitgedacht Dam and consisted of mainly large pools, very shallow riffles and slow flowing runs. Fish velocity depth classes present were: fast shallow (abundant) and slow shallow (moderate) and no slow shallow or deep habitats. Banks were notably eroded and the marginal vegetation formed cover as overhanging vegetation moderately present with undercut banks and root wads moderately abundant. The substrate in the fast shallow habitats was sparse consisting of a few rocks and embedded pebbles resulting in loss of interstitial spaces causing a loss of available fish habitat. The substrate as cover in the slow shallow habitat was also very sparse with a lot of silt. No aquatic macrophytes were present at this site. During the 2012 pollution events which took place in the catchment of the Boesmanspruit, this site was sampled and no fish were recorded at that time. The fish assemblage recorded for the present consisted of only two species of an expected nine species of indigenous fish for this reach. Only a single *Chiloglanis pretoriae,* a riffle dwelling species, was collected in the fast shallow habitat. The poor cover and the intolerance for modified water quality are the reasons why only one specimen was collected. *Labeobarbus polylepis* was also recorded and were in a very poor condition with lots of fin damage and all of them were infected with digenean parasites, commonly known as “black spot”. This may be because off the poor habitat and water quality conditions. A strong smell of sewage was noted.

The CPUE (catch per unit effort) calculated for this site is 0.3 (15 individuals; 50 minutes) indicating a very low abundance. The reasons for the low abundance of fish and species collected could be related to reduced water quality.
A Fish Response Index (FRAI) score of 54.1% was calculated for this reach based on all available information, placing this reach in an ecological Class D (largely modified with low diversity and abundance of species).

Invertebrates

The first monitoring on record at the X1BOES-ROODE site was collected seasonally (April, July and October 1966, and January 1967) by J Matthew (Matthew 1968). Thereafter, monitoring results are available for a site in the reach downstream from the Boesmanspruit Dam (X1BOES-BOESM), collected over eight sampling events between May 2012 and April 2014. Three sampling events are on record for the X1BOES-ROODE site, which include April 2012, January 2013 and this survey in July 2014.
At the X1BOES-ROODE site in 2014, taxa preferring slow flowing to moderate flowing water was dominant.

Taxa associated with the cobble biotope dominated, but taxa sensitive to high water quality was mostly absent or present at low abundances. Taxa recorded in 1966/67 at the X1BOES-ROODE site that were absent from the recent sampling events includes Tricorythidae and Polymitarcidae. Based on studies by Palmer & Scherman (2000), salinity tolerance of *Tricorythustinctus* (Ephemeroptera: Tricorythidae) decrease with increases in sulphates (SO_4^{2-}). Sulphate increases in natural ecosystems are generally associated with mining effluents (Dallas & Day 2004).
Poor conditions at the site are attributed to the high algal growth on the rocks, which is linked to the quality of the water and habitat.

Chemical and Physical Water Quality

Table 21. Results for water quality constituents measured at the Boesmanspruit site (X1BOES-ROODE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**08**			

Sampling Date	**09 July 2014**			
Sampling Time	**11h40**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**7.6**			
pH	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**12.2**			
Saturation (%)	**116.3**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**28.2**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**183.3**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.7**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**47**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**67**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**13**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.094**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**13**		<2,000	

* = Not measured by Laboratory NA = Not available

Despite the slight increases in electrical conductivity, nitrates, E. coli, sulphates and sodium compared to the other sites in the ecoregion, all water quality results fell within an expected range (Table 21).

On Site Impacts Recorded

- General waste are dumped over the bridge into the stream and riparian zone;
- High growth of filamentous green algae on rocks in and out of current, as well as in the marginal vegetation, and;
- Marginal vegetation dominated by exotic tree species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class D (58%) suggesting a severely impaired habitat.

BOESMANSPRUIT

Site Code	X1BOES-ROODE	**Reach**	X11B-01272
Longitude	-26.02357° S	**Quaternary Catchment**	X11B
Latitude	30.06092° E	**Elevation**	1,562 m.a.s.l.
Aquatic Ecoregion Lev I	11. Highveld	**Aquatic Ecoregion Lev II**	11.04
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 12. Eastern Highveld Grassland
River Gradient	0.0043	**Geomorphological Zone**	Lower Foothills

Figure 51. Upstream view of the site on the Boesmanspruit, X1BOES-ROODE (09 July 2014, G Diedericks).

Figure 52. Downstream view of the site on the Boesmanspruit, X1BOES-ROODE (09 July 2014, G Diedericks).

SQ REACH NUMBER X11C-01147

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11C-01147	X1WITK-WITKL	Witkloofspruit	1,541	S-25.96086 E 30.04052	C 62.4%	C 76.8%	C 69.6%	C	C 70%	C 69.8%	33.47

General description

Reach X11C-01147: Witkloofspruit

The Witkloofspruit originates from two main tributaries, the Blesbokspruit to the north-west and the Leeubankspruit from the north-east (Figure 53 & 54). The Blesbokspruit originates south from the Total Garage on Wonderfontein at an elevation of 1,780 m.a.s.l., and the Leeubankspruit at an elevation of 1,840 m.a.s.l. on the farm Leeuwbank. The two tributaries merge upstream from the KaalPlaas Dam, to form the Witkloofspruit. The stream flows in a south-south easterly direction towards the Nooitgedacht Dam. The reach (X11B-01272) length is 33.5 km, of which a section falls within the Nooitgedacht Dam. The sampling point in the reach is located at an elevation of 1,541 m.a.s.l, and is categorised geomorphologically as transitional. Large portions of the catchment is dominated by natural vegetation, which fall into the Eastern Highveld Grasslands vegetation type. Land-use in the upper catchment includes livestock grazing, crop irrigation, three coal mines, and several (64) small dams. The two larger dams on the main channel is the KaalPlaas and Strathrae Dam. A total of 12 dams are located on the main channel, and 52 on tributaries.

Fish

The aquatic site sampled on the third tributary feeding into Nooitgedacht Dam, consisted primarily of deep pools, runs and rapids. The fish velocity depth classes present were fast shallow (abundant), slow shallow (moderate) and slow deep (moderate). The fish cover present consisted largely of substrate with boulders and rocks in the riffles with a lot of silt and leaf litter in the pools. A moderate abundance of overhanging vegetation was present at the slow habitats, but none at the fast shallow habitat which had sparse undercut banks and root wads as cover type. During previous surveys a total of six of an expected seven species were recorded (DWA, 2014). During the fish assemblage of the present survey four species were recorded. Three flow dependant species, *Chiloglanis pretoriae*, *Labeobarbus polylepis* and *Amphilius uranoscopus* were collected with one limnophilic species, *Clarias gariepinus*.

The CPUE (catch per unit effort) calculated for this site is 0.4 (14 individuals; 39 minutes) indicating a very low abundance of fish.

A Fish Response Index (FRAI) score of 62.4% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first monitoring on record at the X1WITK-WITKL site was collected during the survey in July 2014. During the 2014 survey, taxa preferring moderate to slow flowing conditions were dominant, but taxa preferring fast flowing taxa was also present as was (to a lesser degree), taxa associated with stagnant water. Taxa associated with the cobble biotope dominated, but taxa sensitive to high water quality was either absent or present at low abundances. The average sensitivity rating for the stones biotope in the Northern Escarpment Mountains aquatic ecoregion for the 2014 sampling period was 7.0, while it was 6.4 for the site on the Witkloofspruit. The ratings for the vegetation and sand/mud/gravel biotopes were in line with averages for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the site on the Witkloofspruit was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 22. Results for water quality constituents measured at the Witwaterspruit site (X1WITK-WITKL) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**44**			
Sampling Date	**14August 2014**			
Sampling Time	**09h45**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**9.5**			
pH	**7.4**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.1**			
Saturation (%)	**82.9**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**10.7**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**69.6**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**16**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**6**		<200	<130

Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.028**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results fell within expected ranges (Table 22).

On Site Impacts Recorded

- High growth of filamentous green algae in pools and areas out of current, and;
- High infestation of the riparian zone upstream from the sampling point with wattle (*Acacia mearnsii*). This results in extremely high quantities of *A. mearnsii* leaf-litter accumulating in pool areas, which will affect the local instream community.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (69.6%) suggesting a moderately impaired habitat.

WITKLOOFSPRUIT

Site Code	X1WITK-WITKL	**Reach**	X11C-01147
Longitude	-25.96086° S	**Quaternary Catchment**	X11C
Latitude	30.04052° E	**Elevation**	1,541 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 12. Eastern Highveld Grassland
River Gradient	0.0215	**Geomorphological Zone**	Transitional

Figure 53. Upstream view of the site on the Witkloofspruit, X1WITK-WITKL (14 August 2014, G Diedericks).

Figure 54. Downstream view of the site on the Witkloofspruit, X1WITK-WITKL (14 August 2014, G Diedericks).

SQ REACH NUMBER X11D-01129

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11D-01129	X1KKOM-WELGE	Klein Komati	1,514	S-25.88793 E 30.12033	C 74.9%	B 87.4%	BC 81.2%	C	C 70%	C 76.4%	39.6

General description

Reach X11D-01129: Klein Komati

The Klein Komati originates from two main tributaries, the one (main Klein Komati) to the north-west and the other from the north-east (Figure 56 & 57). The Klein Komati originates south from the Sunbury Railway Station on the farm Paardeplaats, at an elevation of 1,860 m.a.s.l, and the north-eastern tributary at an elevation of 1,920 m.a.s.l. just south of Belfast. The stream flows in a south-south easterly direction towards the Komati River, merging with the Komati downstream from the Nooitgedacht Dam. The reach (X11D-01129) length is 39.6 km. The sampling point in the reach is located at an elevation of 1,514 m.a.s.l, and is categorised geomorphologically as an upper foothills zone. In terms of vegetation types, the headwaters of the Klein Komati catchment are located in the Lydenburg Montane Grassland, with the largest portion of the catchment in the Eastern Highveld Grasslands and the lower sections fall within the KaNgwane Montane Grassland. The catchment falls within two aquatic ecoregions, with the largest and upper portion within the Highveld, and the lower portion in the Northern Mountain Escarpment ecoregion. Land-use in the upper catchment includes livestock grazing, crop irrigation, two coal mines, and several (112) small dams. A total of nine dams are located on the main channel, and 103 on tributaries. On Google Earth, there are also signs of wetland channelisation in several parts of the upper catchment.

Fish

The biomonitoring site sampled for fish consisted of a sequence of short riffles and runs and large pools. The fish velocity depth classes present were fast shallow (moderate), fast deep (sparse), slow shallow (moderate) and slow deep (rare). The fish cover present consisted largely of substrate with rocks and boulders. No overhanging vegetation and undercut banks and root wads were observed. During previous surveys seven of an expected ten species were recorded (DWA, 2014). During the present survey fish assemblage only two species were recorded, of which only *Chiloglanis pretoriae* was collected in abundance. The only other species collected was *Barbus anoplus*. Although *B. anoplus* is considered to be moderately tolerant to a wide variety of habitats, modified flow conditions and water quality impairment, only four individuals were collected and all of them were infected with the digenean parasite known as “black spot”. The low number of species can be expected because of the largely modified ecological state of this reach.

The CPUE (catch per unit effort) calculated for this site is 1.5 (55 individuals; 37 minutes) indicating a relative abundance of fish present, but was dominated by one species, *Chiloglanis pretoriae* (51 individuals).
A Fish Response Index (FRAI) score of 74.9 % was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first SASS monitoring on record at the X1KKOM-WELGE site was in February and August 2012. Comparing the results between the 2012 and 2014 surveys indicates differences in diversity and sensitivity ratings, with the highest diversity during 2012 and the more sensitive (SASS5) taxa encountered in 2014. This might be linked to seasonal changes.

During the 2014 survey, taxa preferring moderate to fast flowing conditions were dominant, with taxa preferring moderate flow also present, and to a lesser degree taxa associated with stagnant water. Taxa associated with the cobble biotope dominated, with taxa rated as sensitive (SASS5) to high water quality dominant and abundant.
The taxa at the site in the different biotopes sampled in 2014 was:

- above the average for the stones biotope for the ecoregion;
- below average for the vegetation biotope in terms of diversity;
- above average for the gravel/sand/mud biotopes in terms of both diversity and sensitivity (SASS5), and;
- above average in the total SASS5 results in terms of sensitivity ratings.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the site on the Klein Komati was rated as slightly impaired (B-class).

Chemical and Physical Water Quality

Table 23. Results for water quality constituents measured at the Klein Komati site (X1KKOM-WELGE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**03**			
Sampling Date	**08 July 2014**			
Sampling Time	**09h50**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**9.1**			
pH	**7.8**			6.5 – 8.5

Dissolved Oxygen (mg/ℓ)	**9.8**			
Saturation (%)	**95.5**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**13.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**88.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**20**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.562**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results fell within expected ranges (Table 23).

On Site Impacts Recorded

- Stream bank souring (Figure 55);
- High sediment inputs at the stream crossing due to poor road drainage;
- The site in the river is used by local communities for washing of clothes, and;
- High infestation of the riparian zone upstream from the sampling.

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Figure 55. Stream bank scouring and high sediment inputs from the road at the stream crossing recorded at the site on the Klein Komati in 2014. The presence of invasive plant species are also evident from the photos (08 July 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (81.2%) suggesting a slightly to moderately impaired habitat**.**

KLEIN KOMATI

Site Code	X1KKOM-WELGE	**Reach**	X11D-01129
Longitude	-25.88793° S	**Quaternary Catchment**	X11D
Latitude	30.12033° E	**Elevation**	1,514 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.010	**Geomorphological Zone**	Upper Foothills

Figure 56. Upstream view of the site on the Klein Komati River, X1KKOM-WELGE (08 July 2014, G Diedericks).

Figure 57. Downstream view of the site on the Klein Komati River, X1KKOM-WELGE (08 July 2014, G Diedericks).

SQ REACH NUMBER X11E-01237

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11E-01237	X1SWAR-HEBRO	Swartspruit	1,432	S-25.92519 E 30.23756	C 74.6%	C 62.1%	C 68.3%	C	B 85%	C 75.5%	29.3

General description

Reach X11E-01237: Swartspruit

The Swartspruit originates on the farm Haarlem, located on south-eastern side of Carolina, at an elevation of 1,800 m.a.s.l. (Figure 59 & 60). The reach length is 29.3 km, flowing in a north-north-easterly direction towards the sampling point (XSWAR-HEBRO) and Komati River. Geomorphologically the site is categorised as upper foothills. In terms of vegetation types, the stream originates in the Eastern Highveld Grasslands, with the lower sections of the river located in the KaNgwane Montane Grassland. The upper reaches fall within the Highveld aquatic ecoregion, and the site and lower section of the river within the Northern Mountain Escarpment. Land-use in the upper catchment includes livestock grazing, crop irrigation, coal mines (4), towns, numerous small dams (36). A total of six dams were counted on the main Swartspruit, and 30 on tributaries. There are several off-channel dams in the vicinity of the sampling site.

Fish

This biomonitoring site is characteristic of an upper foothill stream with a low gradient and gentle flowing river. The fish velocity depth classes were dominated by shallow habitat with fast shallow in abundance and slow shallow moderately abundant. Fast deep was rare and slow deep absent. The fish cover present rated from sparse to rare for overhanging vegetation and sparse for undercut banks and root wads. The substratum as cover was moderately in abundance and consisted of rocks, cobbles and pebbles. Embeddedness was evident limiting the available habitat for especially the flow dependent fish species. The fish assemblage recorded at the site consisted of only one species of an expected eleven species. Only the flow dependent and modified physico-chemical intolerant *Chiloglanis pretoriae* was collected in relative abundance.

The CPUE (catch per unit effort) calculated for this site is 0.8 (27 individuals; 34 minutes) indicating a relative abundance of this single species collected. The low number of fish species collected may be related to the possibility of the alien species Rainbow trout (Oncorhynchus mykiss) escaping from holding ponds next to the river, into the river, predating on the indigenous fish. The poorly designed river crossing just downstream from the site will also act as a barrier for the up-stream migration of fish.

A Fish Response Index (FRAI) score of 74.6% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring on record. Taxa associated with moderate flow dominated, followed by fast and slow. Taxa preferring stagnant water was also present, but at low abundances. The highest abundance and diversity of taxa was in the cobbles biotope, followed by vegetation and gravel/sand/mud. High sediment deposition limited taxa diversity, with lower diversity than expected recorded in stones, vegetation and gravel/sand/mud biotopes.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1KOMA-MOEDI site on the Komati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 24. Results for water quality constituents measured at the Swartspruit site (X1SWAR-HEBRO) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**05**			
Sampling Date	**08 July 2014**			
Sampling Time	**15h10**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**12.9**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.3**			
Saturation (%)	**121.2**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**11.1**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**72.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**8**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4)	**<5**		<1,000	

Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.344**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

The percentage saturated oxygen was slightly elevated (121.2%), but readings at 06h00 in the morning over different seasons are required to meaningfully interpret this result. Other water quality results measured and analysed fell within expected ranges (Table 24).

On Site Impacts Recorded

- The poor design of the stream crossing at the sampling site effectively blocks the movement of fish species, especially during low flow conditions (Figure 58). Tributaries are critical refuge areas for fish, and are often utilised extensively as breeding and nursery areas;
- The design ensures impediment of the stream above the crossing, allowing sediment deposition “smothering” the upstream riffle areas for at least 200 m;
- Stream bank scouring and erosion downstream from the crossing is severe, as the poor design allows the stream to overtop the structure, and scour the unprotected stream banks, and
- Off-channel dams stocked with exotic trout. It is highly likely that bass are also present in these dams.

Figure 58. Poor design of the stream crossing ensures the blockage of fish movement, especially during low flow conditions. The deposition of sediments above the crossing (photo on right) covers the substrate for approximately 200 m (08 July 2015, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (68.3%) slightly to moderately impaired habitat.

SWARTSPRUIT

Site Code	X1SWAR-HEBRO	**Reach**	X11E-01237
Longitude	-25.92519° S	**Quaternary Catchment**	X11E
Latitude	30.23756° E	**Elevation**	1,423 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.0125	**Geomorphological Zone**	Upper Foothills

Figure 59. Upstream view of the site on the Swartspruit, X1SWAR-HEBRO (08 July 2014, G Diedericks).

Figure 60. Downstream view of the site on the Swartspruit, X1SWAR-HEBRO (08 July 2014, G Diedericks).

SQ REACH NUMBER X11G-01188

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11G-01188	X1NDUB-SAPPI	Ndubazi	1,165	S-25.84470 E 30.47466	C 75.9%	C 69.7%	C 72.8%	C	C 70%	C 71.6%	22.34

General description

Reach X11G-01188: Ndubazi

The Ndubazi River originates at an elevation of 1,800 m.a.s.l., on the farm Bergstroom, which forms part of Sappi's Ndubazi commercial tree plantation (Figure 61 & 62). The bulk of the Ndubazi Catchment drains Sappi managed land. The river flows in a north-north-easterly direction (36°) towards the Komati River. The reaches is listed as 22.3 km, with the sampling point (X1NDUB-SAPPI) located close to its confluence with the Komati River. The sampling site is located at an elevation of 1,165 m.a.s.l, and is categorised geomorphologically as an upper foothills stream. The bulk of the catchment falls within a commercial tree plantation, with *Pinus* spp. the dominant species. The entire reach falls into the KaNgwane Montane Grasslands vegetation type. Small portions of the headwaters fall within the Highveld aquatic ecoregion, but the bulk are located within the Northern Escarpment Mountains. Impacts and activities in this reach is mainly from forestry.

Fish

This biomonitoring site is characteristic of an upper foothill stream with a low gradient with sequences of riffles and runs with some pools present. Fast shallow habitat was the only fish velocity depth class present in abundance. The slow deep, fast deep and slow shallow habitats were sparsely in abundance. The fish cover present rated from sparse to moderately abundant for overhanging vegetation and moderate for undercut banks and root wads. The substratum as cover was moderately in abundance in the fast habitats and consisted of rocks, cobbles and pebbles, but rare to sparse for the slow habitats with evidence of siltation. The fish assemblage recorded at the site consisted of only two species of an expected ten species of indigenous fish. Only the flow dependent *Chiloglanis pretoriae* and *Amphilius uranoscopus* were collected with *C. pretoriae* in relative abundance.

The CPUE (catch per unit effort) calculated for this site is 0.8 (26 individuals; 32 minutes) indicating a relative abundance of fish species collected.

A Fish Response Index (FRAI) score of 75.9% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first monitoring on record at the X1NDUB-SAPPI site was collected in April 2001, April 2002, May 2003, June 2007, August 2013 and the monitoring for this survey in July 2014.

Taxa diversity varied over the different sampling periods, but the ASPT[1] remained similar. This is one of the only sites in the Komati Catchment where the Lepidostomatidae family (shredders) were recorded in 2014. The other site was on the Mlumati River.

At the X1NDUB-SAPPI site in 2014, taxa preferring fast flowing waters were dominant, followed by moderate flowing water. Taxa associated with the cobble biotope dominated, and taxa associated with marginal and aquatic vegetation was also dominant. Sensitive taxa associated with high water quality was well represented, but occurred at low abundances. The taxa collected in the stones and vegetation biotopes had higher diversity and sensitivity averages than the average for other sites in the ecoregion. The gravel/sand/mud biotope had lower than average diversity. The abundance of individual families rated as sensitive were low, and this was attributed to fine silt deposition in the slower flowing portions of the stream. Such deposition limits available instream habitat.

The moderately impaired conditions despite the high water quality at the site are attributed to the high deposition of fine silt with high quantities of leaf litter trapped in silted pool areas.

Chemical and Physical Water Quality

Table 25. Results for water quality constituents measured at the Ndubazi site (X1NDUB-SAPPI) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**10**			
Sampling Date	**10 July 2014**			
Sampling Time	**08h35**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**6.7**			
pH	**8.1**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**9.8**			
Saturation (%)	**90.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**5.3**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**34.5**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		

[1]ASPT = Average Score Per Taxon

Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**23**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.089**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

The electrical conductivity results was the lowest recorded for the catchment in 2014 survey. All water quality results fell within an expected range (Table 25).

On Site Impacts Recorded

- Excessively high deposition of fine silt, and;
- Stream crossing designs in the upper catchment potentially blocks the movement of fish species during low flow events.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (72.8%) suggesting a moderately impaired habitat.

NDUBAZI

Site Code	X1NDUB-SAPPI	**Reach**	X11G-01188
Longitude	-25.84470° S	**Quaternary Catchment**	X11G
Latitude	30.47466° E	**Elevation**	1,165 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.0077	**Geomorphological Zone**	Upper Foothills

Figure 61. Upstream view of the site on the Ndubazi River, X1NDUB-SAPPI (10 July 2014, G Diedericks).

Figure 62. Downstream view of the site on the Ndubazi River, X1NDUB-SAPPI (10 July 2014, G Diedericks).

SQ REACH NUMBER X11K-01194

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X11K-01194	X1GLAD-VYGEB	Gladdespruit	1,026	S-25.86514 E 30.66661	C 75.8%	C 67.5%	C 71.6%	C	D 50%	C 62.4%	9

General description

Reach X11K-01194: Gladdespruit

The Mhlambanyathi stream originates on the farm Normandie at an elevation of 2,000 m.a.s.l. (Figure 63 & 64) The river length from source to entering the Komati River is 49.6 km, flowing in a south-east-southerly direction (144°) towards the Komati River. The river is divided into three reaches on the main channel, and one on a tributary (Poponyane). The sampling point is located on the lowest reach, X11K-01194, which is 9.0 km in length. Geomorphologically the stream is located in an upper foothills zone.

In terms of vegetation types, the stream originates in the Lydenburg Montane Grassland, followed by the KaNgwane Montane Grassland, intersected by Northern Escarpment Dolomite Grassland and Northern Escarpment Quartzite Sourveld. The stream close to its Komati confluence falls within the Swaziland Sour Bushveld, and includes the sampling point (XGLAD-VYGEB). The entire catchment falls within the Northern Mountain Escarpment aquatic ecoregion. Land-use in the upper catchment includes commercial forestry, trout farms, open-cast mining, livestock grazing, crop irrigation, and several small dams (23). Nine dams were counted on the main Gladdespruit and 14 on tributaries.

Fish

This biomonitoring site is characteristic of an upper foothill stream with a low gradient with riffles, runs and pools. All of the fish velocity depth classes were present which included fast shallow (abundant), fast deep (sparse), fast shallow (sparse) and slow deep (abundant). The fish cover present rated moderately for overhanging vegetation and sparse for undercut banks and root wads. The substratum varied from moderate to abundant for the fast habitats and consisted of boulders, rocks, cobbles and pebbles and sparse for the slow habitats which consisted of sand and silt. The fish assemblage recorded at the site consisted of five species of an expected 12 species. The assemblage was dominated by the two flow dependant species, *Chiloglanis pretoriae* and *Labeobarbus marequensis*. *Amphilius uranoscopus,* which is also dependant of flow, was also present but in relative low numbers. Two limnophilic species, *Pseudocrenilabrus philander* and *Clarias gariepinus*, were also recorded, but in much lower numbers.

The CPUE (catch per unit effort) calculated for this site is 3.6 (191 individuals; 53 minutes) indicating a high abundance of fish present.

A Fish Response Index (FRAI) score of 75.8% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with moderate and slow flow dominated, and to a lesser degree fast and stagnant. The highest abundance and diversity of taxa was in the cobbles biotope, followed by vegetation and gravel/sand/mud. Taxa diversity was higher than expected for the stones biotope when compared to averages for the ecoregion, but some sensitive taxa were absent. The vegetation biotope supported a high number of taxa compared to other sites in the ecoregion, while the gravel/sand/mud biotope supported less. Overall taxa diversity was low, but sensitivity ratings above average.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1GLAD-VYGEB site on the Gladdespruit was rated as moderately impaired (C-class), which is mainly attributed to slight changes in water quality when compared to results for other streams in the same ecological zone.

Chemical and Physical Water Quality

Table 26. Results for water quality constituents measured at the Gladdespruit stream's site (X1GLAD-VYGEB) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**45**			
Sampling Date	**14 August 2014**			
Sampling Time	**14h45**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**15.6**			
pH	**7.6**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.4**			
Saturation (%)	**96.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**22.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**146.3**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**12**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic		

		2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**35**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**17**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**9**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.483**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**15**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality levels of certain constituents measured are slightly elevated compared to similar stream measured in the ecoregion. Increases in sulphates, sodium and chlorides could be linked to the geology and soils, but there is a possibility of low levels of contaminated wastewater discharges. All water quality results measured and analysed, however, fell within expected ranges (Table 26).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (71.6%) suggesting a moderately impaired habitat.

GLADDESPRUIT

Site Code	X1GLAD-VYGEB	**Reach**	X11K-01194
Latitude	-25.86514° S	**Quaternary Catchment**	X11K
Longitude	30.66661° E	**Elevation**	1,026 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0067	**Geomorphological Zone**	Upper Foothills

Figure 63. Upstream view of the site on the Gladdespruit, X1GLAD-VYGEB (14 August 2014, G Diedericks).

Figure 64. Downstream view of the site on the Gladdespruit, X1GLAD-VYGEB (14 August 2014, G Diedericks).

SQ REACH NUMBER X12A-01305

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12A-01305	X1BUFF-DOORN	Buffelspruit	1,370	S-26.06264 E 30.39378	C 75.7%	BC 78.1%	C 76.9%	C	D 50%	C 65.4%	33.6

General description

Reach X12A-01305: Buffelspruit

The Buffelspruit originates on the farm Appeldoorn, 14.4 km south-east (126°) from the town of Carolina, at an elevation of 1,780 m.a.s.l. (Figure 66 & 67). The reach length is 33.6 km and flowing in an east-north-easterly direction (65°) towards the Komati River. The Buffelspruit Catchment includes several tributaries, of which the Hlatjiwe and Phophenyane are allocated reach codes. The Buffeslpruit's name changes to the Seekoeispruit after in merges with the Phophenyane.

The sampling point (X1BUFF-DOORN) on the Buffelspruit is located on the river downstream from a road crossing on a district road on the farm Doornkloof. The reach length is 33.6 km, and the reach code X12A-01305. The site is at an elevation of 1,370 m.a.s.l., categorised geomorphologically as an upper foothills zone.
A small portion of the upper catchment falls within the Eastern Highveld Grassland, but the bulk of the Buffelspruit falls within the KaNgwane Montane Grassland. The sampling site and upper portion of the Buffelspruit are located in the Highveld aquatic ecoregion. Land-use in the upper catchment is predominantly commercial forestry, but there are also livestock grazing, crop irrigation, and several small dams(19). Two dams were counted on the main Buffelspruit and 17 on tributaries. High quantities of sand are present in the river at the sampling site.

Fish

This river reach in the Buffelspruit is representative of an upper foothill stream with a low gradient with riffles, runs and pools. The fish velocity depth classes present were fast shallow in abundance with both slow shallow and slow deep moderately abundant. No fast deep habitat was present at the time of the survey. The fish cover present rated moderately for both overhanging vegetation and for undercut banks and root wads. The substratum as cover rated moderate for the fast habitat and sparse for the slow habitats. Sedimentation is evident limiting the available cover for fish. The fish assemblage recorded at the site consisted of two species of an expected 11 species. The flow dependant species, *Chiloglanis pretoriae* and *Amphilius uranoscopus* were collected with only *C. pretoriae* in abundance. All of the *A. uranoscopus* collected were infected with a digenean parasite which may be indicative of the poor habitat present.

The CPUE (catch per unit effort) calculated for this site is 1.7 (67 individuals; 37 minutes) indicating a relative high abundance of fish present.

A Fish Response Index (FRAI) score of 75.7% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with moderate and fast flow dominated, and slow to stagnant less so. The highest abundance and diversity of taxa was in the cobbles biotope, with very low taxa diversity and abundance in the vegetation biotope. The riparian zone was dominated by invasive exotic wattle (*Acacia mearnsii*), which suppress the indigenous margin vegetation. Sensitive taxa still dominate the stream community. Overall taxa diversity was low, but sensitivity ratings were above average.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1BUFF-DOORN site on the Buffelspruit was rated as slightly to moderately impaired (B/C-class). High sand deposition and the abundance of invasive tree species reduce instream habitat availability.

Chemical and Physical Water Quality

Table 27. Results for water quality constituents measured at the Buffelspruit stream's site (X1BUFF-DOORN) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**01**			
Sampling Date	**07July 2014**			
Sampling Time	**12h40**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**12.1**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.3**			
Saturation (%)	**81.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**16.8**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**109.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.5**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic		

		>10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**43**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.575**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**12**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality levels of certain constituents measured are slightly elevated compared to similar streams measured in the ecoregion. Sulphate, sodium, iron and nitrates was slightly elevated. Increases in sulphates and sodium could be linked to the geology and soils. All water quality results measured and analysed, however, fell within expected ranges (Table 27).

On Site Impacts Recorded

- Excessive sand and silt deposition in the stream;
- Stream bank scouring common throughout most of the channel surveyed;
- High quantities of domestic waste are dumped in the stream and riparian zone at the bridge;
- Weed infestation in the riparian zone is extremely high, affecting stream bank stability and excluding natural vegetation (Figure 65);
- The road drainage is poor, allowing high loads of loose soil and sand entering the stream during rainfall events.

Figure 65. Wattle infestation in the riparian zone and stream bank scouring at the X1BUFF-DOORN monitoring site (07 July 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (76.9%) suggesting a moderately impaired habitat.

BUFFELSPRUIT

Site Code	X1BUFF-DOORN	**Reach**	X12A - 01305
Latitude	-26.06264° S	**Quaternary Catchment**	X12A
Longitude	30.39378° E	**Elevation**	1,370 m.a.s.l.
Aquatic Ecoregion Lev I	11. Highveld	**Aquatic Ecoregion Lev II**	11.04
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16: KaNgwane Montane Grassland
River Gradient	0.0067	**Geomorphological Zone**	Upper Foothills

Figure 66. Upstream view of the site on the Buffelspruit, X1BUFF-DOORN (07 July 2014, G Diedericks).

Figure 67. Downstream view of the site on the Buffelspruit, X1BUFF-DOORN (07 July 2014, G Diedericks).

SQ REACH NUMBER X12B-01246

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12B-01246	X1HLAT-RIETF	Hlatjiwe	1, 382	S-26.02361 E 30.36111	C 76.1%	C 77.2%	C 76.7%	C	D 50%	C 76.7%	22.8

General description

Reach X12B-01246: Hlatjiwe

The Hlatjiwe River originates on the farm Leeuwpoort, 14.3 km north-east (76°) from the town of Carolina, at an elevation of 1,760 m.a.s.l. (Figure 69 & 70). The reach length from is 22.8 km, flowing in an easterly direction (81°) towards the Buffelspruit. The sampling point (X1HLAT-RIETF) on the Hlatjiwe is located upstream from an old abandoned asbestos mine on the farm Rietfontein. Most of the catchment drains Sappi commercial tree plantations. The site is at an elevation of 1,382 m.a.s.l., categorised geomorphologically as an upper foothills zone. The entire catchment falls within the KaNgwane Montane Grassland. The sampling site and upper portion of the Buffelspruit are located in the Northern Escarpment Mountains aquatic ecoregion. Land-use in the upper catchment is predominantly commercial forestry, but there are also trout farms, livestock grazing, small scale crop irrigation, and several small dams(45). Five dams were counted on the main Buffelspruit and 40 on tributaries. Impacts and activities in this reach include mining and forestry.

Fish

The site on this first order stream consisted of mainly shallow riffles and long stretches of silt filled pools where bank scouring was evident. At this biomonitoring site three fish velocity depth classes were present: fast shallow (abundant), fast deep (rare), slow shallow (moderate). No slow deep habitat was present. Overhanging vegetation present as fish cover rated from rare to sparse with undercut banks and root wads moderately abundant in both the slow shallow and fast shallow habitats. The substrate in the fast deep habitats were moderate consisting of boulders and rocks, but in the fast shallow the cobbles and pebbles were imbedded resulting in loss of interstitial spaces causing a loss of available fish habitat. The fish assemblage recorded at the site consisted of only three species of an expected ten species for this reach, but the confidence on the number of fish species expected to occur is relatively low. The reophilic species *Chiloglanis pretoriae* and *Amphilius natalensis* were collected in the fast fish velocity habitats. Only one *Barbus anoplus*, a limnophilic species, was collected.

The CPUE (catch per unit effort) calculated for this site is 1.0 (41 individuals; 43 minutes) indicating a low abundance of fish present. The reason for the low abundance of fish and species collected can be related to bank scouring causing sedimentation and a loss of available fish habitat as well as the river crossing just downstream from the site sampled acting as a barrier for fish movement.

A Fish Response Index (FRAI) score of 76.1% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with fast flow dominated, and to moderate, slow and stagnant waters less so. The highest abundance and diversity of taxa was in the cobbles biotope, but the diversity and abundance was lower than the average for the ecoregion. Taxa diversity and abundance in the vegetation biotope was also lower than expected. Taxa diversity and the dominance of sensitive taxa were lower than the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1HLAT-RIETF site on the Hlatjiwe River was rated as moderately impaired (C-class). High deposition of fine silt and what appears to be recent bank scouring are considered as the main reason for current conditions.

Chemical and Physical Water Quality

Table 28. Results for water quality constituents measured at the Hlatjiwe stream's site (X1HLAT-RIETF) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**02**			
Sampling Date	**07July 2014**			
Sampling Time	**15h05**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**10.9**			
pH	**7.8**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.9**			
Saturation (%)	**109.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**8.7**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**56.6**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic		

		2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**81**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.293**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed, however, fell within expected ranges (Table 28).

On Site Impacts Recorded

- Stream bank scouring is severe both up- and downstream from the stream crossing;
- Small culverts at the crossing is partially blocked with logs and debris, promoting upstream sediment deposition (as flow slows down) and overtopping of the structure;
- Periphyton abundant on instream rock surfaces;
- Weed infestation in the riparian zone with exotic invasive plans is extremely high, affecting stream bank stability and excluding natural vegetation;
- An old abandoned asbestos mine is located in the riparian zone (see Appendix), and figure 68
- A stream crossing constructed to the asbestos mine is more than likely blocking fish movement, especially during low and normal flow conditions.

Figure 68. Waste dump of an old abandoned asbestos mine at the edge of the Hlatjiwe River on the left. On the right, a stream crossing at the abandoned mine is blocking the movement of fish species in the system (07 July 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (76.7%) suggesting a moderately impaired habitat.

HLATJIWE

Site Code	X1HLAT-RIETF	**Reach**	X12B - 01246
Latitude	-26.02361° S	**Quaternary Catchment**	X12B
Longitude	30.36111° E	**Elevation**	1,382 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16: KaNgwane Montane Grassland
River Gradient	0.0143	**Geomorphological Zone**	Upper Foothills

Figure 69. Upstream view of the site on the Hlatjiwe River, X1HLAT-RIETF (07 July 2014, G Diedericks).

Figure 70. Downstream view of the site on the Hlatjiwe River, X1HLAT-RIETF (07 July 2014, G Diedericks).

SQ REACH NUMBER X12D-01235

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12D-01235	X1SEEK-DOORN X1SEEK-WINKE	Seekoeispruit	1, 043 965	S- 25.94773 E 30.57494 S- 25.96139 E 30.61846	C 71.3%	C 73.2%	C 72.3%	C	D 50%	C 62.4%	26.72

General description

Reach X12D-01235: Seekoeispruit

The X1SEEK-DOORN site on the Seekoeispruit is located downstream from the Aventura Badplaas Resort (Figure 71 & 72), and the X1SEEK-WINKE site a further 6.7 km downstream (Figure 73 & 74). The X1SEEK-DOORN site is located on Aventura's boundary, on the farm Doornpoort, and the X1SEEK-WINKE site on the farm Winkelhaak, downstream from Badplaas and the Embhuleni village. The one sampling point is at an elevation of 1,043 m.a.s.l. and the other at 965 m.a.s.l. The reach length is 26.7 km. Geomorphologically, the upstream site falls within the upper foothills zone, and the downstream site within the lower foothills zone. The sites are located in the Swaziland Sour Bushveld vegetation type, and within the Northern Mountains Escarpment aquatic ecoregion. Land-use in the upper catchment includes livestock grazing, a hydro-station, commercial forestry, trout farms, crop irrigation and numerous small dams.

Fish

This reach can be seen as a transitional zone between an upper and a lower foot hill stream with an increase in slower habitat and decrease in fast habitat. The aquatic habitat surveyed at the upstream site (X1SEEK-DOORN) consisted of mainly riffles, runs and pools. The fish velocity depth classes present were predominantly fast habitat types with fast shallow (abundant), fast deep (moderate), slow shallow (none) and slow deep (moderate). The downstream site (X1SEEK-WINKE) consisted of a deep water pool with infrequent rapids, riffles and runs. The fish velocity depth classes included abundant fast shallow and fast deep habitats, with the slow shallow (rare) and slow deep (moderate). At both sites the overhanging vegetation rated moderate with moderate undercut banks and root wads observed. For both sites the substratum rating for the slow velocity depth classes was sparse. For the fast fish velocity depth classes the substrate ranged from moderate to abundant comprising of boulders, rocks, cobbles and pebbles. The fish assemblage recorded during the present survey at site X1SEEK-DOORN consisted of five species and at site X1SEEK-WINKE three species. In total six of the 14 expected fish species were recorded for this reach, comprising of the reophilic *Amphilius uranoscopus*, *Chiloglanis pretoriae*, *Labeobarbus marequensis*, and limnophilics *Barbus paludinosus*, *Pseudocrenilabrus* *philander* and *Tilapia sparrmanii* with *C. pretoriae* the most abundant species at both of the sites. *Amphilius uranoscopus* was only collected at the upper site and 75% was infected with a digenean parasite causing white spots all over the body. The presence of parasites indicates stress related conditions due to deteriorated habitat quality. The principle applies that fish under stress conditions are more vulnerable to parasite infestations.

The CPUE (catch per unit effort) calculated for the X1SEEK-DOORN site is 2.3 (120 individuals; 52 minutes) and for the X1SEEK-WINKE site 2 (86 individuals; 42 minutes), indicating a slightly lower abundance at the downstream site. This can be attributed to availability of fish habitat for sampling.

A Fish Response Index (FRAI) scored respectively of 71.7% and 70.9% was calculated for this reach based on all available information. An average FRAI score of 71.3% was used placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at these two sites on record. At the upstream site, X1SEEK-DOORN, taxa associated with moderate, fast and slow flowing hydraulic biotopes dominated, while taxa associated with a relative high (> than average) number of taxa associated with stagnant waters also present. At the X1SEEK-WINKE site, taxa associated with moderate and fast flows dominated. The highest abundance and diversity of taxa at both sites was in the cobbles biotope at both sampling points. The diversity of taxa associated with the vegetation biotope was more at the upstream site than at the downstream site. Sensitive taxa was dominant at both sites.

Taxa diversity in the stones biotope was greater at the upstream site (X1SEEK-DOORN) than the average for the ecoregion, but lower at the downstream site (X1SEEK-WINKE). Taxa recorded in the vegetation biotope at both sites were better both in terms of diversity and sensitivity ratings when compared to averages for the ecoregion, while it was lower for the gravel/sand/mud biotope. Overall more taxa were recorded at the upstream (X1SEEK-DOORN) than at the downstream (X1SEEK-WINKE) site. The downstream site's overall score was also lower than the average for the ecoregion.

The combined stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1SEEK-DOORN and X1SEEK-WINKE sites in reach X12D-01235 on the Seekoeispruit was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 29. Results for water quality constituents measured at the X1SEEK-DOORN site (No. 27) and the X1SEEK-WINKE site (No. 46) on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS		SOUTH AFRICAN GUIDELINES		
			Aquatic	Livestock Use	Recreational Use
Water Sample No.	**27**	**46**			
Sampling Date	**18 Jul 2014**	**14 Aug 2014**			
Sampling Time	**12h35**	**17h10**			
CONSTITUENTS					
System Variables					
Water Temperature (°C)	**12.3**	**16.8**			
pH	**8.4**	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**9.1**	**8.3**			
Saturation (%)	**103.6**	**96.4**	80 - 120		
Clarity (cm)	**>120**	**>120**			<100
Quality Indicators					
Electrical Conductivity (mS/m @ 25°C)	**34.5**	**12.1**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**224.3**	**78.7**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**	**<10**			
Nutrients					
Free Ammonia (NH_3) mg/ℓ	**<0.2**	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**	**NA**			
Ortho-Phosphate (P) mg/ℓ	**<0.05 oligo - euro**		<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.8**	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	**NA**		<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms					
E coli (counts/100 mℓ)	**36**	**91**		<200	<130
Inorganic Salts					
Total Hardness (mg $CaCO_3$/ℓ)	*	*			
Sulphate (SO_4) mg/ℓ	**8**	**<5**		<1,000	
Inorganic – Toxic					
Chloride (Cl) mg/ℓ	**6**	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**<0.025**	**0.350**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**	**9**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results were slightly different between the two sites, but all water quality constituents measured and analysed fell within expected ranges (Table 29).

On Site Impacts Recorded

- The hydro-station at Aventura Badplaas diverts water through the hydro-station, which left a stretch of approximately 460 m of river stagnant at the time of the survey;
- A high degree of exotic weed infestation of the riparian zone at the X1SEEK-DOORN sampling site, and;
- Stream bank trampling at the downstream site, X1SEEK-WINKE.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (72.3%) suggesting a moderately impaired habitat.

SEEKOEISPRUIT

Site Code	X1SEEK-DOORN X1SEEK-WINKE	**Reach** **Quaternary Catchment**	X12D-01235 X12D
Latitude X1SEEK-DOORN **Longitude**	-25.94773°S 30.57494 E	**Elevation X1SEEK-DOORN**	1,043 m.a.s.l.
Latitude X1SEEK-WINKE **Longitude**	-25.96139 S 30.61846°E	**Elevation X1SEEK-WINKE**	965 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14. Swaziland Sour Bushveld
River Gradient -DOORN **River Gradient -WINKE**	0.0091 0.0048	**Geomorphological Zone**	Upper Foothills Lower Foothills

Figure 71. Upstream view of the site on the Seekoeispruit, X1SEEK-DOORN (18 July 2014, G Diedericks).

Figure 72. Downstream view of the site on the Seekoeispruit, X1SEEK-DOORN (18 July 2014, G Diedericks).

Figure 73. Upstream view of the site on the Seekoeispruit, X1SEEK-WINKE (14 August 2014, G Diedericks).

Figure 74. Downstream view of the site on the Seekoeispruit, X1SEEK-WINKE (14 August 2014, G Diedericks).

SQ REACH NUMBER X12E-01287

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12E-01287	X1TEES-WELVE X1TEES-HEUNI	Teespruit	1, 138 868	S- 26.05785 E 30.65012 S- 26.01573 E 30.80877	C 69.4%	C 75%	C 72.4%	C	C 70%	C 71.3%	66.12

General description

Reach X12E-01287: Teespruit

The X1TEES-WELVE site on the Teespruit is located on the farm Welverdiend, 36.7 km downstream from its source (Figure 77 & 78), and the X1TEES-HEUNI site a further 21.4 km downstream (Figure 79 & 80). The upstream sampling point is at an elevation of 1,138 m.a.s.l. and the other at 868 m.a.s.l. The reach length is 66.2 km. Geomorphologically both sites fall within the upper foothills zone. Most of the upper catchment of the Teespruit falls within the KaNgwane Montane Grassland veld type, while further downstream the vegetation type is categorised as Swaziland Sour Bushveld. The upstream site (X1TEES-WELVE) is located in the grassland veld type and the downstream site (X1TEES-HEUNI) in the bushveld vegetation type. Both sites are located within the Northern Mountains Escarpment aquatic ecoregion. Land-use in the upper catchment includes mostly commercial forestry, with livestock grazing, small settlements and numerous small dams with exotic fish.

Fish

Both of the two sites sampled on this reach are typical of an upper foothill stream. The aquatic habitat surveyed at the upstream site (X1TEES-WELVE) consisted of mainly riffles, runs and pools. All of the fish velocity depth classes were present as follows, fast shallow (abundant), fast deep (moderate), slow shallow (rare) and slow deep (abundant). The downstream site (X1TEES-HEUNI) consisted predominantly of rapids, riffles and runs with fast habitats such as fast shallow (very abundant) and fast deep (abundant). Deep water pools were also present but could not be sampled because of inaccessibility. The fish velocity depth classes present which could be sampled in the slow habitat types were slow shallow (sparse) and slow deep (sparse). At both sites the overhanging vegetation rated moderate to very abundant with undercut banks and root wads observed only at the upstream site. The substratum as fish cover rated poorly at X1TEES-WELVE because of the embeddedness of the boulders, rocks and cobbles (sparse for slow deep, slow shallow and fast deep, with fast shallow moderate). At the X1TEES-HEUNI signs of sedimentation were noted but not as pertinent as with the upstream site. Substrate as cover at the downstream site rated as sparse for both the slow habitat types and moderate to abundant for the fast habitat types. The fish assemblage recorded during the present survey at site X1TEES-

WELVE consisted of three species and at site X1TEES-HEUNI eight species. In total eight of the twelve expected species were recorded for this reach, comprising of the reophilic species *Amphilius uranoscopus*, *Chiloglanis pretoriae* and *Labeobarbus marequensis*, and limnophilic species Barbus paludinosus, Barbus trimaculatus, Barbus unitaeniatus, *Pseudocrenilabrus philander* and *Tilapia sparrmanii*. About 50% of the *A. uranoscopus* collected was infected with a digenean parasite of which its cysts appear as white spots. No other parasites could be detected in the field. The presence of parasites indicates stress related conditions due to deteriorated habitat quality.

The CPUE (catch per unit effort) calculated for the X1TEES -WELVE site is 1.9 (72 individuals; 37 minutes) and for the X1TEES-HEUNI site is 4.0 (294 individuals; 74 minutes) indicating a higher abundance of fish at the downstream site. This can be attributed to sedimentation and loss of available fish habitat at the upstream site.

A Fish Response Index (FRAI) scored respectively of 68.7% and 70.1% was calculated for this reach based on all available information. An average FRAI score of 69.4% was recorded placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at these two sites on record. At the upstream site, X1TEES-WELVE, taxa associated with moderate and fast flows were dominant, with less taxa associated with slow flow and stagnant waters. Taxa preferring high water quality dominated, with cobble habitat the most diverse. At the X1TEES-HEUNI site, taxa associated with moderate and slow flows dominated. The diversity of taxa associated with the vegetation biotope was more at the upstream site than at the downstream site. Sensitive taxa were dominant at both sites, but more so at the upstream site (X1TEES-WELVE).

Taxa diversity in the stones biotope was higher than the average for the ecoregion, but also lower in the number of sensitive taxa at both these sites. Overall more taxa were recorded at the upstream (X1TEES-WELVE) than at the downstream (X1TEES-HEUNI) site.

The combined stream conditions for the reach based on the aquatic macro-invertebrate community in 2014 at the X1TEES-WELVE and X1TEES-HEUNI sites was rated as moderately impaired (C-class). High sediment deposition at the upstream site, and high disturbance created by communities at the downstream site are considered as the main causes for the current status.

Chemical and Physical Water Quality

Table 30. Results for water quality constituents measured at the X1TTES-WELVE site (No. 14) and the X1TEES-HEUNI site (No. 26) on the Komati River compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS		SOUTH AFRICAN GUIDELINES		
			Aquatic	Livestock Use	Recreational Use
Water Sample No.	**14**	**26**			
Sampling Date	**11 Jul 2014**	**18 Jul 2014**			
Sampling Time	**10h00**	**09h10**			
CONSTITUENTS					
System Variables					
Water Temperature (°C)	**5.8**	**11.8**			
pH	**7.9**	**8.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)		**9.9**			
Saturation (%)		**102.6**	80 - 120		
Clarity (cm)	**>120**	**>120**			<100
Quality Indicators					
Electrical Conductivity (mS/m @ 25°C)	**7.4**	**12.0**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**48.1**	**78.0**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**	**<10**			
Nutrients					
Free Ammonia (NH_3) mg/ℓ	**<0.2**	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**	**NA**			
Ortho-Phosphate (P) mg/ℓ	**<0.05 oligo - euro**		<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	**NA**		<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms					
E coli (counts/100 mℓ)	**36**	**8**		<200	<130
Inorganic Salts					
Total Hardness (mg $CaCO_3$/ℓ)	*	*			
Sulphate (SO_4) mg/ℓ	**<5**	**<5**		<1,000	
Inorganic – Toxic					
Chloride (Cl) mg/ℓ	**<5**	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.354**	**0.098**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	**<0.025**	≤0.18	<10	
Sodium (Na)	**8**	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Water quality results were slightly different between the two sites, but all water quality constituents measured and analysed fell within expected ranges (Table 30).

On Site Impacts Recorded

- High sand deposition in riffles, glides and pools at both sampling locations ;

- Stream bank scouring at site X1TEES-WELVE;
- Poor road drainage at site X1TEES-WELVE, allowing loose soil and sand to enter the stream directly during rainfall events (Figure 75);
- Mining of sand from the riparian zone at site X1TEES-WELVE (Figure 76);
- High quantities of domestic waste in the stream and riparian zone, and;
- Brick-making in the riparian zone.

Figure 75. No road drainage at site X1TEES-WELVE, allowing loose soil to entered the river during rainfall events (11 July 2014, G Diedericks).

Figure 76. Sand are mined from the river and clay from the riparian zone to make bricks at site X1TEES-HEUNI (18 July 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (72.4%) suggesting a moderately impaired habitat.

TEESPRUIT

Site Code	X1TEES-WELVE X1TEES-HEUNI	**Reach** **Quaternary Catchment**	X12E-01287 X12E
Latitude -WELVE **Longitude**	-26.05785°S 30.65012 E	**Elevation -WELVE**	1,138 m.a.s.l.
Latitude-HEUNI **Longitude**	-26.01573 S 30.80877°E	**Elevation -HEUNI**	868 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16: KaNgwane Mountain Grassland
	Lowveld		SVl 14. Swaziland Sour Bushveld
River Gradient -WELVE **River Gradient -HEUNI**	0.0133 0.0063	**Geomorphological Zone**	Upper Foothills

Figure 77. Upstream view of the site on the Teespruit, X1TEES-WELVE (11 July 2014, G Diedericks).

Figure 78. Downstream view of the site on the Teespruit, X1TEES-WELVE (11 July 2014, G Diedericks).

Figure 79. Upstream view of the site on the Teespruit, X1TEES-HEUNI (11 July 2014, G Diedericks).

Figure 80. Downstream view of the site on the Teespruit, X1TEES-HEUNI (11 July 2014, G Diedericks).

SQ REACH NUMBER X12H-01318

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12H-01318	X1SAND-KORTB	Sandspruit	798	S- 26.03510 E 30.92432	C 77.4%	B 87.1%	B 82.3%	C	C 70%	C 77%	8.29

General description

Reach X12H-01318: Sandspruit

The Sandspruit originates on the farm Brandybal, bordering the north-eastern part of the small town, draining in a general north-east by eastern (53°) direction towards the Komati River (Figure 81 & 82). The Sandspruit merge with the Komati River in the Songimvelo Nature Reserve. The X1SAND-KORTB sampling point is located on the Laagegenoeg farm, which is on the Songimvelo Nature Reserve. The site is at an elevation of 798 m.a.s.l, and the reach length 8.3 km. The stream at the site is categorised geomorphologically as an upper foothills zone. The upper tributaries of the Sandspruit catchment falls within the KaNgwane Montane Grassland, and the lower portions within the Swaziland Sour Bushveld vegetation type. The monitoring site, X1SAND-KORTB, is located in the Swaziland Sour Bushveld. The entire Sandspruit catchment is located in the Northern Escarpment Mountains aquatic ecoregion. The dominant land-use in the catchment are livestock grazing, subsistence farming and rural settlement areas.

Fish

The aquatic habitat surveyed at this site consisted of mainly riffles and runs. At this biomonitoring site three of the fish velocity depth classes were present: fast shallow (abundant), fast deep (moderate) and slow shallow (moderate). Overhang vegetation as fish cover was moderately abundant at the fast shallow habitat and abundantly present at the slow shallow habitat. The presence of undercut banks and root wads rated from moderate to abundant. The substrate in the fast shallow habitats was abundant and consisted of boulders, rocks, cobbles and pebbles with a lot off available fish habitat. The substrate in the slow shallow rated as sparse and in the fast deep as moderate. The fish assemblage recorded at the site consisted of six species of an expected 16 species for this reach. The reophilic species *Labeobarbus marequensis*, *Chiloglanis pretoriae* and *Labeo molybdinus,* as well as the limnophilic Clarias gariepinus, were collected in the fast fish velocity habitats. Other lymnophylics collected were the two cichlid species, *Pseudocrenilabrus philander* and *Tilapia sparrmanii*, which was collected in the slow shallow habitat.

The CPUE (catch per unit effort) calculated for this site is 1.1 (57 individuals; 52 minutes) indicating a relative abundance of fish.

A Fish Response Index (FRAI) score of 77.4% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with moderate and slow flows dominated, followed by taxa preferring stagnant water and fast flows. The stones biotope had a higher diversity and sensitivity rating than the average for the ecoregion, but less taxa and an absence of sensitive taxa in the gravel/sand/mud biotopes. Overall, taxa diversity was higher than the average for the ecoregion, but a lower number of sensitive taxa.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MAWE-TJAKA site on the Mawelawela was rated as slightly impaired (B-class).

Chemical and Physical Water Quality

Table 31. Results for water quality constituents measured at the Sandspruit stream's site (X1SAND-KORTB) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**19**			
Sampling Date	**16July 2014**			
Sampling Time	**12h35**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**15.6**			
pH	**8.4**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.1**			
Saturation (%)	**116.9**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**35.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**233.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.8**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**10**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**12**		<1,000	

Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**8**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.073**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**9**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 31).

On Site Impacts Recorded

- High sand deposition;
- High quantities of domestic waste in the stream and riparian zone, and;
- High periphyton growth on submerged rocks.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class B (82.3%) suggesting a slightly to moderately impaired habitat.

SANDSPRUIT

Site Code	X1SAND-KORTB	**Reach**	X12H-01318
Latitude	-26.03510° S	**Quaternary Catchment**	X12H
Longitude	30.92432° E	**Elevation**	798 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0125	**Geomorphological Zone**	Upper Foothills

Figure 81. Upstream view of the site on the Sandspruit, X1SAND-KORTB (16 July 2014, G Diedericks).

Figure 82. Downstream view of the site on the Sandspruit, X1SAND-KORTB (16 July 2014, G Diedericks).

SQ REACH NUMBER X12J-01202

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12J-01202	X1MTSO-DIEPG	Mtsoli	734	S- 26.00281 E 31.07402	C 76.9%	B 82.5%	BC 79.7%	C	C 70%	C 75.5%	54.4

General description

Reach X12J-01202: Mtsoli

The Mtsoli River originates on Sappi commercial tree plantations west of the Brighton Kop on the farm Estada, at an elevation of 1,809 m.a.s.l. The stream flows in a south-east of southern direction (150°) for approximately 54.4 km towards the Komati River. The sampling point, X1MTSO-DIEPG is located approximately 4.9 km upstream from the Mtsolis' confluence with the Komati River, at an elevation of 734 m.a.s.l. The stream at the sampling point is geomorphologically categorised as an upper foothills zone. A large portion of the catchment falls within the Barberton Montane Grassland vegetation type, and the other portion in the Swaziland Sour Bushveld. The sampling site (X1MTSO-DIEPG) is located in the Swaziland Sour Bushveld. The entire catchment falls within the Northern Escarpment Mountains aquatic ecoregion. The uppermost portion of the catchment falls within commercial tree plantations, after which the stream flows through the Songimvelo Nature Reserve, before flowing through an old mining area towards the Komati River.

Fish

This river surveyed is typical of a low gradient upper foothill stream and the site sampled consisted of mainly riffles and runs. At this biomonitoring site all of the fish velocity depth classes were present: fast shallow (very abundant), fast deep (moderate) and slow shallow (sparse) and slow deep (moderate). Overhang vegetation as fish cover was abundant and the undercut banks and root wads rated from moderate to abundant. The substrate in the fast shallow habitats was abundant and consisted of boulders, rocks, cobbles and pebbles with a lot of available fish habitat. The substrate in the slow shallow rated as sparse and both the fast deep and slow deep as moderate. The fish assemblage recorded at the site consisted of six species of an expected 19 species for this reach. The reophilic species *Amphilius uranoscopus*, *Labeobarbus marequensis*, *Chiloglanis pretoriae* and *Labeo molybdinus,* were collected in the fast fish velocity habitats *C. pretoriae* the most abundant species. Lymnophylics collected were *Barbus trimaculatus* and *Tilapia sparrmanii*, which was collected in the slow shallow and slow deep habitat.

The CPUE (catch per unit effort) calculated for this site is 2.4 (116 individuals; 49 minutes) indicating a relative high abundance of fish.

A Fish Response Index (FRAI) score of 76.9% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with slow, and moderate to fast flow biotopes dominated in 2014. Taxa diversity in the stones biotope was similar to the average for the ecoregion, but the sensitivity rating was lower. The diversity and sensitivity of the vegetation and gravel/sand/mud biotopes were also less than the averages for the ecoregion. Overall the diversity of taxa was higher than the average for the ecoregion, but the sensitivity rating was lower.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MTSO-DIEPG on the Mtsoli was rated as slightly impaired (B-class).

Chemical and Physical Water Quality

Table 32. Results for water quality constituents measured at the Mtsoli stream's site (X1MTSO-DIEPG) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**21**			
Sampling Date	**16 July 2014**			
Sampling Time	**17h00**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**13.2**			
pH	**8.4**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.5**			
Saturation (%)	**111.2**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**8.8**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**57.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**21**		<200	<130

Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.029**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**<2**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 32).

On Site Impacts Recorded

- The riparian zone is severely infested with several species of exotic invasive weed species;
- Stream bank scouring is common in several sections of the river, and;
- Stream flow is partially blocked under the bridge with logs and debris, resulting in deposition upstream from the structure.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (79.7%) suggesting slightly to moderately impaired habitat.

MTSOLI

Site Code	X1MTSO-DIEPG	**Reach**	X12J-01202
Latitude	-26.00281° S	**Quaternary Catchment**	X12J
Longitude	31.07402° E	**Elevation**	734 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0063	**Geomorphological Zone**	Upper Foothills

Figure 83. Upstream view of the site on the Mtsoli, X1MTSO-DIEPG (16 July 2014, G Diedericks).

Figure 84. Downstream view of the site on the Mtsoli, X1MTSO-DIEPG (16 July 2014, G Diedericks).

SQ REACH NUMBER X12K-01333

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12K-01333	X1MLON-KRANS	Mlondozi	740	S- 26.05772 E 31.03248	C 73%	D 45.6%	CD 59.3%	C	C 70%	C 63.9%	23.8

General description

Reach X12K-01333: Mlondozi

The Mlondozi originates on the farm Tygerskloof in South Africa, and then flows through Swaziland towards the Komati River (Figure 85 & 86). At its origin, the elevation is 1,620 m.a.s.l., flowing for 18.1 km (straight line) in a north-east by northerly direction (34°) towards the Komati River. The site is located a few kilometres upstream from its confluence with the Komati River and downstream of an iron mine. This iron mine in Swaziland is owned by the Swaziland King and an India-based mining company, reworking the old mine The site is at an elevation of 740 m.a.s.l., categorised geomorphologically as an upper foothills zone. The entire catchment upstream from the sampling point (X1UNSP-BMINE) falls within the KaNgwane Montane Grassland vegetation type, and in the Swaziland Sour Bushveld closer towards the Komati River. The entire catchment is located in the Northern Escarpment Mountains aquatic ecoregion. The uppermost portion of the catchment falls predominantly within commercial forestry areas, and then flows through rural settlements, with livestock grazing and subsistence farming..

Fish

This low gradient river site consisted of mainly riffles and runs. Three of the fish velocity depth classes were present: fast shallow (very abundant), fast deep (sparse) and slow shallow (moderate). No overhang vegetation or undercut banks and root wads were available as fish cover. The substrate as cover for fish was very poor with mainly bedrock and sand with a few rocks and cobbles embedded in sand. The fish assemblage recorded at the site consisted of only two species of an expected 15 species for this reach. The two species collected, *Labeobarbus marequensis* and *Labeo molybdinus*, are both reophilic species. Sandy runs, the typical habitat for *Chiloglanis swierstrai*, were present and this species was expected to occur, but was not collected. A reason for the very low number of species is the lack of suitable habitat and cover present at the site sampled.

A very low catch per unit effort (CPUE) of 0.2 was recorded for this site (10 individuals; 52 minutes), indicating a very low abundance of fish present at the time of the survey.

A Fish Response Index (FRAI) score of 73.0% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Taxa associated with moderate to slow flow biotopes dominated in 2014. Taxa diversity in all the biotopes was the lowest for the ecoregion. In the stones biotope, only families out of a average of 20 for the ecoregion were recorded. This was the same case in every biotope and the overall SASS score. Extremely high sediment deposition and movement was recorded in the stream channel, with severe bank scouring. The bank scouring indicates alteration of catchment hydrology, and with the high sediment inputs it is likely to be as a result of the mining activities at the old iron ore mine in Swaziland.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MLON-KRANS on the Mlondozi was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 33. Results for water quality constituents measured at the Mlondozi stream's site (X1MLON-KRANS) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**25**			
Sampling Date	**17 July 2014**			
Sampling Time	**15h20**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**19.0**			
pH	**8.4**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.1**			
Saturation (%)	**98.1**	80 - 120		
Clarity (cm)	**82**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**34.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**224.5**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.8**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**36**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**8**		<1,000	
Inorganic – Toxic				

Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**<0.025**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

The water temperature was higher than the rest of the sites in the ecoregion, which is attributed to the wideness of the channel (caused by scouring and deposition) and the lack of pools due to the high deposition. Water temperature in the shallow wide channel have therefore altered not only the physical habitat but also the thermal regimes. All water quality results measured and analysed fell within expected ranges (Table 33).

On Site Impacts Recorded

- Extremely high deposition of sediment in the stream substrate;
- Severe stream bank and bed scouring;
- High quantities of domestic waste in the stream and riparian zone, and;
- Cattle trampling of the stream banks.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class CD (59.3%) suggesting a moderately to severely impaired habitat.

MLONDOZI

Site Code	X1MLON-KRANS	**Reach**	X12K-01333
Latitude	-26.05772° S	**Quaternary Catchment**	X12K
Longitude	31.03248° E	**Elevation**	740 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.008	**Geomorphological Zone**	Transitional

Figure 85. Upstream view of the site on the Mlondozi, X1MLON-KRANS (17 July 2014, G Diedericks).

Figure 86. Downstream view of the site on the Mlondozi, X1MLON-KRANS (17 July 2014, G Diedericks).

SQ REACH NUMBER X12K-01332

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X12K-01332	X1MHLA-KRANS	Mhlangampepa	733	S- 26.04997 E 31.05354	C 73.8%	C 73.9%	C 73.9%	C	B 85%	BC 78.6%	16.97

General description

Reach X12K-01332: Mhlangampepa

The Mhlangampepa (Blinkwaterspruit on some maps) originates in the Malolotja Nature Reserve in Swaziland at an elevation of 1,800 m.a.s.l. (Figure 87 & 88). The stream flows in a northern direction (357°) for approximately 17 km towards the Komati River. The sampling point, X1MHLA-KRANS is located approximately 903 m upstream from the streams' confluence with the Komati River, at an elevation of 733 m.a.s.l. The stream at the sampling point is geomorphologically categorised as a transitional zone. A large portion of the catchment falls within the KaNgwane Montane Grassland vegetation type, and in the Swaziland Sour Bushveld closer towards the Komati River. The sampling site (X1MHLA-KRANS) is located in the Swaziland Sour Bushveld. The entire catchment falls within the Northern Escarpment Mountains aquatic ecoregion. The uppermost portion of the catchment falls within a national park in Swaziland, after which the stream flows through South Africa with very little human disturbance until its gets closer to the Komati River confluence. Rural settlements with livestock grazing and subsistence farming is the main land-use outside of the Malolotja National Park.

Fish

This aquatic site sampled is characteristic of a low gradient stream with sequences of riffles, runs and small but deep pools. Fish velocity depth classes present were fast shallow (abundant) fast deep (sparse) and slow deep (moderate). The fish cover present rated moderate for overhanging vegetation as well as for the undercut banks and root wads. The substrate as fish cover was moderate to abundantly present in the form of boulders, rocks, cobbles and pebbles. Six of the expected 15 species of fish for this reach was recorded during the present fish survey. The flow dependent species collected were *Amphilius uranoscopus*, *Labeobarbus marequensis* and *Chiloglanis pretoriae.* Limnophilic species collected were *Barbus anoplus*, *Pseudocrenilabrus philander* and *Tilapia sparrmanii*. The flow dependant *Amphilius uranoscopus* and the small barb, *Barbus anoplus*, were collected within this reach for the first time.

The CPUE (catch per unit effort) calculated for this site is 0.8 (38 individuals; 47 minutes) indicating a low abundance. Although a relative diversity of fish species were collected, the abundance of fish collected was low.

A Fish Response Index (FRAI) score of 73.8% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate to fast flow biotopes dominated in 2014. Taxa diversity in the stones biotope was lower than the average for the ecoregion, but the sensitivity rating was considerably higher. Of all the sites sampled in 2014, this site had the only record of Platycnemididae larvae. Overall the diversity of taxa was lower than the average for the ecoregion, but the sensitivity rating was higher.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MHLA-KRANS on the Mhlangampepa stream was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 34. Results for water quality constituents measured at the Mhlangampepa stream's site (X1MHLA-KRANS) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**24**			
Sampling Date	**17 July 2014**			
Sampling Time	**14h20**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**13.0**			
pH	**8.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**10.9**			
Saturation (%)	**116.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**4.8**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**31.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**11**		<200	<130
Inorganic Salts				

Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**8**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.031**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**<2**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 34).

On Site Impacts Recorded

- High quantities of natural organic matter accumulates in pools areas of the stream, and;
- Some cattle trampling of the stream banks, but most of the stream banks are still intact.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (73.9%) suggesting a moderately impaired habitat.

MHLANGAMPEPA

Site Code	X1MHLA-KRANS	**Reach**	X12K-01332
Latitude	-26.04997° S	**Quaternary Catchment**	X12K
Longitude	31.05354° E	**Elevation**	733 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0208	**Geomorphological Zone**	Transitional

Figure 87. Upstream view of the site on the Mhlangampepa, X1MHLA-KRANS (17 July 2014, G Diedericks).

Figure 88. Downstream view of the site on the Mhlangampepa, X1MHLA-KRANS (17 July 2014, G Diedericks).

SQ REACH NUMBER X13A-01337

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13A-01337	X1MALO-MALOL	Malolotja	815	S- 26.08253 E 31.10888	A 92.%	A 94.5%	A 93.3%	A	A 95%	A 94%	18

General description

Reach X13A-01337: Malolotja

The Malolotja River in Swaziland, originates on the Malolotja Nature Reserve and a small portion (some of the tributaries) on communal lands outside the reserve (Figure 89 & 90). The elevation at the source is 1,700 m.a.s.l. From its origin, the Malolotja River flows in a north-north easterly direction (22°) towards the Komati River. The site is located on the reserve at an elevation of 815 m.a.s.l. Measured along the stream from its source to the confluence with the Komati River is approximately 18 km. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone. A large portion of the catchment falls within the KaNgwane Montane Grassland and the lower portions in the Swaziland Sour Bushveld. The sampling site (X1MALO-MALOL) is located in the Swaziland Sour Bushveld. The upper portion of the catchment falls into the Northern Escarpment Mountains aquatic ecoregion, and the lower portion (and site) within the North Eastern Highlands. A small portion of the catchment is in communal lands, with old mining sites, but the bulk of the catchment drains the Malolotja National Park which is natural grassland mostly in pristine condition. The site is therefore a very good reference, with extremely low sedimentation, and the marginal and riparian vegetation in excellent condition. Stream banks are intact, with no evidence of stream bank scouring.

Fish

This biomonitoring site in the Malolotja River is an upper foothill stream that is representative of the upper catchment high gradient mountain stream. It is characterised as a small mountain streams with multiple riffles, runs and small pools. This stream is largely unimpacted by any anthropogenic influences and appears to be natural. The fish velocity depth classes recorded were slow shallow (sparse) and the fast shallow (very abundant) with the slow deep and fast deep absent. The fish cover present identified was abundant to very abundant with abundant overhanging vegetation and undercut banks and root wads. The substrate rated very abundant in both the slow shallow and fast shallow fish velocity depth classes consisting of boulders, cobbles, pebbles and gravel.

At this site six of the ten expected fish species were recorded. Species collected during the surveys were the reophilic *Labeobarbus polylepis*, *Amphilius natalensis and Amphilius uranoscopus*. Both the highly sensitive

Amphilius species are reophilic, flow dependant species with a high (4.6 to 5) flow-depth preference for fast deep and fast shallow fish velocity depth classes. Both these species are totally intolerant (4.8 to 4.9) to reduced flow conditions, have a very high (5) preference to substrate and is highly intolerant to water quality changes (4.8 to 4.9). Their presence and relative high abundance as recorded at this monitoring site can be explained based on these intolerant ratings. The flow-sensitive species *Chiloglanis pretoriae* and *Chiloglanis emarginatus* were recorded at high abundance indicating a largely unimpacted natural river with a natural flow regime. *Barbus anoplus* were recorded in high abundance (128 individuals), these limnophilic species favours slow flowing water with sufficient plant and root cover. Based on the intolerance rating this species is moderately tolerant to no flow conditions and modified water quality (physico-chemical).

The age classes reflect juveniles, sub-adults and adults indicating that the breeding functions is functional. The CPUE (catch per unit effort) for this site is a very high 16.76 (570 individuals; 34 minutes) which indicates a high species diversity and abundance.

A Fish Response Assessment Index (FRAI) score of 92% was calculated for this reach based on all available information, placing this reach in an Ecological Class A (Largely natural with a high diversity and high abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with fast and moderate flows were dominant, followed by slow and stagnant preferring taxa. Taxa diversity and sensitivity of the stones and vegetation biotopes was above the average for the ecoregion. The gravel/sand/mud biotope was extremely scarce. Overall the diversity and dominance of sensitive taxa was far higher than the average for the ecoregion. Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MALO-MALOL on the Malolotja stream was rated as natural (A-class).

Chemical and Physical Water Quality

Table 35. Results for water quality constituents measured at the Malolotja stream's site (X1MALO-MALOL) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**31**			
Sampling Date	**05 August 2014**			
Sampling Time	**10h10**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**11.6**			
pH	**8.2**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.9**			
Saturation (%)	**124.8**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**5.0**			
Total Dissolved Solids (mg/ℓ)	**32.5**		<1,000	

[EC (mSm @ 25°C) x 6.5]				
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**6**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.137**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

Saturated oxygen was elevated at the time of sampling. In order to meaningfully interpret the results, measuring at 06h00 in the morning over different seasons are required. All water quality results measured and analysed fell within expected ranges (Table 35).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class A (93.3%) suggesting a largely natural habitat.

MALOLOTJA

Site Code	X1MALO-MALOL	**Reach**	X13A-01337
Latitude	-26.08253° S	**Quaternary Catchment**	X13A
Longitude	31.10888° E	**Elevation**	815 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Highlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0143	**Geomorphological Zone**	Upper Foothills

Figure 89. Upstream view of the site on the Malolotja River, X1MALO-MALOL (05 August 2014, G Diedericks).

Figure 90. Downstream view of the site on the Malolotja River, X1MALO-MALOL (05 August 2014, G Diedericks).

SQ REACH NUMBER X13A-01255

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13A-01255	X1NKOM-MALOL	Nkomazana	641	S- 26.02851 E 31.16358	D 57.1%	CD 60.1%	CD 58.6%	CD	CD 60%	CD 59.2%	20.6

General description

Reach X13A-01255: Nkomazana

The Nkomazana River in Swaziland, originates at an elevation of 1,300 m.a.s.l. and is a tributary to the Malolotja River (Figure 91 & 92). From its source to its origin, the Malolotja River flows in a south-south westerly direction (210°) towards the Maguga Dam. The biomonitoring site is located in the Nkomazana River which is approximately 1.2 km upstream (along the River) from the dam. The river length is approximately 20.6 km. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone. A large portion of the catchment falls within the Barberton Montane Grassland and the lower portions in the Swaziland Sour Bushveld. The sampling site (X1NKOM-MALOL) is located in the Swaziland Sour Bushveld. The entire catchment falls into the North Eastern Highlands aquatic ecoregion. The origin and a large portion of the catchment drains commercial forestry plantations, from the river flows through communal lands.

Fish

This biomonitoring site is representative of an upper foothill stream, below 1000 m.a.s.l. This stream is characterised as a moderately inclined mountain stream, dominated by in-stream boulders with increased flow velocities, and a high diversity of habitat types, which includes riffles and runs, cascades and pools. The upper catchment has largely been transformed to monoculture forestry and communal lands. The fish velocity depth classes recorded were fast shallow (very abundant) and slow shallow (sparse) with fast deep and slow deep habitats absent. The fish cover present identified was moderate with moderate overhanging vegetation and moderate undercut banks and root wads. The substrate rated abundant consisting of boulders and cobbles. Sediment and siltation deposits were recorded in the pools where stream velocity is reduced encouraging deposition. This excessive sedimentation results in the loss of available fish habitat as instream structures are embedded, resulting in a loss of interstitial spaces.

During the survey four of the fifteen expected fish species were recorded in relative low abundance, namely *Labeobarbus marequensis, Amphilius uranoscopus, Labeo molybdinus* and *Chiloglanis pretoriae*. The fish assemblage was dominated by reophilic flow dependant 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 habitat deterioration due to siltation and sedimentation. The CPUE (catch per unit effort) for this site is 2.54 (individuals 79; 31 minutes). The CPUE values are extremely low for this reach indicating reduced conditions due to the loss of deep fish velocity depth classes.

A Fish Response Assessment Index (FRAI) score of 57.1% was calculated for this reach based on all available information, placing this reach in an Ecological Class D (severely impaired with a low diversity and low abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate, fast and slow flows were dominant, with taxa associated with stagnant waters scarce. Taxa diversity of the stones was below the average for the ecoregion, but sensitive taxa still dominated. The vegetation and sand/mud/gravel biotopes were below the average for the ecoregion, both in terms of diversity and sensitivity. Overall the diversity was lower than the average for the ecoregion, but sensitive taxa was on average.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1NKOM-MALOL on the Nkomazana stream was rated as moderately to severely impaired (C/D-class).

Chemical and Physical Water Quality

Table 36. Results for water quality constituents measured at the Nkomazana stream's site (X1NKOM-MALOL) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**29**			
Sampling Date	**04 August 2014**			
Sampling Time	**12h40**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**14.5**			
pH	**7.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.4**			
Saturation (%)	**126.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**9.7**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**63.1**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.4**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic		

		0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**31**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.036**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

Saturated oxygen was elevated at the time of sampling. In order to meaningfully interpret the results, measuring at 06h00 in the morning over different seasons are required. All water quality results measured and analysed fell within expected ranges (Table 36).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class CD (58.6%) suggesting a moderately to largely impaired habitat.

NKOMAZANA

Site Code	X1NKOM-MALOL	**Reach**	X13A-01255
Latitude	-26.02851° S	**Quaternary Catchment**	X13A
Longitude	31.16358° E	**Elevation**	641 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Highlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.008	**Geomorphological Zone**	Upper Foothills

Figure 91. Upstream view of the site on the Nkomazana River, X1NKOM-MALOL (04 August 2014, G Diedericks).

Figure 92. Downstream view of the site on the Nkomazana River, X1NKOM-MALOL (04 August 2014, G Diedericks).

SQ REACH NUMBER X13B-01276

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13B-01276	X1MKHO-MAGUG	Mkhomazane	652	S- 26.03989 E 31.26615	C 64.3%	C 66.7%	C 65.5%	C	C 70%	C 67.4%	18.1

General description

Reach X13B-01276: Mkhomazane

The Mkhomazane River in Swaziland, originates at an elevation of 1,374 m.a.s.l. (Figure 94 & 95). From its origin, the Mkhomazane River flows in a south-south easterly direction (153°) towards the Maguga Dam. The site is located 903 m upstream (along the river) from the Maguga Dam. The river length is approximately 18.1 km. Geomorphologically the stream at the sampling point is categorised as a transitional zone. The entire upper portion of the catchment drains through Peak Timbers and Swaziland Timbers. The vegetation type is described as Swaziland Sour Bushveld. The sampling site (X1MKHO-MAGUG) and catchment falls into the North Eastern Highlands aquatic ecoregion. The origin and a large portion of the catchment drains commercial forestry plantations, flows past a sawmill and more commercial forestry land before flowing through rural settlement areas. This reach is partly inundated by the Maguga Dam. Impacts and activities in this reach include forestry, settlements, subsistence farming and grazing.

Fish

This biomonitoring site is upstream from the Maguga Dam at a river crossing forming a deep pool upstream from the crossing and riffles and runs downstream from the crossing. All of the fish velocity depth classes were present which included fast shallow (moderate), fast deep (moderate), slow shallow (sparse) and slow deep (moderate). The fish cover present rated moderately to abundant for overhanging vegetation and moderate for undercut banks and root wads. The substratum varied from moderate to abundant for the fast habitats and consisted of boulders, rocks, cobbles and pebbles and sparse for the slow habitats which consisted of sand and silt. The fish assemblage recorded at the site consisted of three indigenous fish species of an expected 15 species as well as one exotic fish species, *Micropterus salmoides*. The three indigenous species, *Amphilius uranoscopus*, *Labeobarbus polylepis* and *Chiloglanis pretoriae*, are all reophilic species. Some (30%) of the *A. uranoscopus* were infected with a digenean parasite forming white spots all over the body of the fish.

The CPUE (catch per unit effort) calculated for this site is 0.6 (29 individuals; 51 minutes) indicating a very low abundance of fish present. Reasons for this low abundance may be the presence of the piscivorous alien and invasive fish, *Micropterus salmoides* and the close proximity of the Maguga Dam.

A Fish Response Index (FRAI) score of 64.3% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with fast, moderate, and slow flows were dominant, with taxa associated with stagnant waters also fairly abundant. Taxa diversity and sensitivity ratings of the stones biotope was below the average for the ecoregion. The vegetation and sand/mud/gravel biotopes were below the average for the ecoregion, both in terms of diversity and sensitivity. Overall the diversity was lower than the average for the ecoregion, but sensitive taxa was on average.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MKHO-MAGUG on the Mkhomazane stream was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 37. Results for water quality constituents measured at the Mkhomazane stream's site (X1MKHO-MAGUG) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**55**			
Sampling Date	**20 August 2014**			
Sampling Time	**15h10**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**17.9**			
pH	**7.8**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.5**			
Saturation (%)	**88.9**	80 - 120		
Clarity (cm)	**60**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**7.8**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**50.7**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.6**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**2,000**		<200	<130
Inorganic Salts				

Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**8**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.528**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**8**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was relatively low, and there was extremely high counts of E coli. Other water quality results measured and analysed fell within expected ranges (Table 37).

On Site Impacts Recorded

- Sand mining in the stream and riparian zone;
- Poor road drainage, allowing loose soil from the road entering the stream directly during rainfall events (Figure 93);
- High sediment deposition in the stream, and;
- High quantities of domestic waste in the stream and riparian zone.

Figure 93. The road approach is steep without drainage, and a gravel source is located next to the river. This results in high sediment inputs into the river during rainfall events (20 August 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (65.5%) suggesting a moderately impaired habitat.

MKHOMAZANE

Site Code	X1MKHO-MAGUG	**Reach**	X13B-01276
Latitude	-26.03989° S	**Quaternary Catchment**	X13B
Longitude	31.26615° E	**Elevation**	652 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Highlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0284	**Geomorphological Zone**	Transitional

Figure 94. Upstream view of the site on the Mkhomazane River, X1MKHO-MAGUG (20 August 2014, G Diedericks).

Figure 95. Downstream view of the site on the Mkhomazane River, X1MKHO-MAGUG (20 August 2014, G Diedericks).

SQ REACH NUMBER X13C-01364

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13C-01364	X1MBUY-MKHOM	Mbuyane	632	S- 26.12210 E 31.29630	D 56.7%	D 57.3%	D 57%	C	C 70%	C 62.6%	38.8

General description

Reach X13C-01364: Mbuyane

The Mbuyane River (also Mkhomati on other maps) in Swaziland, originates at an elevation of 1,300 m.a.s.l. (Figure 97 & 98). From its origin, the Mbuyane River first flows in a south easterly direction (137°) from where it turns north (3°) towards the point where it merges with the Komati River. The Mbuyane River merges with the Komati River 6.8 km downstream (along the river) from the dam. The X1MBUY-MKHOM site is located 6.3 km (along the river) from its confluence with the Komati River. The river length is stated as 38.8 km, but the measurements on Google Earth is incorrect. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone. The upper portion of the catchment is located in the KaNgwane Montane Grassland veld type, merging into the Swaziland Sour Bushveld in its lower reaches. The catchment falls within four aquatic ecoregions, namely the Highveld, Northern Escarpment Mountains, North Eastern Highlands and Lowveld. The sampling site (X1MBUY-MKHOM) is located in the Lowveld aquatic ecoregion, at an elevation of 632 m.a.s.l.
Land-use in the catchment primarily is rural settlement areas, with a high degree of subsistence farming.

Fish

This river can be characterised as a relative small upper foothill stream that has been largely transformed due to intensive sedimentation resulting in a loss of available fish habitat. The fish velocity depth classes recorded were fast shallow (very abundant) and slow shallow (sparse) with slow deep and fast deep absent. Due to the sedimentation no deep habitats could be located and the only intact fish habitat observed were artificially created below a low water bridge. It is at this remaining habitat that all the fish were collected. The fish cover present identified was sparse with sparse overhanging vegetation and undercut banks and root wads. The substrate rated sparse and consisted of gravel and sand with isolated rocks.

Only three flow sensitive species of the expected 15 fish species were recorded namely *Chiloglanis pretoriae, Chiloglanis emarginatus and Amphilius uranoscopus.* These species were recorded at relative abundance at the only remaining fish habitat.

Excessive siltation and sedimentation in the upper catchment results in filling of interstitial spaces modifying the substratum (boulders, cobbles, stones and gravel) causing reduced available fish habitat. This modified in-stream fish habitat impacts negatively on these sensitive 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 habitat deterioration due to excessive siltation and sedimentation. The CPUE (catch per unit effort) for this reach is 3.35 (104 individuals;31 minutes) which indicate a reduced CPU at this site.

A Fish Response Assessment Index (FRAI) score of 56.7% was calculated for this reach based on all available information, placing this reach in an Ecological Class D (Severely impaired with a low diversity and low abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate and fast flows were dominant, with taxa associated with slow and stagnant waters present. Taxa diversity and sensitivity ratings of the stones biotope was below the average for the ecoregion. The vegetation biotope diversity was higher than the average for the ecoregion, but the sensitivity rating was lower. The diversity in the gravel/sand/mud biotopes were lower than the average for the ecoregion, but the sensitivity rating was higher. Overall the diversity was lower than the average for the ecoregion, but sensitive taxa was more than the average. Sediment inputs, deposition and movement is high, which limits habitat availability, and poor conditions are attributed to habitat alterations rather than water quality.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MBUY-MKHOM on the Mbuyane stream was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 38. Results for water quality constituents measured at the Mbuyane stream's site (X1MBUY-MKHOM) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	**Livestock Use**	**Recreational Use**
Water Sample No.	**32**			
Sampling Date	**05 August 2014**			
Sampling Time	**13h25**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**17.3**			
pH	**8.2**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.0**			
Saturation (%)	**128.3**	80 - 120		
Clarity (cm)	**70**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**4.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**29.9**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			

Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.4**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**370**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.236**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was relatively low, and there were high counts of E coli. Other water quality results measured and analysed fell within expected ranges (Table 38).

On Site Impacts Recorded

- Extremely high sediment deposition;
- High embeddedness. The rocks are very difficult to move, suggesting that high sediment inputs have been problematic in this system for several years;
- High degree of stream bank scouring;
- The road approach to the bridge is steep with no drainage. Loose soils from the road enters the stream directly during rainfall events (Figure 96), and;
- Weed infestation in the riparian zone is relatively high.

Figure 96. The road approach from both sides of the stream is steep with no drainage. Loose soil from the road enters the river directly during rainfall events (05 August 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class D (57%) suggesting a largely impaired habitat.

MBUYANE

Site Code	X1MBUY-MKHOM	**Reach**	X13C-01364
Latitude	-26.12210° S	**Quaternary Catchment**	X13C
Longitude	31.29630° E	**Elevation**	632 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0182	**Geomorphological Zone**	Upper Foothills

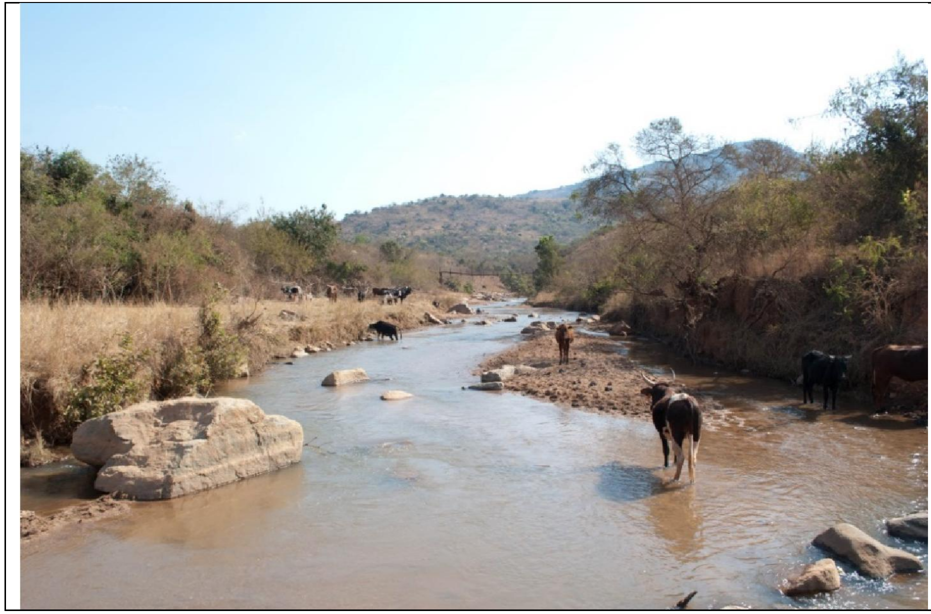

Figure 97. Upstream view of the site on the Mbuyane River, X1MBUY-MHKOM (05 August 2014, G Diedericks).

Figure 98. Downstream view of the site on the Mbuyane River, X1MBUY-MHKOM (05 August 2014, G Diedericks).

SQ REACH NUMBER X13E-01389

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13E-01389	X1NYON-NYONY	Nyonyane	359	S- 26.13236 E 31.48093	C 74.7%	D 53.6%	C 64.2%	C	C 70%	C 66.7%	9

General description

Reach X13E-01389: Nyonyane

The Nyonyane River in Swaziland, originates at an elevation of 1,200 m.a.s.l, flowing first in an easterly and then a north-easterly direction towards the point where it merges with the Komati River (Figure 99 & 100). The X1NYON-NYONY site is located 2.6 km (along the river) upstream from the Nyonyane's confluence with the Komati River. The reach length provided is 9.0 km, but when measured accurately it is actually 10.6 km, an error of 15.3%. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone.

The entire catchment is located in the Granite Lowveld, and within the Lowveld aquatic ecoregion. The sampling site (X1NYON-NYONY) is at an elevation of 359 m.a.s.l. Land-use in the catchment primarily is rural settlement areas, with a high degree of subsistence farming. There are sugar cane plantation downstream from the sampling point.

Fish

This stream is characterised as a moderately inclined mountain stream, dominated by in-stream boulders with increased flow velocities, and a high diversity of habitat types, which includes riffles and runs, cascades and pools. The catchment has largely been transformed by rural development and subsistence farming within the riparian zone, resulting in a loss of habitat such as overhanging vegetation with undercut banks. Due to the high erodability of the soils and landuse practise, siltation and sedimentation is a major problem. The excessive siltation reduce available fish habitat within riffle and run areas, as the rocks and boulders are embedded in sediments resulting in a loss of interstitial spaces. The fish velocity depth classes recorded were only limited to shallow habitats - fast shallow (abundant) and slow shallow (moderate) - with the deep habitats (slow deep and fast deep) absent due to sediment deposition. The fish cover present identified was sparse with sparse overhanging vegetation and undercut banks and root wads. The substrate also rated sparse. Sediment and siltation deposits were recorded in the pools where stream velocity is reduced encouraging deposition.

In spite of poor habitat ratings, the fish assemblage were better than expected with seven of the sixteen fish species recorded. Three of the species collected were reophilic species, *Labeobarbus marequensis, Labeo* *cylindricus and Barbus trimaculatus*, whilst *Chiloglanis pretoriae, Chiloglanis emarginatus and Barbus eutaenia* were flow sensitive species collected at this site. The presence of Chiloglanis emarginatus is unique as the red data status of this species is near threatened with this endemic species only occurring in tributaries of the Phongola and Komati rivers. According to literature (Skelton, 2001) this species is threatened by water abstraction, river regulation and sedimentation. This highly sensitive species is flow dependant with a high flow-depth preference for fast deep (5) and fast shallow (3.2) fish velocity depth classes. *Chiloglanis emarginatus* is also totally intolerant (5) to reduced flow conditions and have a very high (5) preference to substrate. It is highly intolerant to modified water quality (5). 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 habitat deterioration due to siltation and sedimentation.

The age classes for the species collected reflected juveniles, sub-adults and adults, indicating that the breeding function for this species is not disrupted at present and a viable population exist. The CPUE (catch per unit effort) for this site is 11.3 (362 individuals; 32 minute) indicating a high abundance. Most of the species collected were at an artificially created riffle downstream of a bridge where increased water velocities scour habitat , creating the preferred fish habitat for reophilic fish species presenting a skewed CPUE. The above results indicate the importance of these small streams as refugia streams to fish survival in the greater Komati River System.

A Fish Response Assessment Index (FRAI) score of 74.7% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (Moderately impaired with a low diversity and moderate abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate and slow flows were dominant, with taxa associated with fast and stagnant waters present. Taxa diversity and sensitivity ratings of the stones biotope was below the average for the ecoregion. The vegetation biotope diversity was lower than the average for the ecoregion, and sensitivity rating similar. The diversity in the gravel/sand/mud biotopes were similar to the average for the ecoregion, but the sensitivity rating was lower. Overall both the diversity and sensitivity rating was lower than the average for the ecoregion. Sediment inputs, deposition and movement is high which limits habitat quality and availability. Poor conditions are attributed to habitat alterations.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1NYON-NYONY on the Nyonyane stream was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 39. Results for water quality constituents measured at the Nyonyane stream's site (X1NYON-NYONY) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**35**			
Sampling Date	**05 August 2014**			
Sampling Time	**12h20**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**18.0**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.2**			
Saturation (%)	**99.1**	80 - 120		
Clarity (cm)	**38**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**6.0**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**39.0**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**980**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**7**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.403**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**7**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was extremely low, and there were very high counts of E coli. Other water quality results measured and analysed fell within expected ranges (Table 39).

On Site Impacts Recorded

- Extremely high sediment deposition, and;
- High quantities of domestic waste in the stream and riparian zone.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (64.2%) suggesting a moderately to largely impaired habitat.

NYONYANE

Site Code	X1NYON-NYONY	**Reach**	X13E-01389
Latitude	-26.13236° S	**Quaternary Catchment**	X13E
Longitude	31.48093° E	**Elevation**	359 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0143	**Geomorphological Zone**	Upper Foothills

Figure 99. Upstream view of the site on the Nyonyane River, X1NYON-NYONY (06 August 2014, G Diedericks).

Figure 100. Downstream view of the site on the Nyonyane River, X1NYON-NYONY (06 August 2014, G Diedericks).

SQ REACH NUMBER X13F-01252

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13F-01252	X1MZIM-MANSE	Mzimnene	331	S- 26.04071 E 31.52635	C 76.3%	D 55.7%	C 66%	CD	D 50%	CD 59.1%	35.89

General description

Reach X13F-01252: Mzimnene

The Mzimnene River in Swaziland, originates at an elevation of 920 m.a.s.l. on Peak Timbers, flowing in a south-east by easterly direction towards its confluence with the Komati River (Figure 101 &102). The X1MZIM-MANSE site is located 7.2 km (along the river) upstream from the Mzimnene's confluence with the Komati River. The reach length provided is 35.9 km. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The entire catchment is located in the Granite Lowveld, and within the Lowveld aquatic ecoregion. The sampling site (X1MZIM-MANSE) is at an elevation of 331 m.a.s.l. Land-use in the catchment includes commercial forestry in the upper catchment, and rural settlement areas, with a high degree of subsistence farming further downstream. Sugarcane plantations are located closer to the Komati River.

Fish

The biomonitoring site sampled for fish consisted of long shallow sandy runs and shallow pools. The two fish velocity depth classes present were fast shallow (abundant) and slow shallow (moderate). Overhang vegetation and undercut banks and root wads as fish cover was sparse. Substrate as cover was a few rocks and boulders embedded in sand. No historical fish species information is available for this reach. The fish assemblage recorded at the site consisted of nine species of an expected 20 species for this reach. Seven of the nine species recorded are flow sensitive species and were the following: *Amphilius uranoscopus*, *Barbus trimaculatus*, *Labeobarbus marequensis*, *Opsaridium peringueyi, Labeo cylindricus, Chiloglanis paratus* with the habitat specialist, *Chiloglanis swierstrai*, also present. Limnophilics collected were *Clarias gariepinus* and *Oreochromis mossambicus*.

The CPUE (catch per unit effort) calculated for this site is 2.1 (101 individuals; 48 minutes) indicating a relative abundance of fish present. *Barbus trimaculatus* was the most abundant species (36).

A Fish Response Index (FRAI) score of 76.3% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate and slow flows were dominant, with taxa associated with stagnant and fast flows present. Taxa diversity and sensitivity ratings of the stones and vegetation biotopes was far below the average for the ecoregion. The gravel/sand/mud biotope had higher diversity than the average for the ecoregion and the sensitivity rating was lower. Over all the diversity and sensitivity rating for the site was lower than the average for the ecoregion. Habitat quality and availability is regarded as the main limitation to current conditions.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MZIM-MANSE site on the Mzimnene stream was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 40. Results for water quality constituents measured at the Mzimnene stream's site (X1MZIM-MANSE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**54**			
Sampling Date	**20 August 2014**			
Sampling Time	**12h30**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**25.5**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**6.6**			
Saturation (%)	**91.4**	80 - 120		
Clarity (cm)	**22**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**11.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**75.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.4**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**2,000**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*****			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**21**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	

Iron (Fe) mg/ℓ	**0.461**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**12**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was extremely low, and there were extremely high counts of E coli. Other water quality results measured and analysed fell within expected ranges (Table 40).

On Site Impacts Recorded

- Severe stream bank and bed scouring;
- Extremely high sediment deposition;
- High quantities of domestic waste in the stream and riparian zone;
- Sand is mined from the river and riparian zone, and;
- The site is used extensively for the washing of cars and clothes (e.g. phosphates, hydrocarbon inputs).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (66%) suggesting a moderately impaired habitat.

MZIMNENE

Site Code	X1MZIM-MANSE	**Reach**	X13F-01252
Latitude	-26.04071° S	**Quaternary Catchment**	X13F
Longitude	31.52635° E	**Elevation**	331 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVl 3: Granite Lowveld
River Gradient	0.0031	**Geomorphological Zone**	Lower Foothills

Figure 101. Upstream view of the site on the Mzimnene River, X1MZIM-MANSE (06 August 2014, G Diedericks).

Figure 102. Downstream view of the site on the Mzimnene River, X1MZIM-MANSE (06 August 2014, G Diedericks).

SQ REACH NUMBER X13G-01216

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13G-01216	X1MBUL-MPHOF	Mbulatana	320	S- 25.92469 E 31.52623	B 84.5%	C 64.1%	C 74.3%	C	C 70%	C 72.5%	19

General description

Reach X13G-01216: Mbulatana

The Mbultana River in Swaziland, originates at an elevation of 980 m.a.s.l close to the Vusweni settlement area, flowing in a south-east by easterly direction towards its confluence with the Mphofu River (Figure 103 & 104). The X1MBUL-MPHOF site is located 920 m (along the river) upstream from the Mbulatana's confluence with the Mphofu River. The reach length provided is 19.0 km. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The entire catchment is located in the Granite Lowveld, and within the Lowveld aquatic ecoregion. The sampling site (X1MBUL-MPHOF) is at an elevation of 320 m.a.s.l. Land-use in the catchment primarily is rural settlement areas, with a high degree of subsistence farming.

Fish

This biomonitoring site is representative of a lower foothill stream, but with elements of both highveld and lowveld aquatic ecoregions. It is characterised as a low inclined, multiple channelled stream with some anastomosing and anabranching. The substratum is dominated by bedrock and contains multiple runs, some riffles, glides and large pools. The riparian vegetation is well-developed providing additional habitat such as overhanging vegetation, root wads and undercut banks, and creates habitat for habitat specialists such as the Mormyridae. The fish velocity depth classes recorded were slow deep (moderate), fast shallow (moderate) and slow shallow (moderate) with fast deep (sparse). The fish cover present identified was moderate with moderate overhanging vegetation and moderate undercut banks and root wads. The substrate varied between sparse and moderate in both the fast and slow fish velocity depth classes.

Fish species unique to the area include *Chiloglanis paratus, Chiloglanis swierstrai, Barbus eutaenia, Barbus radiatus and Barbus afrohamiltoni.* At this site thirteen of the expected eighteen fish species were recorded in high abundance. The species diversity included limnophilic species favouring slow flowing water, although during certain phases of life history stages a biotope of flowing water is required. These included *Barbus trimaculatus, Labeobarbus marequensis, Labeo cylindricus and Labeo molybdinus*. For most of the fish species all the age classes, juveniles, sub-adult and adult, were reflected indicating that the breeding function is functional. The

CPUE (catch per unit effort) for this site is 23.5 (965 individuals; 41 minute) which indicate a high diversity and abundance of recorded species.

A Fish Response Assessment Index (FRAI) score of 84.5% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity and abundance of species). The relative high ecological class B can be related to habitat diversity and available fish habitat.

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with stagnant water and slow flows were dominant, with taxa associated with moderate and fast flows present. Taxa diversity and sensitivity ratings of the stones biotope was below the average for the ecoregion. The vegetation biotope diversity was higher than the average for the ecoregion, and sensitivity rating lower. Both the diversity and sensitivity rating in the gravel/sand/mud biotopes were lower than the average for the ecoregion. Overall both the diversity and sensitivity rating was lower than the average for the ecoregion. Sediment inputs, deposition and movement is high which limits habitat quality and availability. The site is extensively used for washing cars and clothes. Poor conditions are attributed to habitat alterations.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MBUL-MPHOFsite on the Mbulatana stream was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 41. Results for water quality constituents measured at the Mbulatana stream's site (X1MBUL-MPHOF) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**39**			
Sampling Date	**07 August 2014**			
Sampling Time	**11h15**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**17.2**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**9.0**			
Saturation (%)	**106.7**	80 - 120		
Clarity (cm)	**37**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**17.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**113.8**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.5**		<100	

Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1,600**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**20**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.821**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**19**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was extremely low, and there were extremely high counts of E coli. Chloride and sodium levels were elevated, especially when compared to other sites in the ecoregion. High chloride levels are generally associated with the discharge of sewage and some industrial effluents. Other water quality results measured and analysed fell within expected ranges (Table 41).

On Site Impacts Recorded

- Extremely high sediment deposition;
- High quantities of domestic waste in the stream and riparian zone;
- Sand is mined from the river and riparian zone for brick-making;
- Road drainage is poor, allowing for loose soil to enter the river during rainfall events, and;
- The site is used extensively for the washing of cars and clothes (e.g. phosphates, hydrocarbon inputs), which provides insight into the regard for freshwater ecosystems.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (74.3%) suggesting a moderately impaired habitat.

MBULATANA

Site Code	X1MBUL-MPHOF	**Reach**	X13G-01216
Latitude	-25.92469° S	**Quaternary Catchment**	X13G
Longitude	31.52623° E	**Elevation**	320 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0065	**Geomorphological Zone**	Lower Foothills

Figure 103. Upstream view of the site on the Mbulatana River, X1MBUL-MPHOF (07 August 2014, G Diedericks).

Figure 104. Downstream view of the site on the Mbulatana River, X1MBUL-MPHOF (07 August 2014, G Diedericks).

SQ REACH NUMBER X13G-01259

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13G-01259	X1MPHO-MPHOF	Mphofu	291	S- 25.93154 E 31.58150	AB 88.1%	D 54.1%	C 71.1%	C	CD 60%	C 66.3%	12.82

General description

Reach X13G-01259: Mphofu

The Mphofu River in Swaziland, originates at an elevation of 860 m.a.s.l., flowing in an east by southerly direction towards its confluence with the Komati River (Figure 105 &106). The X1MPHO-MPHOF site is located 6.0 km (along the river) upstream from the Mphofu's confluence with the Komati River. The reach length provided is 12.8 km. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The entire catchment is located in the Granite Lowveld, and within the Lowveld aquatic ecoregion. The sampling site (X1MPHO-MPHOF) is at an elevation of 291 m.a.s.l. Land-use in the catchment primarily is rural settlement areas, with a high degree of subsistence farming. Sugarcane plantations are located closer to the Komati River.

Fish

This river reach in the Mphofu River is representative of a lower foothill stream, with elements of the temperate lowveld aquatic ecoregions. This reach is dominated by a sandy substratum and contains multiple runs, some riffles, glides and large pools. It is characterised as a low inclined, multiple channelled stream with some anastomosing and anabranching with abundant instream vegetation. The riparian vegetation is well-developed providing additional habitat such as overhanging vegetation, root wads and undercut banks, and creates habitat for habitat specialists such as the Mormyridae. The fish velocity depth classes recorded were only the shallow fish velocity depth classes which comprised of fast shallow (moderate) and slow shallow (moderate). The deep depth class (fast deep; slow deep) were totally absent due to excessive siltation. The fish cover present identified was abundant with abundant overhanging vegetation and abundant undercut banks and root wads. The substrate rated abundant with gravel, cobbles and rocks.

Reophilic fish species recorded were *Labeobarbus marequensis, Labeo cylindricus and Chiloglanis pretoriae and Chiloglanis swierstrai.* The limnophilic species favouring slow flowing water recorded were *Barbus unitaeniatus, Barbus viviparus*, the mormyrid species *Marcusenius macroplepidotus* and the two Cichlidae species *Oreochromis mossambicus and Coptodon rendalli.* At this site thirteen of the expected sixteen fish species were recorded in high abundance. For most of the fish species all the age classes, juveniles, sub-adult and adult, were reflected indicating that the breeding function is functional. The CPUE (catch per unit effort) for this site is 28.2 (933 individuals; 33 minute) which indicate a high diversity and abundance of recorded species.

A Fish Response Assessment Index (FRAI) score of 88.1% was calculated for this reach based on all available information, placing this reach in an Ecological Class AB (slightly impaired with a high diversity and abundance of species). The relative high ecological class AB can be related to habitat diversity and available fish habitat.

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate and slow flows were dominant, with taxa associated with stagnant and fast flows present. Taxa diversity and sensitivity ratings of the stones biotope was far below the average for the ecoregion. The vegetation and gravel/sand/mud biotope had higher diversity than the average for the ecoregion and the sensitivity rating was lower. Overall the diversity was lower than the average for the ecoregion, but the sensitivity rating was slightly higher. Habitat quality and availability is regarded as the main limitation to current conditions.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MPHO-MPHOF site on the Mphofu stream was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 42. Results for water quality constituents measured at the Mphofu stream's site (X1MPHO-MPHOF) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**38**			
Sampling Date	**07 August 2014**			
Sampling Time	**09h35**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**16.2**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.8**			
Saturation (%)	**100.2**	80 - 120		
Clarity (cm)	**31**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**18.2**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**118.3**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.6**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic		

		2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1,000**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4)	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**21**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.758**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**20**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was extremely low, and there were extremely high counts of E coli. Chloride and sodium levels were elevated, especially when compared to other sites in the ecoregion. High chloride levels are generally associated with the discharge of sewage and some industrial effluents. Other water quality results measured and analysed fell within expected ranges (Table 42).

On Site Impacts Recorded

- Extremely high sediment deposition;
- High quantities of domestic waste in the stream and riparian zone;
- Sand is mined from the river and riparian zone for brick-making;
- Road drainage is poor, allowing for loose soil to enter the river during rainfall events, and;
- The site is used extensively for the washing of cars and clothes (e.g. phosphates, hydrocarbon inputs).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (71.1%) suggesting a moderately impaired habitat.

MPHOFU

Site Code	X1MPHO-MPHOF	**Reach**	X13G-01259
Latitude	-25.93154° S	**Quaternary Catchment**	X13G
Longitude	31.58150° E	**Elevation**	291 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0029	**Geomorphological Zone**	Lower Foothills

Figure 105. Upstream view of the site on the Mphofu River, X1MPHO-MPHOF (07 August 2014, G Diedericks).

Figure 106. Downstream view of the site on the Mphofu River, X1MPHO-MPHOF (07 August 2014, G Diedericks).

SQ REACH NUMBER X13J-01141

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13J-01141	X1MZIN-MASHU	Mzinti	255	S- 25.69248 E 31.73264	C 75%	C 62.4%	C 68.7%	C	C 70%	C 69.3%	43.43

General description

Reach X13J-01141: Mzinti

The Mzinti River originates in Swaziland at an elevation of 580 m.a.s.l, flowing in a north-east by easterly direction (54°) towards its confluence with the Komati River (Figure 107 &108). The X1MZIN-MASHU site is located 32.8 km from its source, 20.2 km downstream from the Mbambiso Dam, and 9.9 km upstream from the confluence with the Komati River. The site is located at the Mashushe Shangwe Nature Reserve, at an elevation of 255 m.a.s.l. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The entire catchment is located in the Granite Lowveld, and within the Lowveld aquatic ecoregion. Land-use in the catchment includes rural settlement areas, with a high degree of subsistence farming further downstream.

Impacts and activities in this reach include the Boschfontein Dam, urbanisation, small and large scale agricultural practises.

Fish

The site on this first order stream consisted of mainly shallow riffles and long stretches shallow sandy runs and pools. At this biomonitoring site only two fish velocity depth classes were present: fast shallow (abundant) and slow shallow (moderate). No slow deep or fast deep habitat was present. Overhanging vegetation present as fish cover rated moderate with no undercut banks and root wads, except for a large dead tree with roots in a pool providing good cover for fish. Most of the limnophilic species, *Barbus trimaculatus* and *Oreochromis mossambicus* were found here. The substrate in the slow shallow habitats were moderate consisting of a few boulders, rocks and cobbles embedded in sand, resulting in loss of interstitial spaces causing a loss of available fish habitat. The fish assemblage recorded at the site consisted of eight species of an expected 19 species for this reach. The reophilic species collected were *Chiloglanis pretoriae, Labeobarbus marequensis* and *Opsaridium peringueyi.* The limnophilic species were *Barbus trimaculatus*, *Barbus paludinosus*, *Oreochromis mossambicus* and the more temperate species, *Barbus toppini* and *Coptodon rendalli*. *C. rendalli* was previously known as *Tilapia rendalli*.

The CPUE (catch per unit effort) calculated for this site is 4.4 (123 individuals; 28 minutes) indicating a high abundance of fish present.

A Fish Response Index (FRAI) score of 75.0% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with stagnant waters, and moderate to slow flows were dominant, while taxa associated with fast flows were present but at low diversity and abundance. Taxa diversity and sensitivity ratings of the stones biotope was far below the average for the ecoregion. The vegetation and gravel/sand/mud biotopes had higher diversity and sensitivity ratings than the average for the ecoregion. Overall the diversity and sensitivity rating for the site was lower than the average for the ecoregion. Habitat quality and availability is regarded as the main limitation to current conditions, but there are also chemical water quality results likely to affect the aquatic community.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MZIN-MASHU site on the Mzinti stream was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 43. Results for water quality constituents measured at the Mzinti stream's site (X1MZIN-MASHU) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**50**			
Sampling Date	**19 August 2014**			
Sampling Time	**08h10**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**16.5**			
pH	**8.1**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.9**			
Saturation (%)	**89.7**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**98.6**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**640.9**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic		

		2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**29**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*****			
Sulphate (SO_4) mg/ℓ	**15**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**169**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**<0.025**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**113**		<2,000	

* = Not measured by Laboratory NA = Not available

Compared to other sites in the ecoregion, electrical conductivity, chloride and sodium levels were considerably higher. Other water quality results measured and analysed fell within expected ranges (Table 43).

On Site Impacts Recorded

- Severe stream bank and bed scouring;
- Extremely high sediment deposition;
- High quantities of domestic waste in the stream and riparian zone;
- High growth of filamentous green algae in marginal vegetation.;
- Sand is mined from the river and riparian zone, and;
- The site is used extensively for the washing of cars and clothes (e.g. phosphates, hydrocarbon inputs), which provides insight into the regard for freshwater ecosystems.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (68.7%) suggesting a moderately impaired habitat.

MZINTI

Site Code	X1MZIN-MASHU	**Reach**	X13J-01141
Latitude	-25.69248° S	**Quaternary Catchment**	X13J
Longitude	31.73264° E	**Elevation**	255 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0029	**Geomorphological Zone**	Lower Foothills

Figure 107. Upstream view of the site on the Mzinti River, X1MZIN-MASHU (19 August 2014, G Diedericks).

Figure 108. Downstream view of the site on the Mzinti River, X1MZIN-MASHU (19 August 2014, G Diedericks).

SQ REACH NUMBER X13K-01068

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13K-01068	X1NKWA-COOPE	Nkwakwa	139	S- 25.53515 E 31.95017	C 68.1%	D 42.4%	D 55.3%	D	D 50%	D 53%	44.67

General description

Reach X13K-01068: Nkwakwa

The Nkwakwa River (Ngwenyi on some maps) originates south-east from the village of Goba close to the South Africa-Mozambique border, at an elevation of 480 m.a.s.l. (Figure 109 &110). The reach length is estimated as 44.7 km. The site (X1NKWA-COOPE) at an elevation of 139 m.a.s.l., is located 1.2 km upstream from the streams confluence with the Komati River. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The upper portion of the catchment is located in the Southern Lebombo Bushveld veld type, and the lower and largest portion of the catchment in the Tshokwane-Hlane Basalt Lowveld. The entire catchment falls within the Lebombo Uplands aquatic ecoregion. The land-use includes mainly towns, rural settlements, and sugarcane with several small dams. Impacts and activities in this reach are mainly agriculture.

Fish

The site on this first order stream consisted of mainly very shallow riffles and long pools. At this biomonitoring site three fish velocity depth classes were present: fast shallow (moderate) and slow shallow (moderate) and slow deep (moderate). No fast deep habitat was present. Overhanging vegetation present as fish cover rated moderate with moderate undercut banks and root wads. The substrate as cover in the slow/fast habitats was sparse consisting of cobbles embedded in sand, resulting in loss of interstitial spaces causing a loss of available fish habitat. In the slow shallow and the slow deep the substrate was also sparse with siltation evident. The fish assemblage recorded at the site consisted of six species of an expected 17 species for this reach. All the species collected were in very low numbers with *Micralestes acutidens* (7) the most abundant species. No reophilic species was collected. Semi-reophilics collected was *Micralestes acutidens* and lmnophylics collected were *Clarias gariepinus, Oreochromis mossambicus, Glossogobius giuris, Barbus trimaculatus* and *Barbus toppini*. The lack of suitable habitat is a reason for the low diversity and abundance of species, but water quality may also play a role.

The CPUE (catch per unit effort) calculated for this site is 0.8 (16 individuals; 20 minutes) indicating a low abundance of fish present.

A Fish Response Index (FRAI) score of 68.1% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with slow flows and stagnant waters were dominant, while taxa associated with moderate and fast flows were present but at low diversity and abundance. Taxa diversity and sensitivity ratings at all biotopes were well below average for the ecoregion. Overall the diversity and sensitivity rating were also well below the average for the ecoregion. The instream habitat was heavily disturbed, with very high deposition of organic material (fine and coarse), and based on the water quality results, there are serious water quality issues.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1NKWA-COOPE site on the Nkwakwa River was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 44. Results for water quality constituents measured at the Nkwakwa River site (X1NKWA-COOPE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**58**			
Sampling Date	**21 August 2014**			
Sampling Time	**16h00**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**22.4**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.4**			
Saturation (%)	**84.8**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**172.0**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**1118.0**		<1,000	
Chemical Oxygen Demand (COD mg/ℓ)	**16**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**4.0**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**130**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**57**		<1,000	

Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**302**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**<0.025**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**154**		<2,000	

* = Not measured by Laboratory NA = Not available

Levels of calculated total dissolved solids suggests the water is unsuitable for consumption by livestock or wild animals. Nitrates, E coli, chloride and sodium levels were considerably higher than levels measured compared to other sites in the ecoregion. Cultivation of sugarcane crops occur within riparian zones, and the riparian areas left unplanted are severely infested with exotic and invasive weed species, reducing their filtering capacity. Poor water quality is attributed to a combination of pollution inputs from sugarcane crops and settlement areas in the upper catchment. Other water quality results measured and analysed falls within expected ranges (Table 44).

On Site Impacts Recorded

- Commercial crops are planted in riparian zones;
- Riparian zones are severely infested with exotic and invasive weed species; and
- High deposition of organic matter and sediments, dominating the stream substrate

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class D (55.3%) suggesting a severely impaired habitat.

NKWAKWA

Site Code	X1NKWA-COOPE	**Reach**	X13K-01068
Latitude	-25.53515° S	**Quaternary Catchment**	X13K
Longitude	31.95017° E	**Elevation**	139 m.a.s.l.
Aquatic Ecoregion Lev I	12. Lebombo Uplands	**Aquatic Ecoregion Lev II**	12.01
Bioregion	Lowveld	**Vegetation Type**	SVI 5: Tshokwane-Hlane Basalt Lowveld
River Gradient	0.0034	**Geomorphological Zone**	Lower Foothills

Figure 109. Upstream view of the site on the Nkwakwa River, X1NKWA-COOPE (21 August 2014, G Diedericks).

Figure 110. Downstream view of the site on the Nkwakwa River, X1NKWA-COOPE (21 August 2014, G Diedericks).

SQ REACH NUMBER X13L-01000

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X13L-01000	X1NGWE-KOMAT	Ngweti	151	S- 25.45656 E 31.91683	C 63.3%	CD 58.7%	CD 61%	CD	D 50%	D 56.3%	44.9

General description

Reach X13L-01000: Ngweti

The Ngweti River originates on the farm One Tree Hill, at an elevation of 360 m.a.s.l. (Figure 111 & 112). The stream flows in an east-north easterly direction towards its confluence with the Komati River. The reach length is estimated as 44.6 km. The site (X1NGWE-KOMAT), at an elevation of 151 m.a.s.l., is located 3.9 km upstream from the streams confluence with the Komati River. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The catchment originate in the Granite Lowveld veld type, followed by the Delgoa Lowveld further downstream, and the Tshokwane-Hlane Basalt Lowveld towards the Komati River. The X1NGWE-KOMAT sampling point falls within the latter veld type. The entire catchment falls within the Lowveld aquatic ecoregion. The land-use includes a large number(49) of small dams, and mostly agricultural crops dominated by sugarcane. Impacts and activities in this reach are mainly water abstraction and agricultural.

Fish

This biomonitoring site is characteristic of a lower foothill stream with a low gradient and gentle flowing river. The fish velocity depth classes were dominated by fast shallow habitat in abundance and slow deep also abundant. Slow shallow was sparse in abundance. Fast deep was absent. The fish cover present rated moderate for overhanging vegetation and for undercut banks and root wads. The substratum as cover was moderately in abundance and consisted of rocks, cobbles and pebbles. Embeddedness was evident limiting the available habitat for especially the flow dependent fish species. The fish assemblage recorded at the site consisted of only two species of an expected 21 species. Only *Clarias gariepinus* and *Micralestes acutidens* were collected in low abundance at the site sampled. *Oreochromis mossambicus* was seen in deeper pools but could not be sampled because of inaccessibility. The low species diversity and abundance may be because of lack of suitable habitat at the sampling point and poor water quality.

The CPUE (catch per unit effort) calculated for this site is 0.1 (6 individuals; 42 minutes) indicating a very low abundance of species collected.

A Fish Response Index (FRAI) score of 63.3% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with slow flows and stagnant waters were dominant, while taxa associated with moderate and fast flows were present but at low diversity and abundance. Taxa diversity and sensitivity ratings in the stones biotope were below average for the ecoregion. Diversity in the vegetation and gravel/sand/mud biotopes were higher than the average for the ecoregion, but the sensitivity ratings were lower. Overall the diversity was high but tolerant taxa dominate. The habitat is dominated by pools and slow flowing waters, but cobble-riffle habitat is present. The main cause for poor conditions is attributed to water quality.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1NGWE-KOMAT site on the Ngweti River was rated as moderately to severely impaired (C/D-class).

Chemical and Physical Water Quality

Table 45. Results for water quality constituents measured at the Ngweti River site (X1NGWE-KOMAT) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**60**			
Sampling Date	**22 August 2014**			
Sampling Time	**11h30**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**21.4**			
pH	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**6.3**			
Saturation (%)	**81.4**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**116.0**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**754.0**		<1,000	
Chemical Oxygen Demand (COD mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**4.0**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**70**		<200	<130

Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	116		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	127		<1,500	
Copper (Cu) mg/ℓ	<0.025		≤0.5	
Iron (Fe) mg/ℓ	<0.025		<10	
Manganese (Mn) mg/ℓ	<0.025	≤0.18	<10	
Sodium (Na)	67		<2,000	

* = Not measured by Laboratory NA = Not available

Total dissolved solids calculated from the electrical conductivity was high, with elevated levels of nitrates, sulphate (highest recorded in the study area) chloride and sodium. Levels were considerably higher than levels measured compared to other sites in the ecoregion. Cultivation of sugarcane crops occur within riparian zones, and the riparian areas left unplanted are severely infested with exotic and invasive weed species, reducing their filtering capacity. Poor water quality is attributed mainly to pollution inputs from agricultural crops in the upper catchment. Other water quality results measured and analysed falls within expected ranges (Table 45).

On Site Impacts Recorded

- Commercial crops are planted in riparian zones, and;
- Riparian zones are severely infested with exotic and invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class CD (61%) suggesting a moderately to severely impaired habitat.

NGWETI

Site Code	X1NGWE-KOMAT	**Reach**	X13L - 01000
Latitude	-25.45656° S	**Quaternary Catchment**	X13L
Longitude	31.91683° E	**Elevation**	151 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.06
Bioregion	Lowveld	**Vegetation Type**	SVI 5: Tshokwane-Hlane Basalt Lowveld
River Gradient	0.0043	**Geomorphological Zone**	Lower Foothills

Figure 111. Upstream view of the site on the Ngweti River, X1NGWE-KOMAT (22 August 2014, G Diedericks).

Figure 112. Downstream view of the site on the Ngweti River, X1NGWE-KOMAT (22 August 2014, G Diedericks).

SQ REACH NUMBER X14A-01173

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14A-01173	X1LOMA-HIGHL	Lomati	1,049	S- 25.83233 E 31.11699	C 68.6%	C 69.3%	C 69%	C	C 70%	C 69.4%	47.7

General description

Reach X14A-01173: Lomati

The Lomati River originates on Sappi's Twello plantation, just north from the Songimvelo Nature Reserve, at an elevation of 1,620 m.a.s.l. (Figure 113 & 114). From its origin, the stream flows in a north-east by easterly direction (55°) towards the Lomati Dam, and from the Lomati Dam the stream flows in a south-south easterly direction (153°) towards the monitoring point X1LOMA-HIGHL. The X1LOMA-HIGHL site is located 2.5 km downstream from the Lomati Dam, and 495 m upstream from its confluence with the Mlumati. The site is located on the farm De Bilt (Sappi Twello) at an elevation of 1,049 m.a.s.l. Geomorphologically the stream at the sampling point is categorised as a transitional zone. The entire catchment upstream from the sampling point is located in the Barberton Montane Grassland. A small portion of the upper catchment is located in the Northern Escarpment Mountains aquatic ecoregion, while the rest of the catchment upstream from the site are located in the North Eastern Highlands. The land-use in the catchment is commercial forestry..

Fish

The aquatic site sampled consisted primarily of deep pools, runs and rapids. The fish velocity depth classes present were fast shallow (abundant), fast deep (sparse), slow shallow (sparse) and slow deep (sparse). The fish cover present consisted largely of substrate with large boulders and rocks in the riffles. A sparse abundance of overhanging vegetation was present at the slow deep and fast shallow habitats, but none at the slow shallow and fast deep. The only habitat with sparse undercut banks and root wads as cover type was the fast shallow habitat. No aquatic macrophytes were present. The fish assemblage of the present survey consisted of four species from an expected 18 species of indigenous fish. Four flow dependant species, *Chiloglanis anoterus*, *Barbus argenteus, Varichorinus nelspruitensis* and *Amphilius uranoscopus* were collected with two limnophilic species, *Barbus brevipinnis* and *Tilapia sparrmanii*. Of significance is the presence of an isolated population of *Varichorinus nelspruitensis* and the presence of *Chiloglanis anoterus* and not *Chiloglanis pretoriae*. These species are outside their natural distribution range.

The CPUE (catch per unit effort) calculated for this site is 1.1 (36 individuals; 32 minutes) indicating a relative abundance of fish.

A Fish Response Index (FRAI) score of 68.6% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Previous SASS sampling data on record at this site (X1LOMA-HIGHL) was collected in May 2001, May 2002, May 2003, May 2006 and June 2009. Results for these different sampling periods are fairly similar, especially in terms of sensitivity ratings. In 2014, taxa associated with slow to moderate flows were dominant, while taxa associated with fast and stagnant waters were present. Taxa diversity for the stones biotope were similar to the average for the ecoregion, but the sensitivity rating was lower than the average. The vegetation biotope had a high diversity, but less sensitive taxa, while the gravel/sand/mud biotope had a lower diversity and a similar sensitivity rating to the rest of the ecoregion. Overall the diversity and sensitivity rating for the site was lower than the average for the ecoregion. No water was flowing out of the Lomati Dam during the 2014 site visit, which will have a considerable impact on the aquatic community.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1LOMA-HIGHL site on the Lomati was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 46. Results for water quality constituents measured at the Lomati stream's site (X1LOMA-HIGHL) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**49**			
Sampling Date	**18 August 2014**			
Sampling Time	**14h45**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**15.4**			
pH	**7.4**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.3**			
Saturation (%)	**96.5**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**9.1**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**59.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		

Indicator Organisms				
E coli (counts/100 mℓ)	**12**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**6**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.195**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**4**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 46).

On Site Impacts Recorded

- Culverts at the stream crossing is partially blocked with logs and debris, impounding the stream above the crossing and forcing the stream to flow over the structure (damage to bridge and stream banks) during high flow events, and;
- Silt deposition in the stream is very high.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (69%) suggesting a moderately impaired habitat.

LOMATI

Site Code	X1LOMA-HIGHL	**Reach**	X14A-01173
Latitude	-25.83233° S	**Quaternary Catchment**	X14A
Longitude	31.11699° E	**Elevation**	1,049 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Highlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 17: Barberton Monatne Grassland
River Gradient	0.037	**Geomorphological Zone**	Transitional

Figure 113. Upstream view of the site on Lomati River, X1LOMA-HIGHL (18 August 2014, G Diedericks).

Figure 114. Downstream view of the site on Lomati River, X1LOMA-HIGHL (18 August 2014, G Diedericks).

SQ REACH NUMBER X14B-01166

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14B-01166	X1UGUT-ZEIST	Ugutugulo	1,007	S- 25.76321 E 31.24677	C 67.3%	C 70.7%	C 69%	C	C 70%	C 69.4%	24.8

General description

Reach X14B-01166: Ugutugulo

The Ugutugulo River (Shiyanlongubo on some maps) is a tributary of the Lomati River, originating on the Twello farm on Sappi, at an elevation of 1,420 m.a.s.l. (Figure 115 & 116). From its origin, the stream flows in an east-north-easterly direction (66°) towards the Shiyanlongubo Dam. From the Dam, the river flows in a south-south easterly direction (159°) towards its confluence with the Lomati River. The X1UGUT-ZEIST site is located where the river flows out of Sappi plantations towards the Shiyanlongubo Dam. The site is located approximately 13.6 km from its source and 1.8 km upstream from the Shiyanlongubo Dam. The site is located on the farm Duurstede (Sappi Twello) at an elevation of 1,007 m.a.s.l. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone. The entire catchment upstream from the sampling point is located in the Barberton Montane Grassland, further downstream below the Shiyanlongubo Dam the vegetation type is Swaziland Sour Bushveld merging into Granite Lowveld near the Lomati confluence. The largest portion of the catchment is located in the Northern Escarpment Mountains aquatic ecoregion, while the lower portion is located in the Lowveld. The land-use upstream from the sampling point (X1UGUT-ZEIST) is commercial forestry. Impacts and activities in this reach include forestry and small settlements with associated subsistence farming. The Shiyalongubo Dam is included in this reach.

Fish

This typical upper foothill river site is just upstream from the Shiyalongubo Dam and consisted of mainly riffles and runs. Three of the fish velocity depth classes were present: fast shallow (abundant), fast deep (sparse) and slow deep (sparse). Overhang vegetation as cover for fish was rated as moderate to abundant with abundant undercut banks and root wads which provided excellent fish cover. The substrate as cover for fish was abundantly present with large boulders, rocks and cobbles. The fish assemblage recorded at the site consisted of only three species of an expected 13 species, but another indigenous species was collected just downstream from the site, totalling four species recorded for the reach. The three species collected at the site are all reophilic species namely *Amphilius uranoscopus*, *Chiloglanis anoterus* and *Varichorinus nelspruitensis.* The fourth species is a limnophilic species, *Coptodon rendalli* and was collected just downstream from the site. *Coptodon rendalli* was not expected to occur in this reach. *Chiloglanis anoterus* was the most abundant fish species collected. The exotic alien and invasive fish, *Lepomis macrochirus*, was sampled just downstream from the site in the Shiyalongubo Dam. A catch per unit effort (CPUE) of 1.6 was recorded for this site (53 individuals; 34 minutes), indicating a relative abundance of fish present at the time of the survey.

A Fish Response Index (FRAI) score of 67.3% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Previous SASS sampling data on record at this site (X1UGUT-ZEIST) was collected in May 2001, May 2002, May 2003, May 2006 and June 2009. Results for these different sampling periods are fairly similar, especially in terms of diversity. In 2014, taxa associated with fast to moderate flows were dominant, while taxa associated with slow and stagnant waters were present. Taxa diversity for the stones biotope were lower than the average for the ecoregion, but the sensitivity rating was similar. The vegetation biotope were on par with the average for the ecoregion, while the gravel/sand/mud biotope had a higher diversity with a similar sensitivity rating. Overall the diversity and sensitivity rating was similar to other sites in the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1UGUT-ZEIST site on the Ugutugulo River was rated as moderately impaired (C-class). Impairments are caused by high weed infestation, bank and bed scouring and fine silt deposition.

Chemical and Physical Water Quality

Table 47. Results for water quality constituents measured at the Ugutugulo stream's site (X1UGUT-ZEIST) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**47**			
Sampling Date	**18 August 2014**			
Sampling Time	**10h30**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**13.3**			
pH	**7.7**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.2**			
Saturation (%)	**90.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**5.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**35.8**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		

Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**23**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.401**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 47).

On Site Impacts Recorded

- The stream crossing upstream from the sampling point blocks fish movement during low and normal flow events;
- Fine silt deposition in the stream is high;
- Portions of the commercial tree compartments in the catchment are too close to the stream;
- Stream bank scouring is extensive, and;
- The riparian zone is heavily infested with exotic invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (69%) suggesting a moderately impaired habitat.

UGUTUGULO

Site Code	X1UGUT-ZEIST	**Reach**	X14B-01166
Latitude	-25.76321° S	**Quaternary Catchment**	X14B
Longitude	31.24677° E	**Elevation**	1,007 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Highlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 17: Barberton Monatne Grassland
River Gradient	0.008	**Geomorphological Zone**	Upper Foothills

Figure 115. Upstream view of the site in the Ugutugulo River, X1UGUT-ZEIST (18 August 2014, G Diedericks).

Figure 116. Downstream view of the site in the Ugutugulo River, X1UGUT-ZEIST (18 August 2014, G Diedericks).

SQ REACH NUMBER X14C-01203

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14C-01203	X1PHOP-MAGUT	Phophonyane	438	S- 25.83217 E 31.36920	C 75.5%	C 73.5%	C 74.5%	C	C 70%	C 72.6%	3.4

General description

Reach X14C-01203: Phophonyane

The Phoponyane River in Swaziland originates at an elevation of 1,280 m.a.s.l., 6.4 km west by north (277°) from the town of Piggs Peak, on Peak Timbers commercial *Eucalyptus*-plantations (Figure 118 & 119). The river flows in a north-east by eastern direction (55°) towards its confluence with the Lomati River in Swaziland, and is an estimated 34.5 km long. The reach, X14C-01203, starts at the Mgobode confluence and ends at the Phoponyane-Lomati confluence, representing 3.4 km. The site (X1PHOP-MAGUT) is located at an elevation of 438 m.a.s.l., about 607 m upstream from the Phoponyane-Lomati confluence. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone. The headwaters is located in the Barberton Montane Grassland, the middle portions in the Swaziland Sour Bushveld and the lower portion to the Lomati confluence are in the Granite Lowveld veld types. The upper portion of the Phophonyane falls within the North Eastern Highlands aquatic ecoregion, and the lower portion in the Lowveld. The reach is located in the Granite Lowveld veld type, and in the Lowveld aquatic ecoregion. The land-use upstream from the sampling point is commercial forestry, rural settlements and subsistence farming.

Fish

Within the Phophonyane catchment high sediment deposition from the Piggs Peak, Ntabeni and Inabosa streams smothers available rocky substrates which in turn affects the available instream habitat, especially in terms of water depth, water temperature fluctuations, dissolved oxygen, the trapping of organic material and reduce potential breeding sites for several fish species. The entire catchment experience excessive sediment deposition, with most of the river categorised with high sediment deposition. The habitat consisted of scoured banks creating a channelised stream which consisted of pools, longitudinal channel with isolated riffles. The fish velocity depth classes monitored included fast shallow (moderate), slow shallow (moderate) and slow deep (moderate) with the fast deep fish velocity depth class absent. The fish cover observed at this site was moderate with moderate overhanging vegetation, undercut banks and root wads and a moderate substrate consisting of mostly sand and silt with embedded stones and cobbles.

The sampling effort for this site consisted of an average of 29 minutes electro-shocking and six of the expected twelve species were recorded in relative abundance (number of individuals 104, representing six species). The CPUE (catch per unit effort) of 3.5 indicates a relative abundance of species. The species collected during this survey included the reophilic and flow dependant species *Labeobarbus marequensis, Chiloglanis anoterus, Barbus eutaenia, Opsaridium peringueyi, Labeo cylindricus and Amphilius uranoscopus*. The presence of *Chiloglanis anoterus* is unique as this species is endemic to the Phongola and Inkomati River Systems with only a small isolated population occurring within the upper Lomati catchment. The species collected reflected all the age classes (juveniles, sub-adults and adults) indicating that breeding is functional at present.

A Fish Response Assessment Index (FRAI) score of 75.5% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with moderate diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with moderate to fast and slow flows were dominant, while taxa associated with stagnant waters were present. Taxa diversity and the sensitivity rating for the stones and gravel/sand/mud biotope were higher than the average for the ecoregion. The diversity for vegetation biotope were higher than average for the ecoregion, but a lower sensitivity rating. Over all the diversity and sensitivity was higher than the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1PHOP-MAGUT site on the Phophonyane River was rated as moderately impaired (C-class). Stream bank scouring and sediment deposition is extensive, which would limit instream habitat.

Chemical and Physical Water Quality

Table 48. Results for water quality constituents measured at the Phophonyane River site (X1PHOP-MAGUT) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**42**			
Sampling Date	**08 August 2014**			
Sampling Time	**09h25**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**14.9**			
pH	**7.5**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.6**			
Saturation (%)	**95.5**	80 - 120		
Clarity (cm)	**82**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**13.0**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**84.5**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		

Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.5**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1,100**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**10**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.562**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**11**		<2,000	

* = Not measured by Laboratory   NA = Not available

Water clarity was low and E coli counts extremely high. All other water quality results measured and analysed fell within expected ranges (Table 48).

On Site Impacts Recorded

- Stream bank scouring is extensive (Figure 117), with bed scouring and high deposition evident;
- Lateral and mid channel gravel and silt bars fairly common;
- High quantities of domestic waste in the river and riparian zone, and;
- The riparian zone is severely infested with exotic invasive weed species.

Figure 117. Stream bank scouring at the X1PHOP-MAGUT site (08 August 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (74.5%) suggesting a moderately impaired habitat.

PHOPHONYANE

Site Code	X1PHOP-MAGUT	**Reach**	X14C-01203
Latitude	-25.83217° S	**Quaternary Catchment**	X14C
Longitude	31.36920° E	**Elevation**	438 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0038	**Geomorphological Zone**	Lower Foothills

Figure 118. Upstream view of the site in the Phoponyane River, X1PHOP-MAGUT. Lateral and mid-channel gravel-silt bars evident (08 August 2014, G Diedericks).

Figure 119. Downstream view of the site in the Phoponyane River, X1PHOP-MAGUT (08 August 2014, G Diedericks).

SQ REACH NUMBER X14D-01174

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14D-01174	X1LOMA-HLELE	Lomati	495	S- 25.81894 E 31.31144	B 84.4%	C 77.9%	BC 81.2%	BC	BC 80%	BC 80.7%	11.3

General description

Reach X14D-01174: Lomati

This reach, X14D-01174, on the Lomati River in Swaziland, starts at the Ugutugulo confluence and ends at the Phopohonyane confluence, representing approximately 11.3 km in river length (Figure 120 & 121). The site (X1LOMA-HLELE) is located at an elevation of 495 m.a.s.l., and is geomorphologically categorised as an upper foothill zone.

The reach is located in the Granite Lowveld veld type, and in the Lowveld aquatic ecoregion. The land-use upstream from the sampling point is commercial forestry, rural settlements and subsistence farming. Two large dams are also located upstream from the sampling point.

Fish

The habitat consisted of riffles, runs, glides and pools with backwater pools on both sides of the riffle. The fish velocity depth classes surveyed included abundant fast shallow, moderate fast deep, sparse slow shallow habitats with the slow deep habitat absent. The fish cover observed for this site was abundant with abundant overhanging vegetation, undercut banks and root wads. The substrate consisted of very abundant gravel, rocks cobbles and boulders. Electro-fishing was used to survey the fish biota and in total an average effort of 32 minutes was applied to this site. At this site eight of the thirteen expected species were recorded in high abundance. The highly sensitive *Amphilius uranoscopus* was present as well as the following flow dependant species, *Labeobarbus marequensis, Barbus eutaenia and Chiloglanis anoterus. Amphilius uranoscopus* have a high (5) flow depth preference for fast deep and fast shallow fish velocity depth classes. This species is further totally intolerant (4.9) to reduced flow conditions, have a very high (5) preference to substrate and is highly (4.8) intolerant to water quality changes.

The CPUE (Catch per unit effort) for this site is 7.0 (226 individuals; 32 minutes) indicating a relative high abundance and diversity of fish species.

A Fish Response Assessment Index (FRAI) score of 84.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired habitat with high diversity and abundance of species.

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with fast to moderate flows were dominant, while taxa associated with slow and stagnant waters were present. Taxa diversity and the sensitivity rating for the stones biotope were considerably higher than the average for the ecoregion. The vegetation biotope were on par with the average for the ecoregion, while the gravel/sand/mud biotope had a higher diversity with a lower sensitivity rating. Overall the diversity was similar to the average for the ecoregion, while the sensitivity rating was higher.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1LOMA-HLELE site on the Lomati River was rated as moderately impaired (C-class). The stream banks were severely impaired, and river bed scouring was also noted.

Chemical and Physical Water Quality

Table 49. Results for water quality constituents measured at the Lomati River site (X1LOMA-HLELE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**41**			
Sampling Date	**07 August 2014**			
Sampling Time	**14h40**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**18.8**			
pH	**7.8**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.8**			
Saturation (%)	**94.5**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**5.4**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**35.1**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**59**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	

Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.015**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 49).

On Site Impacts Recorded

- The bridge upstream from the sampling point washed away during recent flood events;
- Stream bank scouring is extensive, with evidence of bed scouring;
- People use the river for washing clothes, and;
- High quantities of leaf litter was present behind and between rocks in the current and out of current.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (81.2%) suggesting a slightly to moderately impaired habitat.

LOMATI

Site Code	X1LOMA-HLELE	**Reach**	X14D-01174
Latitude	-25.81894° S	**Quaternary Catchment**	X14D
Longitude	31.31144° E	**Elevation**	495 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0061	**Geomorphological Zone**	Upper Foothills

Figure 120. Upstream view of the site in the Lomati River, X1LOMA-HLELE (07 August 2014, G Diedericks).

Figure 121. Downstream view of the site in the Lomati River, X1LOMA-HLELE (07 August 2014, G Diedericks).

SQ REACH NUMBER X14E-01151

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14E-01151	X1LOMA-MBONG	Lomati	333	S- 25.75736 E 31.43655	B 83.7%	C 77.1%	BC 80.4%	C	C 70%	C 75.9%	20.8

General description

Reach X14E-01151: Lomati

This reach of the Lomati River in Swaziland starts at the Phophonyane confluence and ends at the Mlilambi confluence in Driekoppies Dam, representing a river length of 20.8 km (Figure 122 & 123). The site (X1LOMA-MBONG) is located at an elevation of 333 m.a.s.l., upstream from the main road between South Africa and Piggs Peak. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone.

The reach is located in the Granite Lowveld veld type, and in the Lowveld aquatic ecoregion. The land-use is mainly rural settlements and subsistence farming.

Fish

This biomonitoring site is situated in the Lomati River and is representative of the lowveld aquatic eco region and is characterised as a low inclined, multiple channelled stream with some anastomosing and anabranching. The substratum is dominated by boulders, rocks, cobbles and contains multiple runs, some riffles and large pools. The fish velocity depth classes recorded were fast shallow (abundant), fast deep (moderate), slow shallow (moderate) with slow deep absent. The fish cover present that was identified was abundant with moderate overhanging vegetation and moderate undercut banks and root wads. The substratum rated very abundant and the boulders and cobbles create interstitial spaces creating sufficient available fish habitat.

During the fish assemblage ten of the expected sixteen species were collected in relative high abundance. Fish species collected at this site reflects all the age classes juveniles, sub-adults and adults, which is a clear indication that a viable population is present with breeding functions not disrupted at present. Species of interest collected at this site are *Labeobarbus marequensis, Barbus eutaenia, Chiloglanis anoterus, Marcusenius pongolensis, Opsaridium peringueyi and Chetia brevis. Chetia brevis*, orange-fringed river bream, is endemic to the Lowveld region of the Komati/Inkomati River system. At present this species is rated as vulnerable and is threatened by pollution and water abstraction. It furthermore favours slow deep habitats with pools and standing water, with a high preference for cover in the form of over-hanging vegetation. The CPUE (catch per unit effort) of 13.38 (415 individual; 31 minutes) indicates a high species diversity and abundance. At this site marginal siltation and bank instability were recorded.

A Fish Response Assessment Index (FRAI) score of 83.7% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired habitat with high diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with fast to moderate flows were dominant, while taxa associated with slow and stagnant waters were present. Taxa diversity and the sensitivity rating for the stones biotope were considerably higher than the average for the ecoregion. The diversity for vegetation and gravel/sand/mud biotopes were lower than average for the ecoregion, but the sensitivity ratings higher. Overall the diversity was similar to the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1LOMA-MBONG site on the Lomati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 50. Results for water quality constituents measured at the Lomati River site (X1LOMA-MBONG) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**43**			
Sampling Date	**08 August 2014**			
Sampling Time	**11h45**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**18.1**			
pH	**8.0**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.3**			
Saturation (%)	**99.5**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**6.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**44.9**		<1,000	
Chemical Oxygen Demand (COD mg/ℓ)	**16**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1,400**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	

Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.327**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**4**		<2,000	

* = Not measured by Laboratory NA = Not available

E coli counts were extremely high, and the COD was elevated. All other water quality results measured and analysed fell within expected ranges (Table 50).

On Site Impacts Recorded

- Fine silt deposition on rocks out of current;
- High quantities of domestic waste in the river and riparian zone, and;
- The riparian zone is severely infested with exotic invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC (80.4%) suggesting a slightly to moderately impaired habitat.

LOMATI

Site Code	X1LOMA-MBONG	**Reach**	X14E-01151
Latitude	-25.75736° S	**Quaternary Catchment**	X14E
Longitude	31.43655° E	**Elevation**	333 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.005	**Geomorphological Zone**	Upper Foothills

Figure 122. Upstream view of the site in the Lomati River, X1LOMA-MBONG (08 August 2014, G Diedericks).

Figure123. Downstream view of the site in the Lomati River, X1LOMA-MBONG (08 August 2014, G Diedericks).

SQ REACH NUMBER X14F-01085

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14F-01085	X1MHLA-RUSOO	Mhlambanyatsi	334	S- 25.63447 E 31.50451	C 76.7%	C 75.5%	C 76.1%	C	C 70%	C 73.5%	41.09

General description

Reach X14F-01085: Mhlambanyatsi

The Mhlambanyatsi River originates at an elevation of 1,200 m.a.s.l. on the farm Waaiheuvel, part of a commercial tree plantation (Figure 124 & 124). The river flows in an east by northern direction (76°) towards its confluence with the Lomati River. The reach length is listed as 41.4 km. The site (X1MHLA-RUSOO) is located to the west of the town Buffelspruit, at an elevation of 334 m.a.s.l., and approximately 10.3 km upstream from the Mhlambanyatsi's confluence with the Lomati River. Geomorphologically the stream at the sampling point is categorised as an upper foothills zone.

The upper portion of the catchment is located in the Barberton Montane Grassland, the middle reaches in the Kaalrug Mountain Bushveld and the lower reaches towards the Lomati confluence in the Granite Lowveld veld type. The upper catchment falls within the North Eastern Highlands aquatic ecoregion, and the lower portion in the Lowveld aquatic. The site, X1MHLA-RUSOO, is located in the Kaalrug Mountain Bushveld veld type and Lowveld aquatic ecoregion. The land-use is mainly commercial forestry, small towns and rural settlements, subsistence farming, water abstraction, irrigated crops, livestock grazing and a dam.

Fish

The aquatic site sampled consisted of mainly riffles and runs with a deep pool just downstream from the river crossing. At this biomonitoring site three fish velocity depth classes were present: fast shallow (very abundant), slow shallow (moderate) and slow deep (sparse). No fast deep habitat was present. Overhanging vegetation present as fish cover rated as moderate with undercut banks and root wads moderately abundant in both the slow shallow and fast shallow habitats. The substrate in the fast shallow habitat was moderate consisting of boulders, rocks, cobbles and pebbles with embeddedness evident, resulting in loss of interstitial spaces causing a loss of available fish habitat.

The fish assemblage recorded at the site consisted of nine species of an expected 17 indigenous species for this reach. The reophilic species collected were *Chiloglanis pretoriae, Amphilius uranoscopus, Labeo cylindricus, Labeobarbus marequensis* and *Barbus eutaenia.* Lymnophylics species collected were *Marcusenius* *pongolensis*, *Oreochromis mossambicus*, *Pseudocrenilabrus philander* and *Barbus viviparus*. The assemblage was dominated by the presence of *Labeo cylindricus*, but *Barbus eutaenia* and *Labeobarbus marequensis* were also collected in abundance. An albino fish, *Marcusenius pongolensis*, was collected at this site. The taxonomy of *Marcusenius* in South Africa was reviewed and the species found in the Inkomati system is now known as *M. pongolensis* instead of *M. macrolepidotus*.

The CPUE (catch per unit effort) calculated for this site is 2.5 (117 individuals; 47 minutes) indicating a relative high abundance of fish present.

A Fish Response Index (FRAI) score of 76.7% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with moderate to fast flows were dominant, while taxa associated with slow and stagnant waters were present. Taxa diversity and the sensitivity rating for the stones biotope was considerably higher than the average for the ecoregion. The diversity for the vegetation biotope was lower than the average for the ecoregion, and the sensitivity rating similar, while gravel/sand/mud diversity were similar but the sensitivity was lower. Overall the diversity and sensitivity rating was more than the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MHLA-RUSOO site on the Mhlambanyatsi River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 51. Results for water quality constituents measured at the Mhlambanyatsi River site (X1MHLA-RUSOO) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**52**			
Sampling Date	**19 August 2014**			
Sampling Time	**13h10**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**18.3**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.4**			
Saturation (%)	**100.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**12.1**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**78.7**		<1,000	
Chemical Oxygen Demand (COD mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			

Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**110**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**8**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**10**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.598**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**6**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 51).

On Site Impacts Recorded

- Stream bank scouring;
- High quantities of domestic waste in the river and riparian zone;
- High fine silt deposition in pools and rocks in slower flowing portions of the river, and;
- The riparian zone is severely infested with exotic invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (76.1%) suggesting a moderately impaired habitat.

MHLAMBANYATSI

Site Code	X1MHLA-RUSOO	**Reach**	X14F-01085
Latitude	-25.63447° S	**Quaternary Catchment**	X14F
Longitude	31.50451° E	**Elevation**	334 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 12: Kaalrug Mountain Bushveld
River Gradient	0.0065	**Geomorphological Zone**	Upper Foothills

Figure 124. Upstream view of the site in the Mhlambanyatsi River, X1MHLA-RUSOO (19 August 2014, G Diedericks).

Figure 125. Downstream view of the site in the Mhlambanyatsi River, X1MHLA-RUSOO (19 August 2014, G Diedericks).

SQ REACH NUMBER X14G-01128

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14G-01128	X1LOMA-SCHOE	Lomati	279	S- 25.68629 E 31.52879	C 67.2%	C 66.8%	C 67%	C	CD 60%	C 64%	23.53

General description

Reach X14G-01128: Lomati

This reach of the Lomati River starts in Swaziland at the Mlilambi confluence in Driekoppies Dam, and goes through the dam to the Mhlambanyati confluence in South Africa, representing a river length of 23.5 km (Figure 126 &127). The site (X1LOMA-SCHOE) is located to the north-west of the town Schoemansdal, at an elevation of 279 m.a.s.l., approximately 5.3 km downstream from Driekoppies Dam Wall. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone.

The reach is located in the Granite Lowveld veld type, and in the Lowveld aquatic ecoregion. The land-use is mainly towns, the dam, rural settlements and subsistence farming. Impacts and activities in this reach are Driekoppies Dam, water abstraction and agriculture.

Fish

This reach is also representative of the lower foothill streams and the site is not far downstream from Driekoppies Dam. The site is characterised by fast flowing riffles and runs. A very short side channel was also present. Only fast fish velocity depth classes were present in the main part of the river at the time of the survey with fast shallow and fast deep abundant. The sparsely abundant slow shallow habitat was only present at the side channel. The fish cover present was overhanging vegetation moderately abundant in the fast habitats and slow habitats with undercut banks and root wads only present at the fast shallow habitat. The substrate rated moderate consisting of rocks, cobbles, pebbles and gravel.

The fish assemblage at this site is expected to consist of 35 indigenous fish species. The present survey consisted of only eight species. The flow dependant species collected were only *Labeo cylindricus* and *Chiloglanis pretoriae* and they were the more abundant species present. The limnophilic species collected in the fast habitat includes *Clarias gariepinus, Petrocephalus wesselsi* and *Marcusenius pongolensis* and species collected in the slow shallow habitat includes *Pseudocrenilabrus philander*, *Coptodon rendalli* and *Barbus viviparus*. *Barbus viviparus* was the only one of the eight smaller barb species expected to occur, to be collected. The endangered *Chetia brevis* has been recorded during a 2006 survey conducted by JS Engelbrecht and F Roux, but none was collected during the present survey. The reasons for this species to be listed in the Red

Data List of Threatened Species are its limited distribution range and main threats to this species are alien and invasive fish, subsistence fishing and agricultural activities (Cambray & Swartz, 2007). 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 habitat deterioration due the construction of multiple weirs acting as barriers. The CPUE (catch per unit effort) is 1 (53 individuals; 51 minutes) which indicate a relative abundance of recorded species.

A Fish Response Index (FRAI) score of 67.2% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with fast to moderate flows were dominant, while taxa associated with slow and stagnant waters were present. Taxa diversity was lower than the average for the ecoregion in the stones and vegetation biotopes, and higher in terms of sensitivity rating for the stones, vegetation and gravel/sand/mud biotopes. The low diversity in the stones biotope was surprising, since the riffle-cobble habitat appeared to be good. Overall the diversity was below the average for the ecoregion, and sensitivity was higher.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1LOMA-SCHOE site on the Lomati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 52. Results for water quality constituents measured at the Lomati River site (X1LOMA-SCHOE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**51**			
Sampling Date	**19 August 2014**			
Sampling Time	**11h05**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**17.9**			
pH	**8.2**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.4**			
Saturation (%)	**99.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**9.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**64.4**		<1,000	
Chemical Oxygen Demand (COD mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05	<0.005 = oligotrophic		

	oligo - euro	0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.3**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**110**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**10**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.396**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**7**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 52).

On Site Impacts Recorded

- Stream bank scouring;
- High quantities of domestic waste in the river and riparian zone, and;
- The riparian zone is severely infested with exotic invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (67%) suggesting a moderately impaired habitat.

LOMATI

Site Code	X1LOMA-SCHOE	**Reach**	X14G-01128
Latitude	-25.68629° S	**Quaternary Catchment**	X14G
Longitude	31.52879° E	**Elevation**	279 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0016	**Geomorphological Zone**	Lower Foothills

Figure 126. Upstream view of the site in the Lomati River, X1LOMA-SCHOE (19 August 2014, G Diedericks).

Figure 127. Downstream view of the site in the Lomati River, X1LOMA-SCHOE (19 August 2014, G Diedericks).

SQ REACH NUMBER X14H-01066

SQ Reach Code (downstream-->)	Site Code	River	Elevation (m.a.s.l.)	GPS Co-ordinates (dd.sssss)	FRAI	MIRAI	Instream Ecological Category	PES Category	Riparian PES	Ecostatus	Length km
X14H-01066	X1LOMA-LEKKE	Lomati	181	S- 25.63518 E 31.77914	C 68.7%	C 68%	C 68.3%	C	D 50%	CD 60.5%	57.33

General description

Reach X14H-01066: Lomati

This reach of the Lomati River starts at the Mhlambanyatsi confluence and ends at the Lomati's confluence with the Komati River (Figure128 &129). This represents a reach length of 57.3 km. The site (X1LOMA-LEKKE) is located 1 km upstream from the Lomati's confluence with the Komati River, east from the town of Phiva, at an elevation of 181 m.a.s.l. Geomorphologically the stream at the sampling point is categorised as a lower foothills zone.

The reach is located in the Granite Lowveld veld type, and in the Lowveld aquatic ecoregion. The land-use is mainly towns, sugarcane and other irrigated agricultural crops, an upstream dam, rural settlements and subsistence farming. Impacts and activities in this reach are Driekoppies Dam, water abstraction and agriculture.

Fish

This reach is also representative of the lower foothill streams and the site is close to the confluence with the Komati River. The site is characterised by large pools with inter-connective rapids, runs and riffles on bedrock. Three fish velocity depth classes were present at the time of the survey which includes fast shallow (moderate), fast deep (abundant) and slow shallow (moderate). The fish cover present was overhanging vegetation moderately abundant in the fast habitats and slow habitats with undercut banks and root wads sparsely present only at the fast shallow habitat. The substrate rated moderate consisting of bedrock, rocks and cobbles.

The fish assemblage at this site is expected to consist of 35 indigenous fish species. The present survey consisted of ten species. The flow dependant species collected were *Labeo cylindricus* (16) and *Chiloglanis pretoriae* (6). The low number of *Chiloglanis pretoriae* can be attributed to the lack of available suitable habitat. Most of the species collected was from backwaters and the species were all no-flow tolerant species. The limnophilic species include *Barbus radiates, Barbus trimaculatus, Marcusenius pongolensis, Clarias gariepinus, Oreochromis mossambicus, Micralestes acutidens, Coptodon rendalli* and *Schilbe intermedius*. This was the only site where *Schilbe intermedius* was collected which normally occurs in deep pools. One exotic species, *Micropterus salmoides*, was also collected. This predatory alien and invasive species has a very negative impact on the indigenous fish. 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 habitat deterioration due the construction of multiple weirs acting as barriers. The CPUE (catch per unit effort) is 2.0 (91 individuals; 45 minutes) which indicate a relative abundance of recorded species.

A Fish Response Index (FRAI) score of 68.7% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 monitoring is the first on record for this sampling point. Taxa associated with slow flows and stagnant waters were dominant, while taxa associated with moderate and fast flows were present. Taxa diversity and the sensitivity rating for the stones biotope was higher than the average for the ecoregion. The diversity and sensitivity rating for the vegetation and gravel/sand/mud biotope similar to the average for the ecoregion. Overall the diversity and sensitivity rating was more than the average for the ecoregion.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1LOMA-LEKKE site on the Lomati River was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 53. Results for water quality constituents measured at the Lomati River site (X1LOMA-LEKKE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**53**			
Sampling Date	**19 August 2014**			
Sampling Time	**15h55**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**21.5**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**8.1**			
Saturation (%)	**102.9**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**39.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**256.8**		<1,000	
Chemical Oxygen Demand (COD mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.9**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			

Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**41**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**10**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**40**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.103**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**31**		<2,000	

* = Not measured by Laboratory NA = Not available

Levels of nitrates, chlorides and sodium were elevated when compared to the site higher upstream on the Lomati (X1LOMA-SCHOE) as well as other sites in the ecoregion. All water quality results measured and analysed, however, fell within expected ranges (Table 53).

On Site Impacts Recorded

- High quantities of domestic waste in the river and riparian zone;
- High deposition of organic matter and sediments in pools and slower flowing portions of the river, and;
- The riparian zone is severely infested with exotic invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C (68.3%) suggesting a moderately impaired habitat.

LOMATI

Site Code	X1LOMA-LEKKE	**Reach**	X14H-01066
Latitude	-25.63518° S	**Quaternary Catchment**	X14H
Longitude	31.77914° E	**Elevation**	181 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0049	**Geomorphological Zone**	Lower Foothills

Figure 128. Upstream view of the site in the Lomati River, X1LOMA-LEKKE (19 August 2014, G Diedericks).

Figure 129. Downstream view of the site in the Lomati River, X1LOMA-LEKKE (19 August 2014, G Diedericks).

Summary Komati River Tributaries Indices

FRAI Categories

Figure 130 summarises the FRAI categories for the 34 SQ reaches done on all the tributaries of the Komati River. These tributaries include the Klein-Komati, Boesmanspruit, Malolotja, and Lomati rivers. The overall FRAI for the tributaries is a Class C which indicates that the tributaries are moderately impaired with a moderate diversity and low abundance of species.

Of concern is the three SQ reaches (X11B-01272 ; X13A - 01255 and X13C - 01364) that rated Class D indicating that these reaches are severely modified with low species abundance and diversity. In the Boesmanspruit catchment (X11B-01272) a coal mining site is located on a tributary of the Boesmanspruit. Impacts and activities in this reach include mining, agriculture and urbanisation. Two mines within the Boesmanspruit sub-catchment, Northern Coal and Siphethe Coal, were issued with directives in terms of section 19 of the National Water Act, 1998 (Act No. 36 of 1998)on 10 July 2012. Acid mine drainage was taking place from these two mines. The two other SQ reaches of concern are within Swaziland. The origin and a large portion of the Nkhomazana (X13A-01255) catchment drains commercial forestry plantations, with parts of the river flowing through communal lands. Sediment and siltation deposits were recorded in the pools where stream velocity is reduced encouraging deposition. This excessive sedimentation results in the loss of available fish habitat as instream structures are embedded, resulting in a loss of interstitial spaces. Within the Mbuyane (X13C-01364) catchment land-use practises primarily consist of rural settlement areas, with a high degree of subsistence farming. The result of these practises being excessive high loads of sedimentation and siltation due to a high road network system, bank instability, trampling by livestock and sheet erosion reducing available fish habitat.

Nevertheless the graph indicate that some of the tributaries in the Komati River system still have high conservation value and act as refugia to numerous fish species. Of high importance is the Malolotja River situated within the Malolotja Nature Reserve (X13A-01337) with a FRAI rating of Class A indicating a largely natural river with high species diversity and abundance. Two other rivers Mbulatana (X13G-01216) and the Mphofu (X13G - 01259) respectively scored Class B and Class AB that indicates slightly modified rivers with moderate species abundance and diversity. Furthermore, two SQ reaches on the Lomati River (X14D-01174) and (X14E-01151) also rated Class B 's, thus indicating the ecological importance of the Lomati River above the Driekoppies Dam.

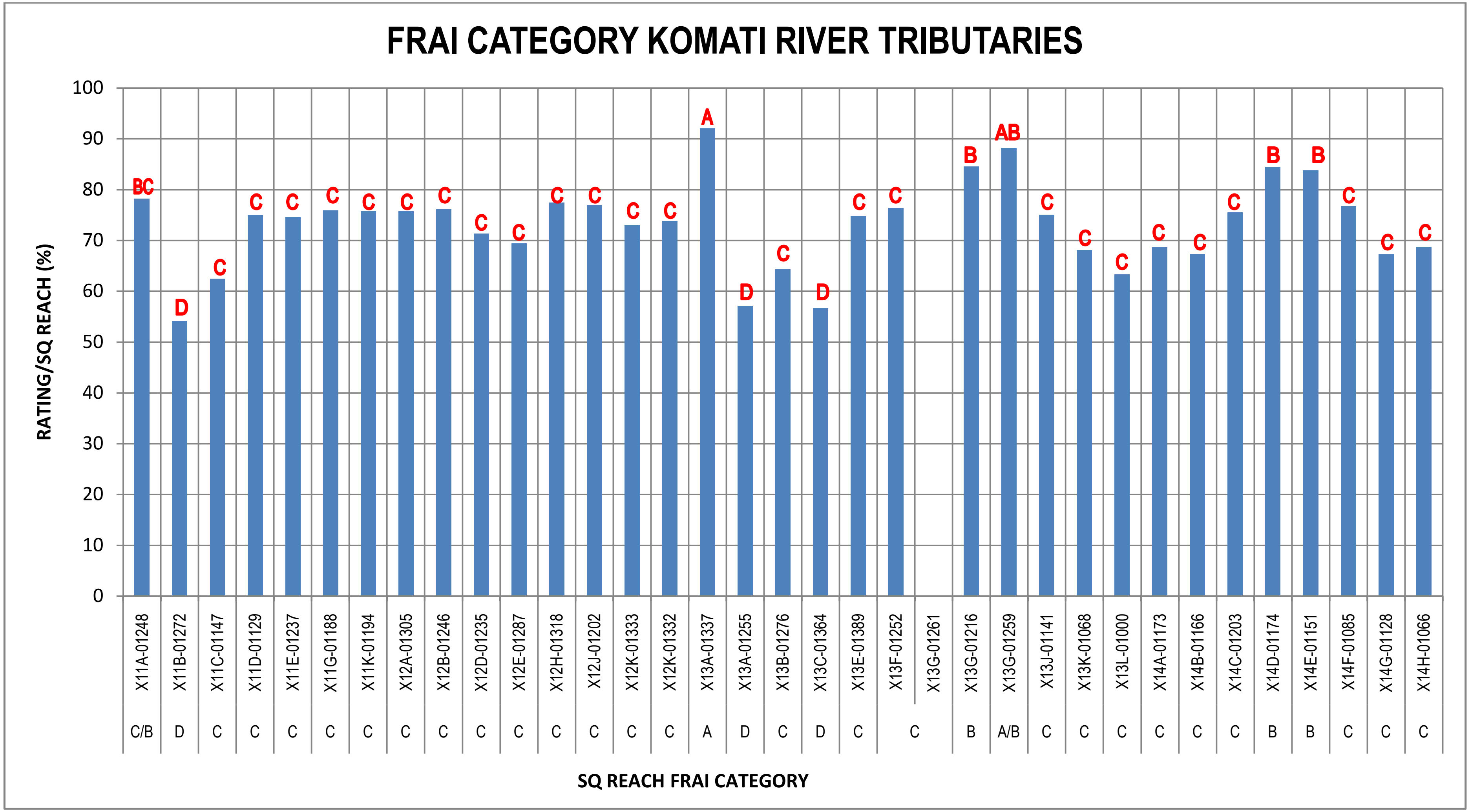

Figure 130: FRAI category for the Komati River tributaries SQ reaches. For SQ reach X13G-01261 no data is available resulting in a blank column. The X14 reaches on the graph represents the Lomati sub-catchment.

MIRAI Categories

Based on the aquatic invertebrate community the Komati River tributaries are overall categorised as Class C moderately impaired. Of concern is numerous tributaries (X12K-01333 - Mlondozi); (X13C-01364 - Muyane); (X13E-01389 - Nyonyane); (X13F-01252 - Mzimene); (X13G-01259 - Mphofu) and (X13K-01068 - Nkwakwa) within Swaziland rating a Class D indicating severely modified river. The low MIRAI rating can be contributed to excessive siltation and sedimentation as well as influx of domestic waste. However, seven SQ reaches ranged from a Class A to Class BC indicating slight to moderately impaired rivers.

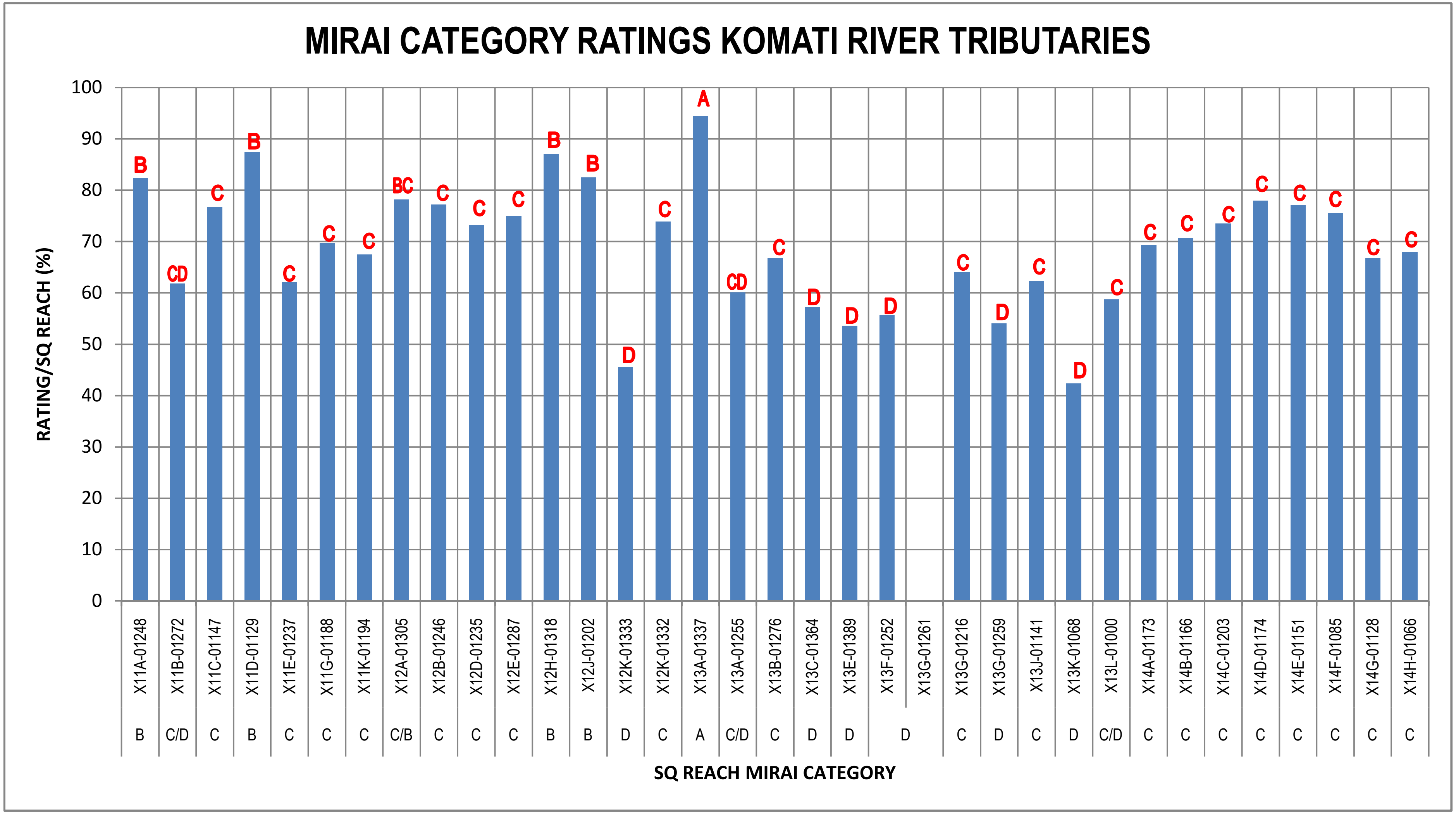

Figure 131: MIRAI category for the Komati River tributaries SQ reaches. For SQ reach X13G-01261 no data is available resulting in a blank column. The X14 reaches on the graph represents the Lomati sub-catchment.

Instream and Integrated Ecostatus Ratings for the Komati River Tributaries

From figures 132 and 133 it is evident that the Instream Ecostatus rating as well as the Integrated Ecostatus rating is a consistent C class, moderately impaired. It is only the Malolotja River that rated a Class A with a few other reaches improving slightly ranging from a class B to a class BC.

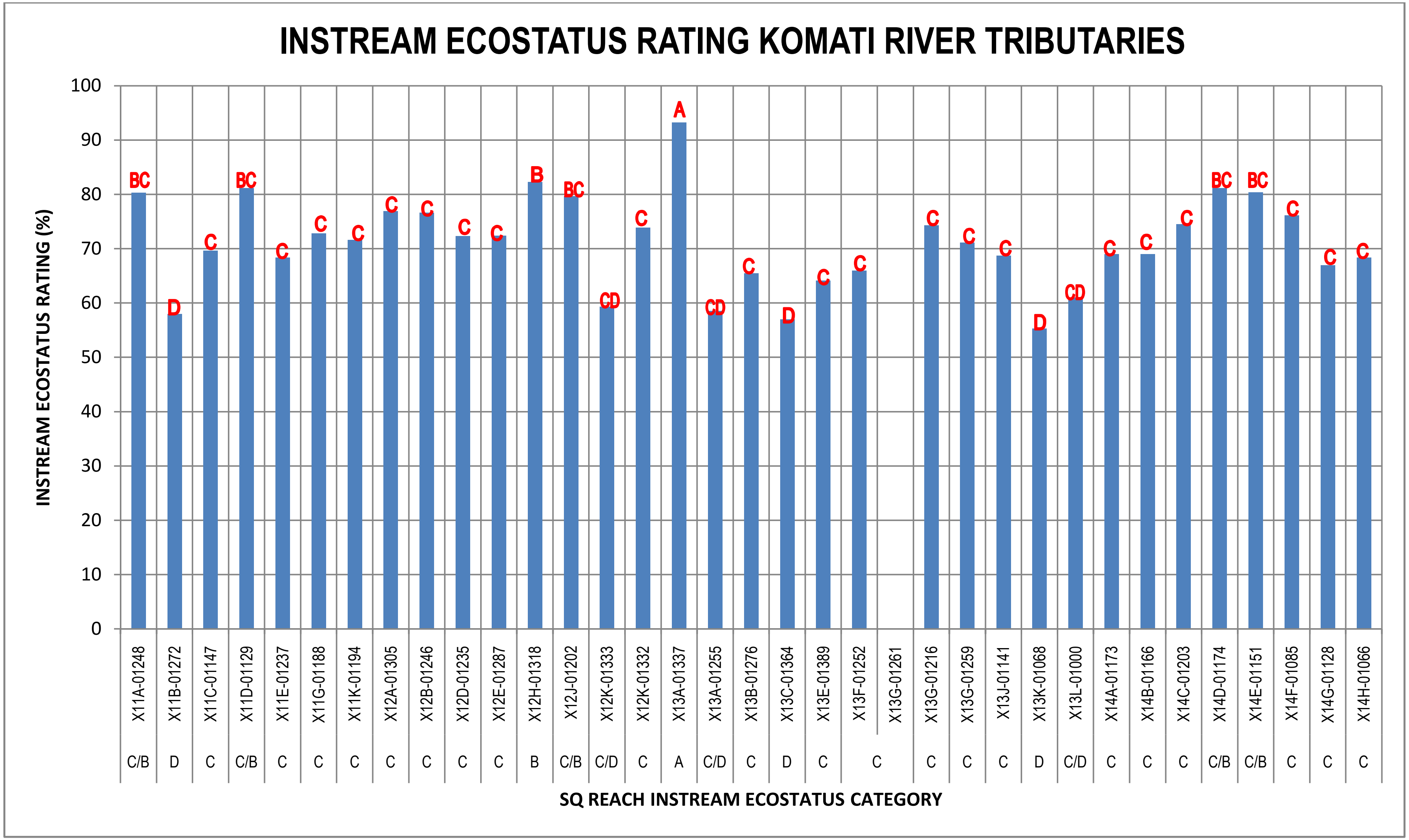

Figure 132: Instream Ecostatus rating for the Crocodile River tributaries SQ reaches. For SQ reach X13G-01261 no data is available resulting in a blank column. The X14 reaches on the graph represents the Lomati sub-catchment.

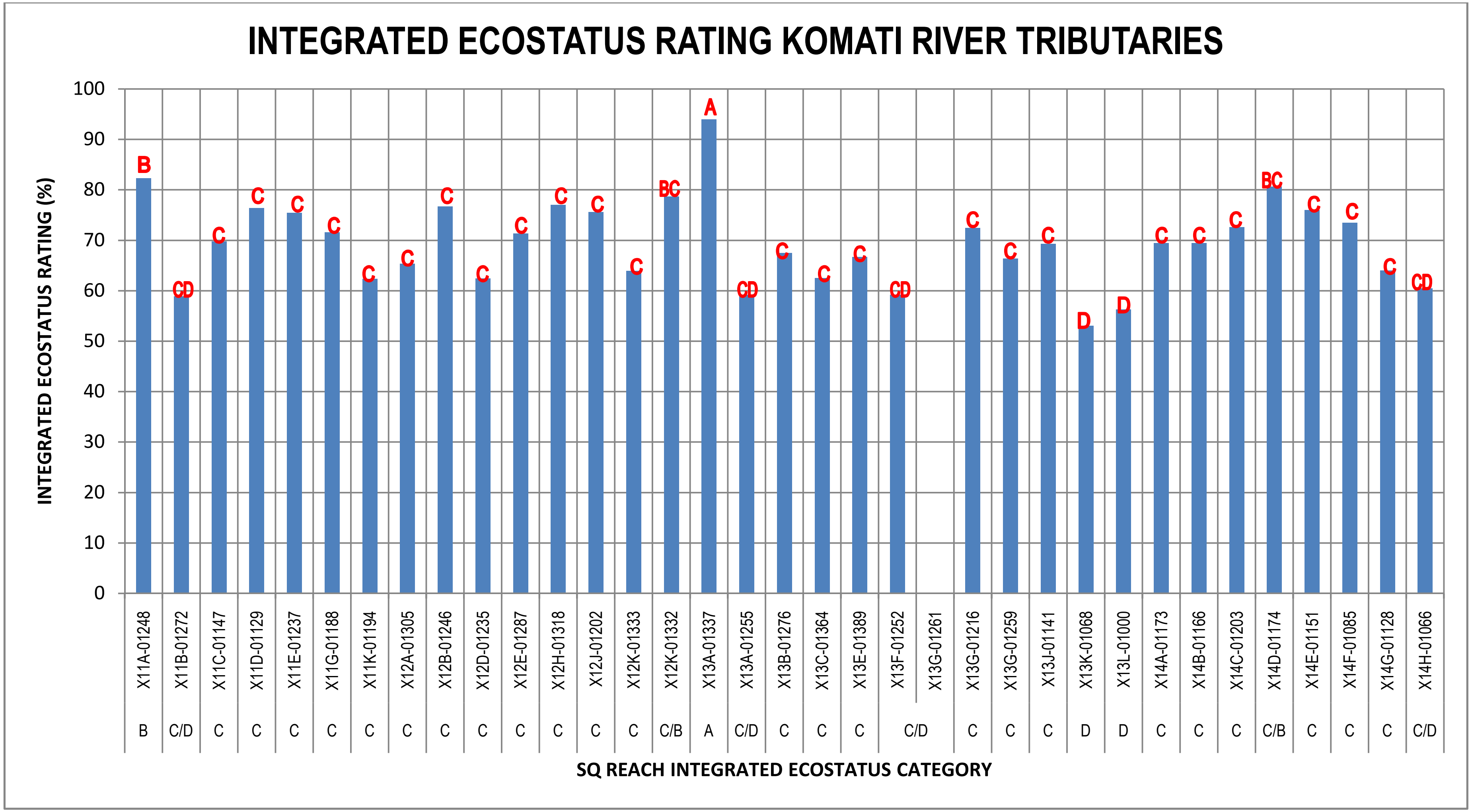

Figure 133: Integrated Ecostatus rating for the Komati River tributaries SQ reaches. For SQ reach X13G-01261 no data is available resulting in a blank column. The X14 reaches on the graph represents the Lomati sub-catchment.

Biomonitoring points for Komati River Tributaries not on the SQ reach cover for the PESEIS.

These monitoring points were done additionally and are not on the X1 SQ reaches as defined and numbered by the Department of Water Affairs. Nevertheless they are important sites in the holistic picture to determine the Ecostatus of the Komati River from source to confluence with the Crocodile River.

Mhlambanyathi stream : not allocated on SQ reach

SQ Reach	SQR Name	Fish Sites	SASS Sites	FRAI	MIRAI	Instream Ecostatus	River Length km
Not allocated	Mhlambanyathi	X1MHLA-GROOT		C	C	C	23.9

General description

The Mhlambanyathi stream originates on the farm Ramkraal at an elevation of 1,978 m.a.s.l. (Figure 134 & 135). The river length from source to entering the Komati River is 23.9 km, flowing in a south-east-southerly direction (140°) towards the Komati River. The sampling point is located 21.1 km from the stream's origin, and the site located in the transitional geomorphologically zone. In terms of vegetation types, the stream originates in the Lydenburg Montane Grassland, followed by the KaNgwane Montane Grassland, intersected by Northern Escarpment Dolomite Grassland and Northern Escarpment Quartzite Sourveld. The stream close to its Komati confluence falls within the Swaziland Sour Bushveld. The sampling point is located in the KaNgwane Montane Grassland. The entire catchment falls within the Northern Mountain Escarpment aquatic ecoregion. Land-use in the upper catchment includes commercial forestry, livestock grazing, crop irrigation, trout farms and several small dams(11). Two dams were counted on the main Mhlambanyathi and nine on tributaries.

Fish

The aquatic site sampled was at a road crossing and consisted primarily of deep pools upstream from the crossing and, riffles and runs downstream. Only two of the fish velocity depth classes were present, fast shallow (abundant) and fast deep (moderate). The overhanging vegetation as cover was abundantly present with sparse undercut banks and root wads only at the fast shallow habitat. The fish cover present consisted largely of substrate with a few rocks together with cobbles and pebbles in the riffles and fines in the slow deep habitat. The fish assemblage of the present survey consisted of three species from an expected ten species of indigenous fish. The only flow dependant species collected was *Chiloglanis pretoriae* (59) which was collected in abundance. Only one of each of the limnophilic species, *Barbus anoplus* and *Tilapia sparrmanii*, was collected.

The CPUE (catch per unit effort) calculated for this site is 1.4 (61 individuals; 43 minutes) indicating a relative abundance of fish.

A Fish Response Index (FRAI) score of 73.4% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring on record. Taxa associated with moderate and slow flow dominated, followed by fast and stagnant. The highest abundance and diversity of taxa was in the cobbles biotope, followed by vegetation and gravel/sand/mud. Taxa diversity was lower than expected for the stones biotope when compared to averages for the ecoregion, but a higher degree of sensitive taxa dominated. The vegetation biotope supported a high number of taxa compared to other sites in the ecoregion, while the gravel/sand/mud biotope supported less. Overall taxa diversity was low, but sensitivity ratings above average.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MHLA-GROOT site on the Mhlambanyathi was rated as moderately impaired (C-class), which is mainly attributed to high deposition of fine silt in the pools and slower flowing areas of the stream.

Chemical and Physical Water Quality

Table 54. Results for water quality constituents measured at the Mhlambanyathi stream's site (X1MHLA-GROOT) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**12**			
Sampling Date	**10 July 2014**			
Sampling Time	**13h15**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**10.0**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.5**			
Saturation (%)	**114.6**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**7.7**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**50.1**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05	<0.005 = oligotrophic		

	oligo - euro	0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**130**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4)	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.379**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory NA = Not available

E coli counts were elevated, on the brink of unacceptable for swimming or human use. Other water quality results measured and analysed fell within expected ranges (Table 54).

On Site Impacts Recorded

- High deposition of fine silt in pools and slower flowing portions of the stream;
- Poor road drainage, allowing for loose soil from the road to enter the stream during rainfall events;
- High reed growth in the riparian zone, testament to high sediment inputs over time;
- High infestation of the riparian zone with exotic weeds, and;
- High periphyton growth on submerged rocks and other stable substrates.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C suggesting a moderately impaired habitat.

MHLAMBANYATHI

Site Code	X1MHLA-GROOT	**Reach**	Not allocated
Latitude	-25.83626° S	**Quaternary Catchment**	X11H
Longitude	30.56834° E	**Elevation**	1,134 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16. KaNgwane Montane Grassland
River Gradient	0.0281	**Geomorphological Zone**	Transitional

Figure 134. Upstream view of the site on the Mhlambanyathi River, X1MHLA-GROOT (10 July 2014, G Diedericks).

Figure 135. Downstream view of the site on the Mhlambanyathi River, X1MHLA-GROOT (10 July 2014, G Diedericks).

Lekkerloop stream: not allocated on SQ reach

SQ Reach	SQR Name	Fish Sites	SASS Sites	FRAI	MIRAI	Instream Ecostatus	River Length km
Not allocated	Lekkerloop	X1LEKK-VERGE		C	B	BC	38.2

General description

The Lekkerloop stream originates on the farm Heerenveen, 20.3 km south-west (215°) from the town of Badplaas, at an elevation of 1,780 m.a.s.l. (Figure 136 & 137). The river length from source to the stream confluence with the Seekoeispruit is 38.2 km, flowing in a north-east by easterly direction (51°) towards the Seekoeispruit.

The sampling point (X1LEKK-VERGE) is located on Nkomazi Private Game Reserve, on the farm Vergelegen. The site is located 2.8 km upstream from its confluence with the Seekoeispruit. The site is at an elevation of 965 m.a.s.l., categorised geomorphologically as an upper foothills zone. The bulk of the catchment falls within the KaNgwane Montane Grassland, but the sampling site is located in the Swaziland Sour Bushveld vegetation type. The upper portion of the catchment are located in the Highveld aquatic ecoregion, and the lower portion in the Northern Escarpment Mountains.

The uppermost portion of the catchment is predominantly commercial forestry, but there are also trout farms, livestock grazing, small scale crop irrigation, and several small dams (9). One dam was counted on the main Lekkerloop and eight on tributaries.

Fish

The aquatic site sampled consisted of small riffles and runs with a long stretch of a shallow pool. At this biomonitoring site only two fish velocity depth classes were present: fast shallow (abundant), slow shallow (moderate). No deep habitats were present. Overhanging vegetation as cover for fish was absent with only sparse undercut banks and root wads present in the slow shallow habitat. The substrate in the fast shallow habitat was abundant consisting of boulders, rocks, cobbles and pebbles with embeddedness evident, resulting in loss of interstitial spaces causing loss of available fish habitat. In the slow habitat the substrate as cover was sparse with siltation evident. The fish assemblage recorded at the site consisted of six species of an expected 19 indigenous species for this reach. The reophilic species collected were *Chiloglanis pretoriae, Amphilius uranoscopus* and *Labeobarbus marequensis.* Lymnophylics species collected were two cichlid species, *Pseudocrenilabrus philander* and *Tilapia sparrmanii* as well as *Barbus paludinosus*. The assemblage was dominated by the presence *Labeobarbus marequensis* (51) which was also collected in abundance.

The CPUE (catch per unit effort) calculated for this site is 2.6 (108 individuals; 41 minutes) indicating a relative high abundance of fish present.

A Fish Response Index (FRAI) score of 72.4% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with slow flow dominated, followed by moderate to fast flows. Taxa associated with stagnant waters were also present. The highest abundance and diversity of taxa was in the cobbles biotope, but the diversity and abundance was lower than the average for the ecoregion. Taxa diversity and abundance in the vegetation biotope was higher than recorded for the ecoregion. The diversity and average sensitivity ratings for the stones biotope was higher for the site than the average for the ecoregion. Taxa diversity in the vegetation biotope was higher than for sites in the ecoregion, but tolerant taxa were dominant. Overall, taxa diversity was high but sensitive taxa were less dominant.
Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1LEKK-VERGE site on the Lekkerloop was rated as slightly impaired (B-class). High deposition of sand which affects instream habitat conditions is considered as the main reason for current conditions.

Chemical and Physical Water Quality

Table 55. Results for water quality constituents measured at the Lekkerloop stream's site (X1LEKK-VERGE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**22**			
Sampling Date	**17July 2014**			
Sampling Time	**08h55**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**9.9**			
pH	**8.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**9.6**			
Saturation (%)	**91.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**7.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**51.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	

Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**3**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.113**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**5**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 55).

On Site Impacts Recorded

- High sand deposition, and;
- Dense localised exotic weed (*Populus* sp.) infestation of the riparian zone.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

LEKKERLOOP

Site Code	X1LEKK-VERGE	**Reach**	Not allocated
Latitude	-25.97977° S	**Quaternary Catchment**	X12D
Longitude	30.65400° E	**Elevation**	965 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0071	**Geomorphological Zone**	Upper Foothills

Figure 136. Upstream view of the site on the Lekkerloop, X1LEKK-VERGE (17 July 2014, G Diedericks).

Figure 137. Downstream view of the site on the Lekkerloop, X1LEKK-VERGE (17 July 2014, G Diedericks).

Mawelawela stream : not allocated on SQ reach

SQ Reach	SQR Name	Fish Sites	SASS Sites	FRAI	MIRAI	Instream Ecostatus	River Length km
Not allocated	Mawelawela	X1MAWE-TJAKA		C	C	C	23.2

General description

The Mawelawela stream originates on the farm Goedehoop, 22.3 km east-north-east (60°) from the town of Badplaas, at an elevation of 1,460 m.a.s.l. (Figure 139 & 140). The river length from source to the stream confluence with the Komati River is 23.2 km, flowing in a south-south-easterly direction (151°) towards the Komati River. The sampling point (X1MAWE-TJAKA) is located north of Tjakastad on the farm Avontuur. The site is located 1.2 km upstream from its confluence with the Komati River. The site is at an elevation of 866 m.a.s.l., categorised geomorphologically as an upper foothills zone. The largest portion of the catchment falls within the Barberton Montane Grassland, with a small portion intersected by the Barberton Serpentine Sourveld. The portion close to the catchments confluence with the Komati River are located in the Swaziland Sour Bushveld vegetation type. The entire Mawelawela catchment are located in the Northern Escarpment Mountains aquatic ecoregion.

The uppermost portion of the catchment falls predominantly within commercial forestry areas, but there is also and old mine from which the mining waste dump erodes into the river. Livestock grazing, game farm and small scale crop irrigation includes the other land uses.

Fish

This typical upper foothill river site consisted of sequences of riffles, runs and pools with a large pool at the road crossing. All of the fish velocity depth classes were present: fast shallow (abundant), fast deep (sparse), slow shallow (moderate) and slow deep (sparse). Overhang vegetation as cover for fish was rated as moderate with abundant undercut banks and root wads which provided excellent fish cover. The substrate as cover for fish was moderately present with large boulders, rocks and cobbles in the fast habitats and sparse in the slow habitats with siltation evident. The fish assemblage recorded at the site consisted of only three species of an expected nine species. The two flow dependant species collected at the site were *Chiloglanis pretoriae* and *Labeobarbus marequensis.* Only one other species, *Tilapia sparrmanii*, a limnophilic, was collected.

A catch per unit effort (CPUE) of 0.8 was recorded for this site (31 individuals; 41 minutes), indicating a relative low abundance of fish present at the time of the survey. This low abundance can be attributed to the poor habitat available and road crossings which act as barriers.

A Fish Response Index (FRAI) score of 71.6% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

The 2014 survey is the first monitoring at this site on record. Taxa associated with moderate flow dominated, followed by slow and to a lesser extent stagnant waters. The highest abundance and diversity of taxa was in the cobbles biotope, with low diversity in the vegetation biotope. Overall, taxa diversity was less than the average for the ecoregion, but the dominance of sensitive taxa was on par.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MAWE-TJAKA site on the Mawelawela was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 56. Results for water quality constituents measured at the Mawelawela stream's site (X1MAWE-TJAKA) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**20**			
Sampling Date	**15July 2014**			
Sampling Time	**15h50**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**14.2**			
pH	**8.1**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**12.4**			
Saturation (%)	**136.0**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**36.5**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**237.3**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**91**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*****			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				

Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**<0.025**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**4**		<2,000	

* = Not measured by Laboratory   NA = Not available

Levels of saturated oxygen was elevated, but readings at 06h00 in the morning over different seasons are required to meaningfully interpret this result. All other water quality results measured and analysed fell within expected ranges (Table 56).

On Site Impacts Recorded

- Stream bed and bank scouring recorded;
- High sand deposition;
- High quantities of domestic waste in the stream and riparian zone;
- Cattle trampling of the stream banks (Figure 138), and;
- The stream crossing blocks the movement of fish during low flow conditions.

Figure 138. Cattle trampling of the stream banks is evident in the photo on the left, and the lack of marginal vegetation at the stream crossing, and the barrier to fish movement during low flow is evident in the photo on the right (15 July 2015, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C suggesting a moderately impaired habitat.

MAWELAWELA

Site Code	X1MAWE-TJAKA	**Reach**	Not allocated
Latitude	-25.96386° S	**Quaternary Catchment**	X12G
Longitude	30.82030° E	**Elevation**	866 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Lowveld	**Vegetation Type**	SVI 14: Swaziland Sour Bushveld
River Gradient	0.0074	**Geomorphological Zone**	Upper Foothills

Figure 139. Upstream view of the site on the Mawelawela, X1MAWE-TJAKA (15 July 2014, G Diedericks).

Figure 140. Downstream view of the site on the Mawelawela, X1MAWE-TJAKA (15 July 2014, G Diedericks).

Unspecified tributary of Mlondozi River : not allocated on SQ reach

SQ Reach	SQR Name	Fish Sites	SASS Sites	FRAI	MIRAI	Instream Ecostatus	River Length km
Not allocated	Unspecified	X1UNSP-BMINE		D	C	CD	21.5

General description

The site was selected to monitor the impacts of an iron ore mine in Swaziland on the Mlondozi River (Figure 143 & 144). The site is located on a tributary of the Mlondozi River, directly downstream from an eroded stream originating from the mining site. The eroding stream is located south-east from the Malolotja Nature Reserve in Swaziland. The main stream originates in South Africa, in a commercial forestry area before flowing through rural settlements in Swaziland in a northerly direction towards the Mlondozi. The length of the main channel from source to its confluence with the Mlondozi is 21.5 km. The sampling point (X1UNSP-BMINE) is 11 km downstream from the source. The site is at an elevation of 1,142 m.a.s.l., categorised geomorphologically as a mountain stream.

The entire catchment upstream from the sampling point (X1UNSP-BMINE) falls within the KaNgwane Montane Grassland vegetation type, and in the Northern Escarpment Mountains aquatic ecoregion. The upper most portion of the catchment falls predominantly within commercial forestry areas, and then flows through rural settlements, with livestock grazing and subsistence farming. The old iron mine in Swaziland is being reworked by the Swaziland King and an Indian based company, and drains a tributary from the mine towards the sampling point. The erosion and soil deposition from this mine tributary is severe, altering the instream habitat from where it enters the stream above the sampling point, all the way to where the Mlondozi flows into the Komati River.

Fish

At this site biomonitoring for fish was conducted for a total sampling effort of 28 minutes. During this effort no fish were collected due to total loss of available fish habitat. The instream habitat has been destroyed due to excessive siltation and sedimentation. The fish velocity depth classes recorded at this site comprised primarily of fast shallow (abundant) and slow shallow (moderate) with a loss of the deep velocity depth class (fast deep and slow deep). Within the fast shallow and slow habitats no instream structures were observed with a loss of fish cover - sparse overhanging vegetation and root wads - and substratum. A Fish Response Assessment Index (FRAI) score of 52% was calculated for this reach based on all available information, placing this reach in an Ecological Class D (severely impaired habitat with low diversity and abundance of species).

Invertebrates

Even though this is a mountain stream, where most taxa are expected in the fast to moderate flow biotopes, taxa in slow to fast and moderate flows dominated in 2014. Taxa diversity in all the biotopes were far lower than the average for the ecoregion, but the sensitivity ratings were similar to the average. This highlights the negative effect of the erosion from the mine altering instream habitat through excessive deposition of soil and sediments. Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1UNSP-BMINE site on a tributary of the Mlondozi was rated as moderately impaired (C-class).

Chemical and Physical Water Quality

Table 57. Results for water quality constituents measured at the Unspecified stream name of a tributary of the Mlondozi(X1UNSP-BMINE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**28**			
Sampling Date	**04August 2014**			
Sampling Time	**09h35**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**10.0**			
pH	**7.3**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**11.2**			
Saturation (%)	**112.7**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**11.1**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**72.2**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.5**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**26**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**<5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.120**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**6**		<2,000	

* = Not measured by Laboratory NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 57).

On Site Impacts Recorded

- Extremely high deposition of soil and mud in the stream substrate (Figure 141 & 142);
- Stream bank and bed scouring;
- High quantities of domestic waste in the stream and riparian zone;
- Cattle trampling of the stream banks, and;
- High infestation of the riparian zone with exotic weeds.

Figure 141. A view (on the left) of the old iron mine in Swaziland. The erosion occurs on the back of the terraced slopes. The photo on the right resembles a road, but it is a >1 m stream channel smothered in gravel and soil deposited in the stream. This stream drains directly from the mine (04August 2015, G Diedericks).

Figure 142. A view of the stream channel at the sampling site X1UNSP-BMINE. Bank scouring, sediment deposition and the high degree of invasive plant species are clearly evident (04 August 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class CD suggesting a moderately to severely impaired habitat.

UNSPECIFIED – TRIBUTARY MLONDOZI

Site Code	X1UNSP-BMINE	**Reach**	Not allocated
Latitude	-26.19211° S	**Quaternary Catchment**	X12K
Longitude	31.01138° E	**Elevation**	1,142 m.a.s.l.
Aquatic Ecoregion Lev I	10. Northern Escarpment Mountains	**Aquatic Ecoregion Lev II**	10.03
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 16: KaNgwane Montane Grassland
River Gradient	0.0873	**Geomorphological Zone**	Mountain Stream

Figure 143. Upstream view of the site on the Mlondozi, X1MLON-BMINE located downstream from the Indian-Swazi Iron Ore Mine (04 August 2014, G Diedericks).

Figure 144. Downstream view of the site on the Mlondozi, X1MLON-BMINE located downstream from the Indian-Swazi Iron Ore Mine (04 August 2014, G Diedericks).

Melete River : not allocated on SQ reach

SQ Reach	SQR Name	Fish Sites	SASS Sites	FRAI	MIRAI	Instream Ecostatus	Reach Length km
Not allocated	Melete	X1MELE-MELET		C	D	CD	13.6

General description

The Melete River in Swaziland, originates at an elevation of 1,100 m.a.s.l, flowing in a northerly direction (5°) towards the point where it merges with the Komati River (Figure 147 & 148). The X1MELE-MELET site is located 1.2 km (along the river) from its confluence with the Komati River. The river length measured is 13.6 km from source to confluence, and the site is located 12.4 km from its source. Geomorphologically the stream at the sampling point is categorised as a transitional zone. The upper portion of the catchment is located in the KaNgwane Montane Grassland veld type, merging into the Swaziland Sour Bushveld and then the Granite Lowveld closer to the Komati River. The catchment falls within the North Eastern Highlands and Lowveld aquatic ecoregions. The sampling site (X1MELE-MELET) is located in the Lowveld aquatic ecoregion, at an elevation of 454 m.a.s.l.

Land-use in the catchment primarily is rural settlement areas, with a high degree of subsistence farming. There are several large erosion dongas visible on Google Earth in the catchment area.

Fish

This stream is characterised as a moderately inclined mountain stream, dominated by sand and gravel with isolated riffles and runs. The catchment has largely been transformed by rural development and subsistence farming within the riparian zone, resulting in a loss of habitat such as overhanging vegetation with undercut banks. Due to the high erodability of the soils and landuse practise, siltation and sedimentation is a major problem. The excessive siltation reduces available fish habitat within riffle and run areas, as the rocks and boulders are embedded in sediments resulting in a loss of interstitial spaces. The fish velocity depth classes recorded were only limited to shallow habitats - fast shallow (moderate) and slow shallow (moderate) - with the deep habitats (slow deep and fast deep) absent due to sediment deposition. The fish cover present identified was sparse with sparse overhanging vegetation and undercut banks and root wads. The substrate also rated sparse. Sediment and siltation deposits were recorded in the pools where stream velocity is reduced encouraging deposition.

In spite of poor habitat ratings, the fish assemblage were better than expected with six fish species recorded. Two of the species collected were reophilic species, *Amphilius uranoscopus and Barbus trimaculatus*, whilst *Chiloglanis emarginatus and Opsaridium peringueyi* were flow sensitive species collected at this site. The presence of *Chiloglanis emarginatus* is unique as the red data status of this species is near threatened with this endemic species only occurring in tributaries of the Phongola and Komati rivers. This species is threatened by water abstraction, river regulation and sedimentation. This highly sensitive species is flow dependant with a high flow-depth preference for fast deep (5) and fast shallow (3.2) fish velocity depth classes. *Chiloglanis emarginatus* is also totally intolerant (5) to reduced flow conditions and has a very high (5) preference to substrate. It is highly intolerant to modified water quality (5). The age classes for the species collected reflected juveniles, sub-adults and adults, indicating that the breeding function for this species is not disrupted at present and a viable population exist. The CPUE (catch per unit effort) for this site is 3.3 (87 individuals; 26 minutes) indicating a low abundance. A Fish Response Assessment Index (FRAI) score of 73.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (Moderately impaired with a low diversity and moderate abundance of species).

Invertebrates

The first SASS sampling on record in this stream was in 2014. Taxa associated with moderate and slow flows were dominant, with taxa associated with fast and stagnant waters present. Taxa diversity and sensitivity ratings of the stones biotope was below the average for the ecoregion. The vegetation biotope diversity was lower than the average for the ecoregion, and sensitivity rating similar. The diversity in the gravel/sand/mud biotopes were similar to the average for the ecoregion, but the sensitivity rating was lower. Overall both the diversity and sensitivity rating was lower than the average for the ecoregion. Sediment inputs, deposition and movement is high limits and therefore habitat quality and availability, and poor conditions are attributed to habitat alterations.
Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MELE-MELET on the Melete stream was rated as severely impaired (D-class).

Chemical and Physical Water Quality

Table 58. Results for water quality constituents measured at the Melete stream's site (X1MELE-MELET) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**33**			
Sampling Date	**05 August 2014**			
Sampling Time	**15h30**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**18.3**			
pH	**7.9**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.6**			
Saturation (%)	**91.8**	80 - 120		
Clarity (cm)	**74**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**7.9**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**51.4**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*			

Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**<0.2**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**1,600**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	
Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**9**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.719**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**9**		<2,000	

* = Not measured by Laboratory NA = Not available

Water clarity was relatively low, and there were very high counts of E coli. Other water quality results measured and analysed fell within expected ranges (Table 58).

On Site Impacts Recorded

- The road approach to the bridge is steep with no drainage. Loose soils from the road enters the stream directly during rainfall events (Figure 145);
- Extremely high sediment deposition;
- Stream bank scouring is extensive;
- Washing of clothes in the stream (Figure 146), and;
- The stream crossing blocks the movement of fish during low flow events

Figure 145. Bank scouring (left photo) downstream from crossing as it overtops during high flow events. The crossing (right) block fish movement during normal and low flow events (05 August 2014, G Diedericks).

Figure 146. Women washing clothes in the river, with bank scouring in the background (05 August 2014, G Diedericks).

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class CD suggesting a moderately to severely impaired habitat.

MELETE

Site Code	X1MELE-MELET	**Reach**	Not allocated
Latitude	-26.08883° S	**Quaternary Catchment**	X13D
Longitude	31.33933° E	**Elevation**	454 m.a.s.l.
Aquatic Ecoregion Lev I	3. Lowveld	**Aquatic Ecoregion Lev II**	3.07
Bioregion	Lowveld	**Vegetation Type**	SVI 3: Granite Lowveld
River Gradient	0.0240	**Geomorphological Zone**	Transitional

Figure147. Upstream view of the site on the Melete River, X1MELE-MELET (05 August 2014, G Diedericks).

Figure 148. Downstream view of the site on the Melete River, X1MELE-MELET (05 August 2014, G Diedericks).

Mlumati River : not allocated on SQ reach

SQ Reach	SQR Name	Fish Sites	SASS Sites	FRAI	MIRAI	Instream Ecostatus	River Length km
Not allocated	Mlumati	X1MLUM-WELGE		C	C	C	8.7

General description

The Mlumati is a tributary of the upper Lomati River, originating on Sappi's Twello plantations Heemstede farm, at an elevation of 1,580 m.a.s.l. (Figure 149 & 150). From its origin, the stream flows in a north-east by easterly direction (57°) towards its confluence with the Lomati River. The X1MLUM-WELGE site is located 900 m upstream from its confluence with the Lomati. The site is located on the farm De Bilt (Sappi Twello) at an elevation of 1,049 m.a.s.l. Geomorphologically the stream at the sampling point is categorised as a transitional zone. The entire catchment upstream from the sampling point is located in the Barberton Montane Grassland. A small portion of the upper catchment is located in the Northern Escarpment Mountains aquatic ecoregion, while the rest of the catchment upstream from the site are located in the North Eastern Highlands. The land-use in the catchment is commercial forestry.

Fish

The aquatic site sampled consisted of sequences of riffles and runs as well as a deep pool and the only fish velocity depth classes present were fast shallow (very abundant) and slow deep (sparse). Overhanging vegetation present as fish cover rated as moderate with undercut banks and root wads rated as moderate to abundant. The substrate in the fast shallow habitat was abundant consisting of boulders, rocks, cobbles and pebbles. Siltation was evident in the pool sampled. The fish assemblage recorded at the site consisted of three species of an expected 17 indigenous species for this reach. The reophilic specie collected was *Amphilius uranoscopus* and two limnophilic species, *Barbus argenteus* and *Barbus brevipinnis*. 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 habitat deterioration

The CPUE (catch per unit effort) calculated for this site is 0.8 (34 individuals; 44 minutes) indicating a relative low abundance of fish present.

A Fish Response Index (FRAI) score of 66.1% was calculated for this reach based on all available information, placing this reach in an ecological Class C (moderately impaired with low diversity and abundance of species).

Invertebrates

Previous SASS sampling data on record at this site (X1MLUM-WELGE) was collected in May 2001, May 2002, May 2003, May 2006 and June 2009. Results for these different sampling periods are fairly similar, with a slight increase in sensitivity ratings in 2014. In 2014, taxa associated with fast to moderate flows were dominant, while taxa associated with slow and stagnant waters were present. Taxa diversity for the stones biotope were lower than the average for the ecoregion, but the sensitivity rating was considerably higher. The vegetation biotope had a high diversity dominated by sensitive taxa, while the gravel/sand/mud biotope had a higher diversity and sensitivity rating than the rest of the ecoregion. Overall the diversity was similar to other sites in the ecoregion, but the sensitivity rating was higher than the average.

Stream conditions based on the aquatic macro-invertebrate community in 2014 at the X1MLUM-WELGE site on the Mlumati was rated as moderately impaired (C-class). Impairments are caused by high weed infestation, bank and bed scouring and fine silt deposition.

Chemical and Physical Water Quality

Table 59. Results for water quality constituents measured at the Mlumati stream's site (X1MLUM-WELGE) compared to the South African Water Quality Guidelines for Aquatic Ecosystems, Livestock Use and Recreation.

DETAILS	RESULTS	SOUTH AFRICAN GUIDELINES		
		Aquatic	Livestock Use	Recreational Use
Water Sample No.	**48**			
Sampling Date	**18 August 2014**			
Sampling Time	**13h35**			
CONSTITUENTS				
System Variables				
Water Temperature (°C)	**15.2**			
pH	**7.5**			6.5 – 8.5
Dissolved Oxygen (mg/ℓ)	**7.8**			
Saturation (%)	**89.1**	80 - 120		
Clarity (cm)	**>120**			<100
Quality Indicators				
Electrical Conductivity (mS/m @ 25°C)	**6.3**			
Total Dissolved Solids (mg/ℓ) [EC (mSm @ 25°C) x 6.5]	**41.0**		<1,000	
Chemical Oxygen Demand (mg/ℓ)	**<10**			
Nutrients				
Free Ammonia (NH_3) mg/ℓ	**<0.2**	≤0.007		
Ionised Ammonia (NH_4) mg/ℓ	*****			
Total Ammonia (NH_3& NH_4) mg/ℓ	**NA**			
Ortho-Phosphate (P) mg/ℓ	<0.05 oligo - euro	<0.005 = oligotrophic 0.005 – 0.025 = mesotrophic 0.025 – 0.25 = eutrophic >0.25 = hypertrophic		
Nitrate (NO_3) mg/ℓ	**0.3**		<100	
Nitrite (NO_2) mg/ℓ	**<0.1**			
Inorganic Nitrogen (mg/ℓ)	NA	<0.5 = oligotrophic 0.5 – 2.5 = mesotrophic 2.5 – 10 = eutrophic >10 = hypertrophic		
Indicator Organisms				
E coli (counts/100 mℓ)	**41**		<200	<130
Inorganic Salts				
Total Hardness (mg $CaCO_3$/ℓ)	*****			
Sulphate (SO_4) mg/ℓ	**<5**		<1,000	

Inorganic – Toxic				
Chloride (Cl) mg/ℓ	**5**		<1,500	
Copper (Cu) mg/ℓ	**<0.025**		≤0.5	
Iron (Fe) mg/ℓ	**0.235**		<10	
Manganese (Mn) mg/ℓ	**<0.025**	≤0.18	<10	
Sodium (Na)	**3**		<2,000	

* = Not measured by Laboratory   NA = Not available

All water quality results measured and analysed fell within expected ranges (Table 59).

On Site Impacts Recorded

- Culverts at the stream crossing is partially blocked with logs and debris, impounding the stream above the crossing and forcing the stream to flow over the structure (damage to bridge and stream banks) during high flow events;
- The crossing blocks fish movement during low and normal flow events;
- Silt deposition in the stream is high;
- Portions of the commercial tree compartments in the catchment are too close to the stream, and;
- The riparian zone is heavily infested with exotic invasive weed species.

Instream Ecological Category

The Instream Ecological Category for this reach was consistent with a Class C suggesting a moderately impaired habitat.

MLUMATI

Site Code	X1MLUM-WELGE	**Reach**	Not allocated
Latitude	-25.83743° S	**Quaternary Catchment**	X14A
Longitude	31.11370° E	**Elevation**	1,049 m.a.s.l.
Aquatic Ecoregion Lev I	4. North Eastern Highlands	**Aquatic Ecoregion Lev II**	4.05
Bioregion	Mesic Highveld Grassland	**Vegetation Type**	Gm 17: Barberton Monatne Grassland
River Gradient	0.0274	**Geomorphological Zone**	Transitional

Figure 149. Upstream view of the site in the Mlumati River, X1MLUM-WELGE (18 August 2014, G Diedericks).

Figure 150. Downstream view of the site in the Mlumati River, X1MLUM-WELGE (18 August 2014, G Diedericks).

5. Komati Catchment Impacts

The Komati River catchment is ecologically severely stressed due to the water demands that are placed on it. ESKOM and agriculture are the two major water users in this catchment. Currently there are 4 major dams that store water and depending on the amount of water required, it is released downstream for irrigation or pumped across the watershed for power generation. There are also various abstraction weirs that affect the aquatic ecosystems and are creating serious obstructions to fish migrations. Dams are also known to change the quality of water entering it and trap sediments essential for downstream geomorphological changes. Return flows from irrigation mobilises a number of chemicals such as pesticides, fertilizers and salts that can affect the quality of water in the system. Point sources along the river discharge water of various qualities into the river systems not knowing what the effect may be on the ecology. Exotic fish species escaping from farm dams have entered the river and predate on indigenous species.

5.1. Upper Komati River

- ### Coal mining

There are several coal mines in the upper catchment, with the most obvious affected stream being the Boesmanspruit. The absence of Tricorythidae in the large parts of the system, linked to increases in sulphates (SO_4^{2-}) (Palmer & Scherman 2000), is partially attributed to mining effluents (Dallas & Day 2004). In a study on the effects of open cast coal mining on mountain streams in Virginia, USA, Pond et al. (2008) indicated shifts in species assemblages, loss of Ephemeroptera taxa, changes in individual metrics and indices, and differences in water chemistry. The Pond et al. (2008) study highligted considerable changes for the following water constituents measured between mined and unmined sites:

- Electrical conductivity
- Hydrogen carbonate (HCO_3)
- Calcium (Ca)
- Chlorine (Cl)
- Hardness
- Total Iron (Fe)
- Magnesium (Mg)
- Dissolved Manganese (Mn)
- Total Manganese (Mn)
- Nickel (Ni)
- Nitrate (NO_3-N)
- Potassium (K)
- Selenium (Se)
- Na (Sodium)
- Sulphates (SO_4)

- ### Farm dams and weirs

The impacts of dams on aquatic ecosystems are well documented, and are mainly related to changes in hydrology, habitat and water quality. One of the concerns is the large number of small farm dams, which alter smaller streams from predominantly lotic to more lentic habitats. Also, these smaller dams are usually stocked with exotic predatory fish, which have detrimental effects on such aquatic ecosystems (Cucherousset & Olden 2011). Another concern is the cumulative impact of the numerous small dams on altering the average water temperature.

- **Commercial forestry**

Commercial forestry is the dominant land-use in the, Ndubazi, Mhlambanyatsi, Gladdespruit, Buffelspruit, Hlatjiwe, Teespruit and Mawelawela catchments. Bank scouring and high silt-sediment deposition are characteristic of these streams, with water quality generally good. Impacts of commercial forestry on aquatic ecosystems are mainly related to alteration or loss of instream habitat, mainly in terms of increased catchment run-off during rainfall events (Furniss et al. 1998; Warkotsch 1989; Wemple et al. 1996; Wemple et al. 2001), resulting in high sediment inputs from extensive road networks. Road network densities are generally very high, making it very costly to maintain to an acceptable standard (Warkotsch 1989). The riparian zones are generally changed from open and/or semi-shaded to fully shaded. The lack of fire in some of these riparian zones, and the shading effect by commercial trees promotes the dominance of woody species, which alters natural stream foodwebs (e,.g. coarse particulate organic matter inputs) and in turn instream community composition.

- **Stream crossings and road drainage**

Stream crossing and roads affect streams in terms of causing potential obstruction to fish movement, and roads transporting loose soil and pollutants (e.g. cattle manure) to stream and river systems during rainfall events. Several examples of stream crossing designs without consideration for the presence or movement of indigenous fish species were encountered. Poor road drainage was also common. The main problem was that drainage from roads enter streams and rivers directly without vegetal filtration to remove sediment. Most tributaries are accessed and utilised by fishes as refugia e.g. for feeding, survival, reproduction, and nursery areas. Fishes will also utilise tributaries to escape from predators in the main channel, and in some cases for thermal refugia (Rice et al. 2008). Structures that block free movement in river ecosystems fragment habitats and in extreme cases makes the habitat unavailable (McCleary et al. 2006). Continuous sediment inputs from road networks threatens the aquatic ecosystems and the capacity and longevity of dams.

5.2. Middle Komati River

- **Iron Mining**

An old iron mine re-opened by the King of Swaziland and an Indian Mining company. Erosion from this mine is having a devastating impact on a tributary of the Mlondozi River and the Mlondozi River itself.

- **Overgrazing and Erosion**

Large number of domesticated stock in the form of cattle were encountered throughout the middle reaches of the Komati River. In severe cases overgrazing of riverbranks and riverbank instability were encountered due to trampling resulting in excessie high sediment loads deposited into rivers. High recorded E. coli counts can in some cases be related to cattle dung being transported with soil into rivers via road networks.

5.3. Lower Komati River

- **Sugarcane production**

In the lower Komati catchment landuse practise has changed the environment to the monoculture production of irrigated sugarcane. These practises result in the majority of land being transformed to agricultural land with irrigation mainly from the Komati River. At the Ngweti and Nkwakwa biomonitoring sites sugarcane has been planted into the riparian zone thus decreasing the filtering effect of this zone for sediments and nutrients.

- **Weirs**

Within the lower Komati River a large number of weirs is present on the main channel thus transforming the lotic habitat to a lentic habitat. This transformation increase habitat of alien and invasive species within the cathcment resulting in competition for available resources to indigenous fish species. Furthermore the damming of the river at these weirs increases thermal water temperatures resulting in disruptions of the normal temperature regimes in rivers. As most of these weirs have no fish ways they create serious obstructions to fish migrations.

6. SUMMARY AND CONCLUSION

The summary of the 2014 biomonitoring of the Komati water catchment are briefly discussed below.

In total 59 biomonitoring points were assessed to determine the Ecostatus of the Komati River catchment, Inkomati River system South Africa. In the Komati River mainstem 31 SQ reaches were assessed of which 16 sites were surveyed and 15 sites were extrapolated as part of the Ecological Status Determination of the Komati River, representing a total river length of 413.76 km. In addition a further 43 biomonitoring sites were surveyed on tributaries of the Komati River representing a total river length of 1109.99km, of these six sites were not allocated on reach. They were included primarily to present the holistic status of the catchment. The actual biomonitoring results indicated a C-class status for both the fish (FRAI - 73.2%) and aquatic macro-invertebrates (MIRAI - 70.9%). The Instream Ecostatus, which is derived from a combination of the data collected for fish and aquatic macro-invertebrates, was also categorised as a C-class (71.9%) (moderately modified). The Integrated Ecostatus, which is derived from the FRAI, MIRAI and VEGRAI data collection, rated also a Class-C (71.3%), thus indicating that the Komati River system is overall categorised as a Class-C indicating a moderately modified river (Table 60).

Although the overall Ecological status of the Komati River is still in a relative good condition, certain tributaries and sections of the lower Komati River are in a poor condition. Rapid flow changes and reductions, excessive siltation and sedimentation, poor water quality, impoundments by weirs causing deficiency in available riffle areas and no fish ways are some of the contributing factors.

Table 60: Summary of indices rated for the Komati River Catchment biomonitoring 2014

	PES	FRAI	MIRAI	INSTREAM ECOSTATUS	RIPARIAN ECOSTATUS	INTEGRATED ECOSTATUS	VEGRAI
NR OF SQ REACHES ASSESSED	81	51	50	51	50	51	50
TOTAL LENGTH OF SQ REACHES ASSESSED	1450.92	1006.98	977.86	1006.98	1004.38	1006.98	1004.38
OVERALL RATING	63.7	73.2	70.9	71.9	70.1	71.3	70.1
OVERALL CATEGORY	C	C	C	C	C	C	C

Fish

During fish surveys conducted at 59 biomonitoring points in total 46 different indigenous fish species were collected (see Appendix). Three alien and invasive fish species and one alien and invasive freshwater crayfish species were recorded. The indigenous fish species of importance are *Chetia brevis,* endemic to the Komati River system and is presently rated as vulnerable, and *Opsaridium peringueyi*, rated as threatened by the IUCN Red list of Threatened species (Cambray & Swartz, 2007).

Low fish species diversity and abundance were recorded in certain reaches, particularly in certain tributaries and below major impoundments. The headwaters are characterised by a high density of farm dams and weirs where the fast flowing mountain streams were altered to lentic habitats, creating ideal conditions for alien fish species. The dams and weirs are linked to flow regulation, water quality changes, physical changes and increased sedimentation. These listed impacts are considered to be the main causes for deterioration. The impact of alien and invasive fish species, as well as the fast spreading invasion of freshwater crayfish (*Cherax quadricarinatus*) is well documented (Cucherousset & Olden 2011; Davies & Day 1998; Mitchell & Knouft 2008) and have a major impacts on indigenous fish species populations.

Flow regulation and timing of flow releases (dam operating rules) are the biggest cause for impaired conditions below major impoundments (Nooitgedacht Dam, Vygeboom Dam, Driekoppies Dam and Maguga Dam). The impacts of large dams on downstream communities are well documented. Fish species historically recorded prior to the construction of impoundment are no longer present in the Komati River main stem, and where present they are in low abundance. Tributaries in the affected reach act as critically important refuges for the survival of these species. Some of these flow sensitive species which are intolerant to habitat and water quality changes include *Amphilius natalensis, Amphilius uranoscopus, Chiloglanis anoterus, Chiloglanis pretoriae*, *Chiloglanis swierstrai*, *Opsaridium peringueyi* and *Barbus argenteus*. The overall Fish Response Assessement Index (FRAI) for the Komati River catchment rated a 73.2% which is a Class C indicating a moderately impaired river with moderate species diversity and abundance.

Aquatic Invertebrates

A total of 68 SASS5 taxa were recorded at the 59 sites sampled in the Komati Catchment. The most records (frequency of occurrence - FROC) at the 59 sites were Chironomidae, followed by Baetidae >2 sp., Coenagrionidae, Gyrinidae, Caenidae, Gomphidae, Simuliidae, Heptageniidae and Libellulidae. A total of 60 SASS5 taxa were encountered at the 17 sites sampled in the main stem Komati River, of which the families Perlidae, Baetidae >2 sp, Heptageniidae, Leptoceridae, Gyrinidae and Chironomidae were recorded at all 17 (FROC = 100%). The first records (for this survey) of Atyidae (freshwater shrimps) in the Komati River was at the Bhale site (X1KOMA-BHALE) at an elevation of 310 m a.m.s.l. The family Tricorythidae was recorded in the Komati River up to the site above Vygeboom Dam, and then again only at the two sites upstream from the confluence of the Komati River with the Lomati. Based on studies by Palmer & Scherman (2000), salinity tolerance of *Tricorythustinctus* (Ephemeroptera: Tricorythidae) decrease with increases in sulphates (SO_4^{2-}). Sulphate increases in natural ecosystems are generally associated with mining (Dallas & Day 2004) and settlement effluents. In total 62 SASS5 taxa were encountered at the 42 sites sampled on tributaries of the Komati River, of which only Chironomidae was recorded at all the site (FROC = 100%). Families with a FROC of >90% included Coenagrionidae, Simuliidae, Baetidae >2 sp., Gyrinidae and Gomphidae.

The highest total SASS5 score and taxa diversity was recorded in the Komati River downstream from the rivers' confluence with the Klein Komati and in the Komati River on the Songimvelo Nature Reserve. The lowest SASS5 total score and diversity was recorded in the Mbulatana River in Swaziland, and the Nkwakwa River draining sugarcane farms. The highest sensitivity rating (ASPT[2]) for sites were recorded on the Klein Komati and Mlumati rivers (7.3), while the lowest was recorded on the Mbulatana River (4.9).

Water chemistry

Water analysis of chemical water samples collected were carried out by Waterlab, (Pty) Ltd. The pH values measured ranged from 7.3 – 8.4 with an average of 7.9. Electrical Conductivity (EC) values ranged between 4.6 and 172 mS/m, with an average of 23.5 mS/m. The highest EC values were recorded in two streams (Nkwakwa and Ngweti) of which the dominant land-use in the catchments are sugarcane. On average however, the EC levels were mostly within acceptable limits (DWAF 1996). Chloride (Cl) levels ranged from <5 to 302 mg/ℓ, with an average value of 27 mg/ℓ. Detectable limits of <5 mg/ℓ was recorded at 52% of the sites sampled, and limits <120 at 95% of the sites. With the absence of South African Standards for freshwater ecosystems, Canadian and British Columbian Standards were used. Levels >120 mg/ℓ was measured at three sites, and >150 mg/ℓ at two. These were on the Ngweti (127 mg/ℓ), Mzinti (169 mg/ℓ) and Nkwakwa (302 mg/ℓ) rivers. Elevated chloride levels are associated with waste water treatment, septic systems, landfill discharges, and agricultural activities (e.g. animal wastes and fertilisers). In the upper catchment of the Mzinti River, the land-use are predominantly urban-rural settlements, while sugarcane is dominant in the Nkwakwa and Ngweti catchments.

Standards for Sulphates (SO_4) levels are generally linked to water hardness also measured in mg/ℓ. The softer (0-30mg/ℓ) the water the lower the acceptable level of sulphate, and for moderatly soft to hard water (76-180 mg/ℓ) the higher the acceptable sulphate levels. Sulphate levels were measured as <20 mg/ℓ at the 93% of the sites, with an average of 17 mg/ℓ. The higest levels were detected in order of magnitute in the:

- Ngweti at 116 mg/ℓ;
- Boesmanspruit at 67 mg/ℓ;
- Nkwakwa at 57 mg/ℓ, and;
- Komati River at Lebombo (31 mg/ℓ).

Detectable limits of nitrate (NO_3) were measured at 62% of the sites, with the highest values measured in the Komati River at Lebombo, and the sugarcane streams, Nkwakwa and Ngweti. No detectable levels of nitrites (NO_2<0.2mg/ℓ), ortho phosphates (P <0.05 mg/ℓ), ammonia (NH_3<0.2mg/ℓ) or copper (Cu <0.025 mg/ℓ) were measured at any of the sampled sites. Chemical Oxygen Demand (COD) was >10 mg/ℓ at four of the sampling sites. These sites were located on the Mngubhudla, Witkloofspruit, Nkwakwa rivers, and the Lomati River at the X1LOMA-MBONG site.

[2]ASPT = Average Score Per Taxon

E. coli counts/100 mℓ have significant risk of infection for young livestock at levels of 200 – 1000 or levels of 1000 – 5000 at <20% of the samples, and significant risks for mature livestock when water samples measuring 200 – 1000 counts/mℓ at >50% of the samples (DWAF 1996). At 17% of the sites, once-off measurements exceeded 200 counts/mℓ, and 1000 counts/mℓ at 12% of the sites. Rivers where measurements were equal to and exceeded 1000 counts/mℓ included the Melete, Mpofu, Mbulatana, Mzimnene, Mkhomazana and one site on the Lomati. All these streams were in located in Swaziland. Sodium (Na) measured exceeded 100 mg/ℓ at two of the sites, namely the Mzinti and Nkwakwa rivers, and <2 mg/ℓ at two sites. The average levels measured between all 60 sites was 16 mg/ℓ. Iron (Fe) measurements ranged from below detectable (<0.025 mg/ℓ) to 0.821 mg/ℓ (Mbulafana), with an average of 0.255 mg/ℓ. Manganese was only detectable (≥0.025 mg/ℓ) at one of the sites sampled in the Mhlangatana stream in Swaziland.

Ecostatus

The Instream Ecostatus Rating is derived from the fish assemblage (FRAI) and the macro-invertebrate assemblage (MIRAI) and it is evident that the Instream Ecological Category Rating is consistent Class C throughout the mainstem and tributaries. The expected trend would be for the high altitude streams close to the source of this river to be of a higher class with a gradual decrease towards the lower-lying reaches. However, in this study the upper SQ reaches are severely impacted by the deteriorating state of tributaries feeding into the mainstem. These tributaries are primarily impacted by mining activities in the upper Komati River. Fortunately, reaches located within Komati Gorge Reserve, Songimvelo Nature Reserve and Malolotja National Park improve slightly indicating that the river is slightly modified with a relative high diversity of species and abundance within these protected areas. Numerous dams and weirs as well as land use practices further impact on the Instream Ecostatus within this river. Other areas of concerns are below large impoundments, namely, Nooitgedacht, Vygeboom, Driekoppies and Maguga dams, where stream regulation and its operating rules impact negatively on the downstream Ecostatus. Of particular concern is the two reaches below the Maguga Dam in Swaziland where the Instream categories decreases indicating largely modified SQ reaches. Downstream of these impoundments the river improves again and the C Class category is maintained throughout to its confluence with the Crocodile River.

7. RECOMMENDATIONS

Although the overall Ecological status of the Komati River is still in a relative good condition, certain tributaries and sections of the lower Komati River are in a poor condition. Based on the impacts observed and discussed above, the following recommendations are included:

- Biomonitoring of the Komati River to be conducted every three years to monitor changes in the Ecostatus.
- Implementation of the ecological reserve and frequent monitoring to track changes and trends, and to determine whether the reserve objectives are met.
- The long-term impact of the invasion of *Cherax quadricarinatus* on the aquatic habitat in the lower Komati River to be determined.
- Addressing forestry management in upper reaches of Komati River to reduce siltation and sedimentation.

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9. APPENDIX - Fish species collected per reach

In this appendix all fish species are listed in alphabetical order, fish collected within a reach is indicated by an X, expected species of the reach were not indicated.

ABREV	SPECIES	X11A-01248 X1VAAL-BOESM	X11B-01272 X1BOES-ROODE	X11C-01147 X1WITK-WITKL	X11D-01129 X1KKOM-WELGE	X11D-01196 X1KOMA-MOEDI	X11E-01237 X1SWAR-HEBRO	X11F-01163 X1KOMA-WATER	X11G-01142 X1KOMA-GEVON	X11G-01188 X1NDUB-SAPPI
ANAT	*Amphilius natalensis*									
AURA	*Amphilius uranoscopus*			X		X		X	X	X
AMAR	*Anguilla marmorata*									
AMOS	*Anguilla mossambica*									
BFRI	*Barbus afrohamiltoni*									
BANN	*Barbus annectens*									
BANO	*Barbus anoplus*				X					
BARG	*Barbus argenteus*							X	X	
BBRI	*Barbus brevipinnis*									
BEUT	*Barbus eutaenia*									
BNEE	*Barbus neefi*									
BPAU	*Barbus paludinosus*									
BRAD	*Barbus radiatus*									
BTOP	*Barbus toppini*									
BTRI	*Barbus trimaculatus*									
BUNI	*Barbus unitaeniatus*									
BVIV	*Barbus viviparus*									
BIMB	*Brycinus imberi*									
CANO	*Chiloglanis anoterus*									
CBIF	*Chiloglanis bifurcus*									
CEMA	*Chiloglanis emarginatus*									
CPAR	*Chiloglanis paratus*									
CPRE	*Chiloglanis pretoriae*	X	X	X	X	X	X	X	X	X
CSWI	*Chiloglanis swierstrai*									
CGAR	*Clarias gariepinus*	X		X				X		
CCAR	*Cyprinus carpio*									
CBRE	*Chetia brevis*									
GGIU	*Glossogobius giuris*									
HVIT	*Hydrocynus vittatus*									
LCON	*Labeo congoro*									
LCYL	*Labeo cylindricus*									
LMAC	*Lepomis macrochirus*									
LMOL	*Labeo molybdinus*									
LROS	*Labeo rosae*									
BMAR	*Labeobarbus marequensis*								X	
BPOL	*Labeobarbus polylepis*		X	X				X		
MMAC	*Marcusenius pongolensis*									
MBRE	*Mesobola brevianalis*									
MACU	*Micralestes acutidens*									
MSAL	*Micropterus salmoides*									
OMYK	*Oncorhynchus mykiss*									
OPER	*Opsaridium peringueyi*									
OMOS	*Oreochromis mossambicus*									
PCAT	*Petrocephalus wesselsi*									
PPHI	*Pseudocrenilabrus philander*								X	
SINT	*Schilbe intermedius*									
TREN	*Coptodon (Tilapia) rendalli*									
TSPA	*Tilapia sparrmanii*	X						X	X	
VNEL	*Varicorhinus nelspruitensis*									

Alien and invasive fish species indicated in red font

ABREV	SPECIES	X11H-01140		X11K-01194	X11K-01227	X12A-01305	X12B-01246	X12D-01235		X12E-01287	
		X1KOMA-LEKKE	X1KOMA-GROOT	X1GLAD-VYGEB	X1KOMA-VYGEB	X1BUFF-DOORN	X1HLAT-RIETF	X1SEEK-DOORN	X1SEEK-WINKE	X1TEES-WELVE	X1TEES-HEUNI
ANAT	*Amphilius natalensis*						X				
AURA	*Amphilius uranoscopus*	X		X	X	X		X		X	X
AMAR	*Anguilla marmorata*										
AMOS	*Anguilla mossambica*										
BFRI	*Barbus afrohamiltoni*										
BANN	*Barbus annectens*										
BANO	*Barbus anoplus*						X				X
BARG	*Barbus argenteus*										
BBRI	*Barbus brevipinnis*										
BEUT	*Barbus eutaenia*										
BNEE	*Barbus neefi*										
BPAU	*Barbus paludinosus*				X			X			
BRAD	*Barbus radiatus*										
BTOP	*Barbus toppini*										
BTRI	*Barbus trimaculatus*										X
BUNI	*Barbus unitaeniatus*										X
BVIV	*Barbus viviparus*										
BIMB	*Brycinus imberi*										
CANO	*Chiloglanis anoterus*										
CBIF	*Chiloglanis bifurcus*										
CEMA	*Chiloglanis emarginatus*										
CPAR	*Chiloglanis paratus*				X						
CPRE	*Chiloglanis pretoriae*	X	X	X	X	X	X	X	X	X	X
CSWI	*Chiloglanis swierstrai*										
CGAR	*Clarias gariepinus*			X							
CCAR	*Cyprinus carpio*										
CBRE	*Chetia brevis*										
GGIU	*Glossogobius giuris*										
HVIT	*Hydrocynus vittatus*										
LCON	*Labeo congoro*										
LCYL	*Labeo cylindricus*										
LMAC	*Lepomis macrochirus*										
LMOL	*Labeo molybdinus*				X						
LROS	*Labeo rosae*										
BMAR	*Labeobarbus marequensis*	X	X	X	X			X	X	X	X
BPOL	*Labeobarbus polylepis*										
MMAC	*Marcusenius pongolensis*										
MBRE	*Mesobola brevianalis*										
MACU	*Micralestes acutidens*										
MSAL	*Micropterus salmoides*										
OMYK	*Oncorhynchus mykiss*										
OPER	*Opsaridium peringueyi*										
OMOS	*Oreochromis mossambicus*				X						
PCAT	*Petrocephalus wesselsi*										
PPHI	*Pseudocrenilabrus philander*		X	X	X				X		X
SINT	*Schilbe intermedius*										
TREN	*Coptodon (Tilapia) rendalli*										
TSPA	*Tilapia sparrmanii*		X		X			X			X
VNEL	*Varicorhinus nelspruitensis*										

Alien and invasive fish species indicated in red font

ABREV	SPECIES	X12G-01200	X12H-01258	X12H-01296	X12H-01318	X12J-01202	X12K-01316	X12K-01332	X12K-01333	X13A-01337	X13A-01324
		X1KOMA-TJAKA	X1KOMA-HOOGE	X1KOMA-KOMAT	X1SAND-KORTB	X1MTSO-DIEPG	X1KOMA-HILLC	X1MHLA-KRANS	X1MLON-KRANS	X1MALO-MALOL	X1KOMA-MALOL
ANAT	*Amphilius natalensis*									X	
AURA	*Amphilius uranoscopus*	X	X	X		X		X		X	X
AMAR	*Anguilla marmorata*										
AMOS	*Anguilla mossambica*	X									
BFRI	*Barbus afrohamiltoni*										
BANN	*Barbus annectens*										
BANO	*Barbus anoplus*							X		X	
BARG	*Barbus argenteus*										
BBRI	*Barbus brevipinnis*										
BEUT	*Barbus eutaenia*										
BNEE	*Barbus neefi*										
BPAU	*Barbus paludinosus*			X			X				
BRAD	*Barbus radiatus*										
BTOP	*Barbus toppini*										
BTRI	*Barbus trimaculatus*		X	X		X					
BUNI	*Barbus unitaeniatus*	X	X	X							X
BVIV	*Barbus viviparus*										
BIMB	*Brycinus imberi*										
CANO	*Chiloglanis anoterus*										
CBIF	*Chiloglanis bifurcus*										
CEMA	*Chiloglanis emarginatus*									X	
CPAR	*Chiloglanis paratus*	X		X							X
CPRE	*Chiloglanis pretoriae*	X	X	X	X	X	X	X		X	X
CSWI	*Chiloglanis swierstrai*						X				X
CGAR	*Clarias gariepinus*		X		X						
CCAR	*Cyprinus carpio*										
CBRE	*Chetia brevis*										
GGIU	*Glossogobius giuris*										
HVIT	*Hydrocynus vittatus*										
LCON	*Labeo congoro*										
LCYL	*Labeo cylindricus*						X				X
LMAC	*Lepomis macrochirus*										
LMOL	*Labeo molybdinus*	X	X	X	X	X	X		X		X
LROS	*Labeo rosae*										
BMAR	*Labeobarbus marequensis*	X	X	X	X	X	X	X	X		X
BPOL	*Labeobarbus polylepis*									X	X
MMAC	*Marcusenius pongolensis*										X
MBRE	*Mesobola brevianalis*										
MACU	*Micralestes acutidens*										
MSAL	*Micropterus salmoides*										
OMYK	*Oncorhynchus mykiss*										
OPER	*Opsaridium peringueyi*										
OMOS	*Oreochromis mossambicus*		X	X			X				X
PCAT	*Petrocephalus wesselsi*										
PPHI	*Pseudocrenilabrus philander*			X	X		X	X			
SINT	*Schilbe intermedius*										
TREN	*Coptodon (Tilapia) rendalli*										
TSPA	*Tilapia sparrmanii*		X	X	X	X	X	X			
VNEL	*Varicorhinus nelspruitensis*										

Alien and invasive fish species indicated in red font

ABREV	SPECIES	X13A-01255 X1NKOM-MALOL	X13B-01276 X1MKHO-MAGUG	X13C-01364 X1MBUY-MKHOM	X13D-01323 X1KOMA-MELET	X13E-01389 X1NYON-NYONY	X13E-01346 X1KOMA-BHALE	X13F-01252 X1MZIM-MANSE	X13G-01282 X1KOMA-IFR03	X13G-01216 X1MBUL-MPOFU	X13G-01259 X1MPOF-MPOFU
ANAT	*Amphilius natalensis*										
AURA	*Amphilius uranoscopus*	X	X	X	X			X			
AMAR	*Anguilla marmorata*										
AMOS	*Anguilla mossambica*										
BFRI	*Barbus afrohamiltoni*									X	
BANN	*Barbus annectens*										
BANO	*Barbus anoplus*										
BARG	*Barbus argenteus*										
BBRI	*Barbus brevipinnis*										
BEUT	*Barbus eutaenia*				X	X				X	
BNEE	*Barbus neefi*										
BPAU	*Barbus paludinosus*										
BRAD	*Barbus radiatus*									X	
BTOP	*Barbus toppini*										
BTRI	*Barbus trimaculatus*					X	X	X	X	X	X
BUNI	*Barbus unitaeniatus*										X
BVIV	*Barbus viviparus*						X		X	X	X
BIMB	*Brycinus imberi*										
CANO	*Chiloglanis anoterus*										
CBIF	*Chiloglanis bifurcus*										
CEMA	*Chiloglanis emarginatus*			X	X	X	X				
CPAR	*Chiloglanis paratus*				X		X	X	X	X	X
CPRE	*Chiloglanis pretoriae*	X	X	X	X	X	X		X	X	X
CSWI	*Chiloglanis swierstrai*				X		X	X	X	X	X
CGAR	*Clarias gariepinus*				X	X	X	X	X	X	X
CCAR	*Cyprinus carpio*										
CBRE	*Chetia brevis*										
GGIU	*Glossogobius giuris*										
HVIT	*Hydrocynus vittatus*										
LCON	*Labeo congoro*										
LCYL	*Labeo cylindricus*				X	X	X	X	X	X	X
LMAC	*Lepomis macrochirus*										
LMOL	*Labeo molybdinus*	X			X				X	X	
LROS	*Labeo rosae*										
BMAR	*Labeobarbus marequensis*	X			X	X	X	X	X	X	X
BPOL	*Labeobarbus polylepis*		X								
MMAC	*Marcusenius pongolensis*				X		X		X		X
MBRE	*Mesobola brevianalis*										
MACU	*Micralestes acutidens*						X				
MSAL	*Micropterus salmoides*		X								
OMYK	*Oncorhynchus mykiss*										
OPER	*Opsaridium peringueyi*				X		X	X			X
OMOS	*Oreochromis mossambicus*							X	X	X	X
PCAT	*Petrocephalus wesselsi*				X						
PPHI	*Pseudocrenilabrus philander*										
SINT	*Schilbe intermedius*										
TREN	*Coptodon (Tilapia) rendalli*										X
TSPA	*Tilapia sparrmanii*								X		
VNEL	*Varicorhinus nelspruitensis*										

Alien and invasive fish species indicated in red font

ABREV	SPECIES	X13J-01210	X13J-01130	X13J-01141	X13K-01068	X13L-00995	X13L-01000	X14A-01173	X14B-01166	X14C-01203	X14D-01174
		X1KOMA-NYATS	X1KOMA-IFR04	X1MZIN-MASHU	X1NKWA-COOPE	X1KOMA-LEBOM	X1NGWE-KOMAT	X1LOMA-HIGHL	X1UGUT-ZEIST	X1PHOP-MAGUT	X1LOMA-HLELE
ANAT	*Amphilius natalensis*										
AURA	*Amphilius uranoscopus*							X	X	X	X
AMAR	*Anguilla marmorata*										
AMOS	*Anguilla mossambica*										
BFRI	*Barbus afrohamiltoni*										
BANN	*Barbus annectens*										
BANO	*Barbus anoplus*								X		
BARG	*Barbus argenteus*							X			
BBRI	*Barbus brevipinnis*							X			
BEUT	*Barbus eutaenia*	X	X							X	X
BNEE	*Barbus neefi*										X
BPAU	*Barbus paludinosus*			X							
BRAD	*Barbus radiatus*										
BTOP	*Barbus toppini*	X		X	X						
BTRI	*Barbus trimaculatus*	X	X	X	X						X
BUNI	*Barbus unitaeniatus*										X
BVIV	*Barbus viviparus*										
BIMB	*Brycinus imberi*										
CANO	*Chiloglanis anoterus*							X		X	X
CBIF	*Chiloglanis bifurcus*										
CEMA	*Chiloglanis emarginatus*										
CPAR	*Chiloglanis paratus*	X				X					
CPRE	*Chiloglanis pretoriae*	X	X	X							
CSWI	*Chiloglanis swierstrai*	X									
CGAR	*Clarias gariepinus*		X		X	X					X
CCAR	*Cyprinus carpio*										
CBRE	*Chetia brevis*										
GGIU	*Glossogobius giuris*				X	X					
HVIT	*Hydrocynus vittatus*										
LCON	*Labeo congoro*										
LCYL	*Labeo cylindricus*	X	X			X				X	
LMAC	*Lepomis macrochirus*								X		
LMOL	*Labeo molybdinus*										
LROS	*Labeo rosae*										
BMAR	*Labeobarbus marequensis*	X	X	X		X				X	X
BPOL	*Labeobarbus polylepis*										
MMAC	*Marcusenius pongolensis*		X								
MBRE	*Mesobola brevianalis*										
MACU	*Micralestes acutidens*	X			X						
MSAL	*Micropterus salmoides*										
OMYK	*Oncorhynchus mykiss*										
OPER	*Opsaridium peringueyi*	X		X						X	
OMOS	*Oreochromis mossambicus*	X	X	X	X	X					
PCAT	*Petrocephalus wesselsi*					X					
PPHI	*Pseudocrenilabrus philander*										
SINT	*Schilbe intermedius*										
TREN	*Coptodon (Tilapia) rendalli*			X					X		
TSPA	*Tilapia sparrmanii*							X			
VNEL	*Varicorhinus nelspruitensis*							X	X		

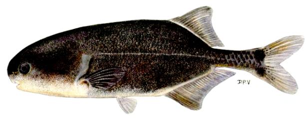
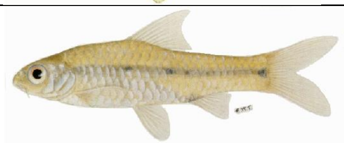
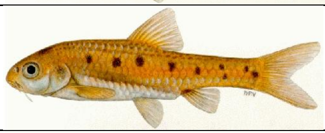
Alien and invasive fish species indicated in red font

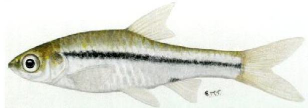
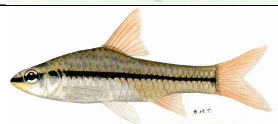
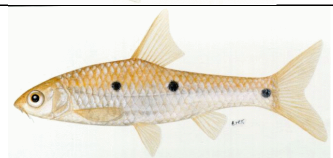
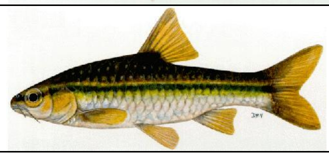
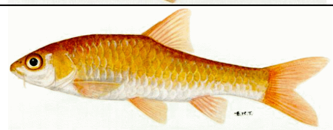
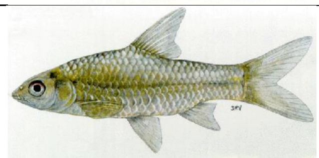
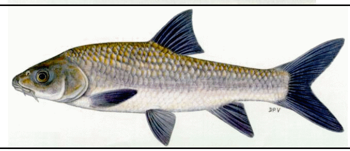
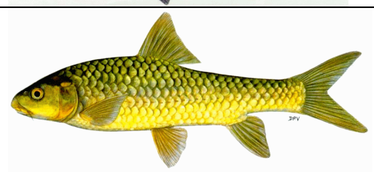
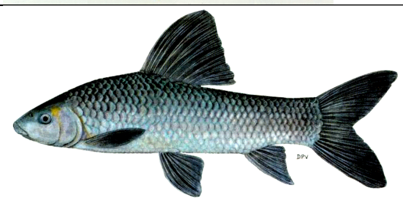
ABREV	SPECIES	X14E-01151	X14F-01085	X14G-01128	X14H-01066	Not on reach					
		X1LOMA-MBONG	X1MHLA-RUSOO	X1LOMA-SCHOE	X1LOMA-LEKKE	X1MHLA-GROOT	X1MAWE-TJAKA	X1LEKK-VERG	X1UNSP-BMINE	X1MELE-MELET	X1MLUM-WELGE
ANAT	*Amphilius natalensis*										
AURA	*Amphilius uranoscopus*	X	X					X		X	X
AMAR	*Anguilla marmorata*										
AMOS	*Anguilla mossambica*										
BFRI	*Barbus afrohamiltoni*										
BANN	*Barbus annectens*										
BANO	*Barbus anoplus*					X					
BARG	*Barbus argenteus*										X
BBRI	*Barbus brevipinnis*										X
BEUT	*Barbus eutaenia*	X	X								
BNEE	*Barbus neefi*										
BPAU	*Barbus paludinosus*							X			
BRAD	*Barbus radiatus*				X						
BTOP	*Barbus toppini*										
BTRI	*Barbus trimaculatus*				X					X	
BUNI	*Barbus unitaeniatus*										
BVIV	*Barbus viviparus*		X	X						X	
BIMB	*Brycinus imberi*										
CANO	*Chiloglanis anoterus*	X									
CBIF	*Chiloglanis bifurcus*										
CEMA	*Chiloglanis emarginatus*									X	
CPAR	*Chiloglanis paratus*										
CPRE	*Chiloglanis pretoriae*		X	X	X	X	X	X			
CSWI	*Chiloglanis swierstrai*										
CGAR	*Clarias gariepinus*	X		X	X					X	
CCAR	*Cyprinus carpio*										
CBRE	*Chetia brevis*	X									
GGIU	*Glossogobius giuris*										
HVIT	*Hydrocynus vittatus*										
LCON	*Labeo congoro*										
LCYL	*Labeo cylindricus*	X	X	X	X						
LMAC	*Lepomis macrochirus*										
LMOL	*Labeo molybdinus*	X									
LROS	*Labeo rosae*										
BMAR	*Labeobarbus marequensis*	X	X				X	X			
BPOL	*Labeobarbus polylepis*										
MMAC	*Marcusenius pongolensis*	X		X	X						
MBRE	*Mesobola brevianalis*										
MACU	*Micralestes acutidens*				X						
MSAL	*Micropterus salmoides*				X						
OMYK	*Oncorhynchus mykiss*										
OPER	*Opsaridium peringueyi*	X								X	
OMOS	*Oreochromis mossambicus*				X						
PCAT	*Petrocephalus wesselsi*			X							
PPHI	*Pseudocrenilabrus philander*		X	X				X			
SINT	*Schilbe intermedius*				X						
TREN	*Coptodon (Tilapia) rendalli*			X	X						
TSPA	*Tilapia sparrmanii*					X	X	X			
VNEL	*Varicorhinus nelspruitensis*										

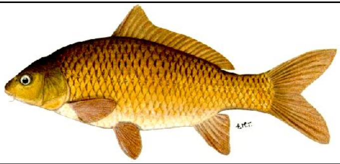
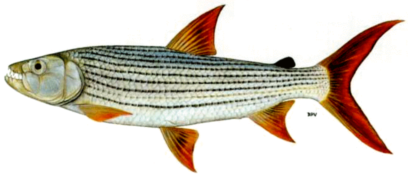
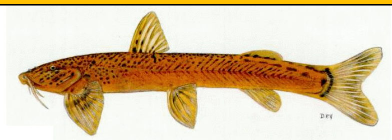
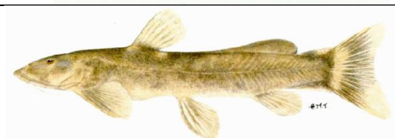
Alien and invasive fish species indicated in red font

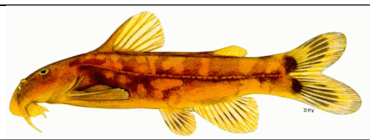
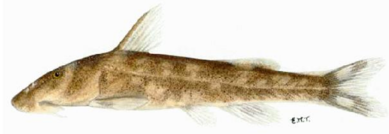
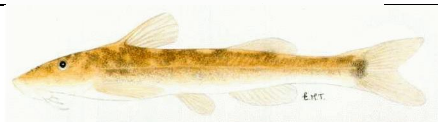
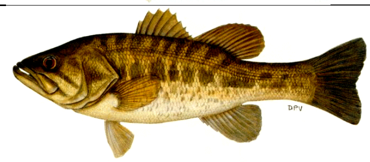
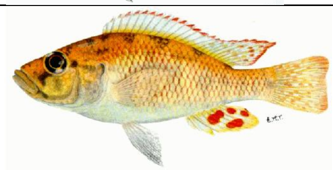
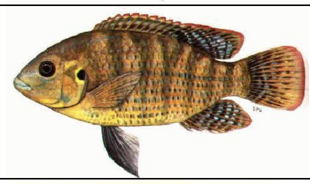
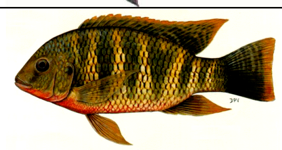
APPENDIX – Photo's of Fish species

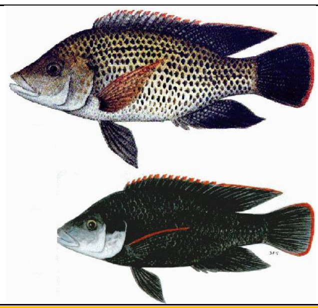
Illustrations of fish species from the Atlas of Southern African Freshwater Species - SAIAB (Scott et al., 2004) recorded at all the sampling sites .

FAMILY MORMYRIDAE - SNOUTFISHES	
Marcusenius pongolensis (previously - *macrolepidotus)* Bulldog	
Petrocephalus catostoma (*wesselsi*) Southern churchill	
FAMILY ANGUILLIDAE - FRESH WATER EELS	
Anguilla mossambica Longfin eel	
Anguilla marmorata Giant mottled eel	
FAMILY CYPRINIDAE - BARBS, YELLOWFISH, LABEOS	
Mesobola brevianalis River sardine	
Opsaridium peringueyi Southern barred minnow	
Barbus anoplus Chubbyhead barb	
Barbus annectens Broadstriped barb	
Barbus brevipinnis Shortfin barb	
Barbus neefi Sidespot barb	
Barbus unitaeniatus Longbeard barb	

Barbus viviparus Bow stripe barb	
Barbus toppini East coast barb	
Barbus radiatus Beira barb	
Barbus trimaculatus Three spot barb	
Barbus eutaenia Orange fin barb	
Barbus argenteus Rose fin barb	
Barbus paludinosus Straight fin barb	
Barbus afrohamiltoni Plump barb	
Labeobarbus polylepis Bushveld small scale yellowfish	
Labeobarbus marequensis Lowveld large scale yellowfish	
Varicorhinus nelspruitensis Incomati chisel mouth	
Labeo congoro Purple labeo	

Labeo cylindricus Red eye labeo	
Labeo molybdinus Leaden labeo	
Cyprinus carpio Carp	
FAMILY CHARACIDAE - CHARACINS	
Brycinus imberi Imberi	
Micralestes acutidens Silver robber	
Hydrocynus vittatus Tigerfish	
FAMILY AMPHILIIDAE - MOUNTAIN CATFISHES	
Amphilius natalensis Natal mountain catfish	
Amphilius uranoscopus Common or stargazer mountain catfish	
FAMILY SCHILBEIDAE - BUTTER CATFISHES	
Schilbe intermedius Silver catfish or Butter barbel	
FAMILY CLARIIDAE - AIR-BREATHING CATFISHES	
Clarias gariepinus Sharptooth catfish	
FAMILY MOCHOKIDAE - SQUEAKERS, SUCKERMOUTH CATLETS	
Chiloglanis anoterus Pennant-tailed suckermouth or rock catlet	

Chiloglanis bifurcus Incomati suckermouth or rock catlet	
Chiloglanis paratus Sawfin suckermouth or rock catlet	
Chiloglanis pretoriae Short spine suckermouth or rock catlet	
Chiloglanis swierstrai Lowveld suckermouth or rock catlet	
FAMILY SALMONIDAE - TROUTS	
Oncorhynchus mykiss Rainbow trout	
FAMILY CENTRARCHIDAE - BASSES AND SUNFISHES	
Lepomis macrochirus Bluegill sunfish	
Micropterus salmoides Largemouth bass	
FAMILY CICHLIDAE - CICHLIDS	
Pseudocrenilabrus philander Southern mouth brooder	
Chetia brevis Orange-fringed river bream	
Tilapia sparrmanii Banded tilapia	
Coptodon rendalli Red breast tilapia	

Oreochromis mossambicus Mozambique tilapia	
FAMILY GOBIIDAE - GOBIES	
Glossogobius giuris Tank goby	

APPENDIX - *Cherax quadricarinatus* : Freshwater crayfish

Freshwater crayfish, *Cherax quadricarinatus*

No freshwater crayfish occur naturally in Africa and the freshwater crayfish, *Cherax quadricarinatus,* a native species from Australia, is one of the more recent alien and invasive species found in South African rivers. Adult males of this species can easily be identified by the red patch on the outer margin of the chelae (Figure A).

Figure A: A male *Cherax quadricarinatus* with distinct red patch on the outer margin of the chelae.

Cherax quadricarinatus was utilised in aquaculture in Swaziland, but has escaped into river systems and is now establishing viable populations in rivers in South Africa. It was first collected in South Africa in the Komati River in 2002 by Francois Roux from the MTPA and Du Preez and Smit (2013) reported the presence of *C. quadricarinatus* from the Ndumu Game Reserve and more recently it was also found at localities on the Komati River, Lomati River and tributaries of the Komati River (Figure B).

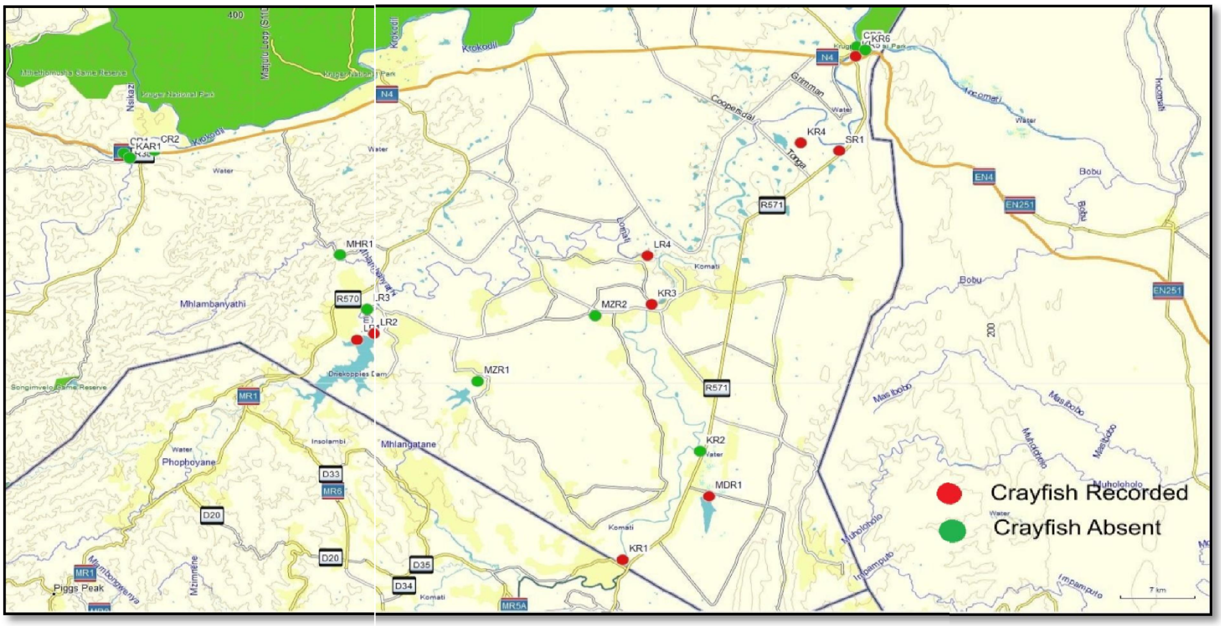


Figure B: Map indicating the sampling localities for the Freshwater crayfish, *Cherax quadricarinatus* in the Nkomazi area (Unpublished report).

During the Komati River biomonitoring in 2014 *C. quadricarinatus* were found at X1KOMA-IFR3 (TONGA), X1NKWA-COOPE (SR1) and X1LOMA-LEKKE (LR4) and also close to the Crocodile River and Komati River confluence (Figure B). It is now clear that these freshwater crayfish occur in the Komati River from the Swaziland border up to just before the confluence with the Crocodile River and in the Lomati River from Driekoppies Dam to the confluence with the Komati River. They have also spread to some other tributaries of the Komati River.

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.

At present a research project on *Cherax quadricarinatus* is registered with the MTPA to determine the distribution and spread of invasion within the Inkomati River system. The impacts of this alien and invasive species will also be determined and in a management plan recommendations to restrict further distribution of this species will be outlined.

De Moor, I.J. 2002. Potential impacts of alien freshwater crayfish in South Africa. African Journal of Aquatic Science 27:2 pp. 125 – 139.

Du Preez, L. and Smit, N. 2013. Double blow: Alien crayfish infected with invasive temnocephalan in South African waters. South African Journal of Science 109(9/10), Art. #2013-0109, 4pp.

APPENDIX - Asbestos Mine

On 07 July 2014 aquatic biomonitoring was conducted on the Hlatjiwe River (X12B-01246) on the farm Rietfontein (S-26.02361 E30.36111). Just downstream from the site chosen for the monitoring, an old asbestos mine was noted with overburden from the mine right on the edge of the river (Figure C). Rain washes over the overburden of asbestos containing rocks and the asbestos fibres end up in the river. The whole area was covered with asbestos fibres and when inhaled, it can cause cancer. This old mine with its dump must be seen as a health hazard and the area should be rehabilitated.

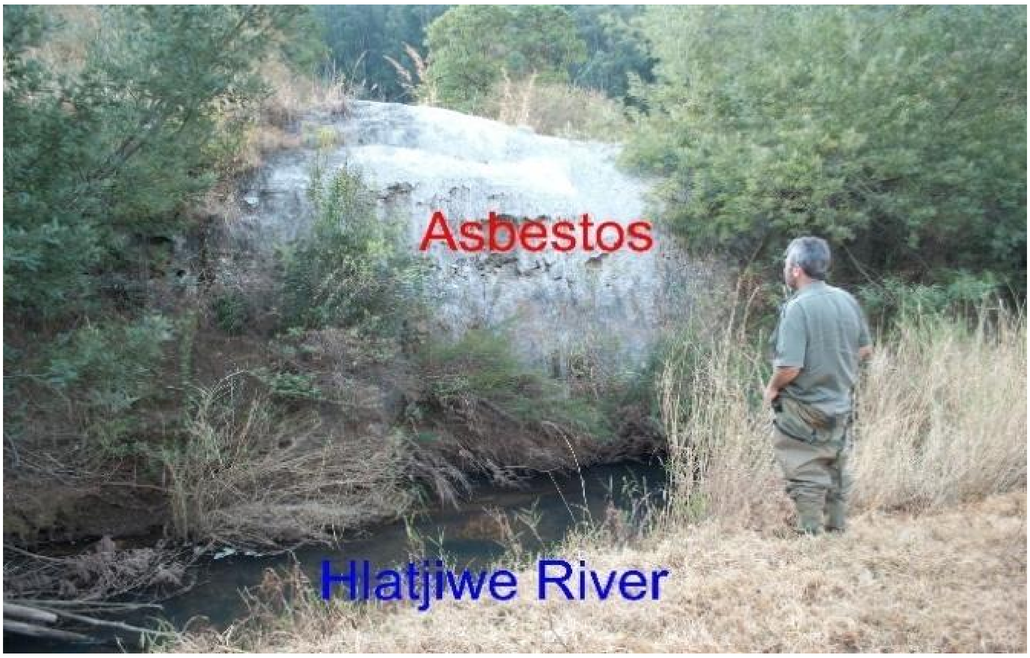


Figure C: Overburden from the asbestos mine on the bank of the Hlatjiwe River (07 July 2014, G Diedericks).

Asbestos is a fibrous silicate mineral occurring in natural deposits and the erosion thereof will be a source of the fibrous contamination. People exposed to drinking water containing asbestos fibres in excess accumulated over some years may have an increased risk of developing malignant intestinal polyps.

Two main groups of asbestos are found namely serpentine with the mineral chrysotile and amphibole with a number of minerals (e.g. crocidolite and riebeckite). The rocks found at the old mining site contain clinochrysotile, previously known as chrysotile (Figure D).

There are no standards for asbestos in water in South Africa, but the Environmental Protection Agency (EPA) do have a standard for maximum contamination level which is 7 million fibres per Litre.

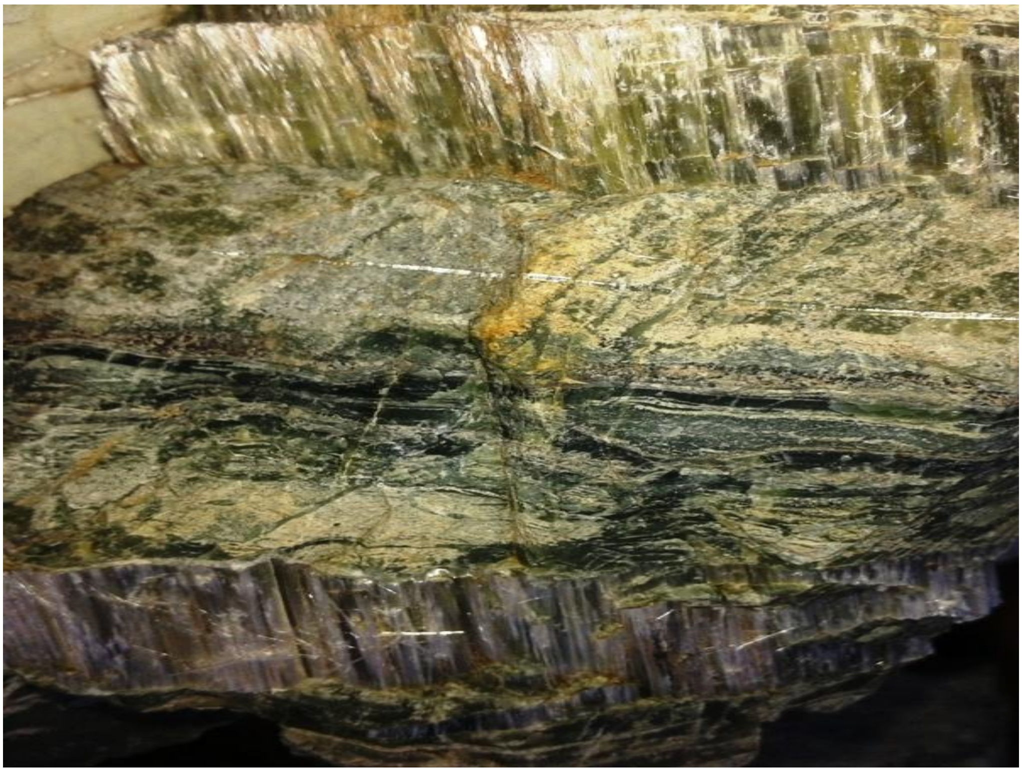


Figure D:. Clinochrysotile (Chrysotile) asbestos in serpentine from the old asbestos mine on the farm Rietfontein (7 July 2014, A.C. Hoffman).

APPENDIX – Maps indicating distribution of fish species recorded