2018 Baseline Aquatic Assessment: Nkosi City,

Mpumalanga Province, South Africa

Iggdrasil scientific services

Address
Plot 424
Zwavelpoort
0036

Postal Address
P.O. Box 2365
Zwavelpoort
0036

Tel: (+27) 072 200 6244 **Fax:** 086 696 5003

email: lorain@iggdrasilscientific.com

Report Status

Report Title:	**2018 Baseline Aquatic Assessment: Nkosi City, Mpumalanga Province, South Africa.**
Compiled by:	**Lorainmari den Boogert, (*Pr.Sci.Nat Ecology and Botany*), Peter Kimberg (*Pr.Sci.Nat Aquatic Science),* Kimberley Anne Perry (*MSc. Water Resource Management (UP), SASS5 Accredited*)**
Reviewed by**:**	**Peter Kimberg (*Pr.Sci.Nat Aquatic Science)*, for The Biodiversity Company**
Client:	**Bokamoso Environmental Consultants**
Client Representative:	**Adele Drake**
Report Status:	**Second Draft Report**
Date of Report:	**15 March 2018**

Declaration

I, Lorainmari den Boogert, declare that -

- I act as the independent specialist;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of specialist

Iggdrasil Scientific Services (Pty) Ltd.

Name of company

22 March 2018

Date

Executive Summary

The proposed Nkosi City development is located approximately 20 km North-East of Nelspruit and approximately 5 km West of the Kruger National Park (KNP) in the Mpumalanga Province of South Africa. The proposed Nkosi City, further referred to as the study area in this report, is located just South-East of residential areas Clau Clau and North East of Daantjie. The study area, falls within quaternary catchments X24B and X24C and within the Inkomati Water Management Area (WMA 5).

There are several non-perennial, unnamed tributaries of the Nsikazi River which flow through the study area. The Nsikazi River is a tributary of the Crocodile River. The Nsikazi River flows into the Crocodile River approximately 16 kilometres to the South of the study area, after which the Crocodile River becomes the southern border of the Kruger National Park.

According to national planning the study area transverses an upstream Freshwater Ecosystem Priority Area (FEPA) and there are no Wetland FEPAs in close proximity to the study area. River systems in the study area comprise of unnamed non-perennial tributaries of the Nsikazi River. At a desktop level the upstream section of the Nsikazi River has a Present Ecological State (PES) of A, Ecological Importance (EI) of High and Ecological Sensitivity (ES) of High. Further down the reach the Nsikazi River has a PES of B, EI of High and ES of High (Department of Water and Sanitation, 2014).

According to the River Condition (RIVCON) data used by National Aquatic Ecosystem Health Monitoring Program (NAEHMP) the Nsikazi River is classified as **RIVCON D** indicating that the river system is largely modified and then further down the reach the Nsikazi River is classified as **RIVCON C** indicating that the river system is moderately modified.

In terms of national and provincial planning the study area is not situated in an area currently earmarked for conservation in a near future. The study area is not deemed critical for meeting national or provincial conservation targets.

The 2018 baseline aquatic assessment at the proposed Nkosi City development was conducted on the 1st to the 3rd of March 2018 and the 12th to the 13th of March 2018. The habitats at all sampling points were firstly evaluated by means of observations with regard to their surroundings, possible causes of impacts or disturbances on aquatic ecosystems, and their suitability for future biomonitoring surveys. The outcome of this evaluation indicated that sampling methods could not be applied at sampling points **NK2, NK3, and NK4** as they consisted of small, isolated pools of water. *In situ* water quality parameters were measured at these sites. This implied that **NK5, NK6, NK7, NK8, NK9, and NK10** could be further assessed, although **NK5** had no flow and therefore it was sampled for species composition records only. *In situ* water quality parameters were measured at all of the sampling points that were sampled.

The Intermediate Habitat Integrity (IHI) results indicate that the tributaries of the Nsikazi River which flow through the proposed Nkosi City development are largely and seriously modified in terms of instream and riparian conditions respectively. A number of anthropogenic activities have been identified at each individual site that could be detrimental to local habitats for aquatic biota, most notably upstream residential areas, invasive aliens, trampling by livestock, etc., as well as road crossings and impoundments, which causes sedimentation and bank erosion.

During the 2018 baseline aquatic assessment, it was found that at upstream sites NK8 and NK9, those located closest to townships such as Daantjie, the South African Scoring System version 5 (SASS5) Ecological Category (EC) was determined to be D. At downstream sites NK6 and NK7 the SASS5 EC was determined to be B, whilst the control site NK10 had a SASS5 EC of C. The Integrated Habitat Assessment system (IHAS) scores at all the sites – although varied – indicated suitability to support a diverse macroinvertebrate community. The impacts related to residential areas located upstream of the proposed Nkosi City development – particularly Daantjie - could potentially explain the poorer results at sampling points **NK8** and **NK9** as compared to sampling points **NK6 and NK7** which are located further downstream.

Based on the Fish Response Assessment Index (FRAI) the state of fish communities ranged from a Class E (seriously modified) at sites **NK9, NK7** and **NK6** to a class D/E (largely/seriously modified) at site **NK10**. The observed fish species are all regarded as tolerant or moderately tolerant of water quality impairment and flow modifications. Therefore, water quality and flow related impacts are likely to have been a significant limiting factor on the fish assemblages.

Based on the results of the level 3 Vegetation Response Assessment Index (VEGRAI) assessment, the state of riparian vegetation communities in the project area ranged from Class D in the upper reaches and in close proximity to the urban areas (**NK8** and **NK9**) to Class D in the more remote and inaccessible downstream areas (**NK6** and **NK7**). The vegetation at site **NK10** had been severely degraded by ongoing sand mining activities and was categorised as being in a Class E.

If alteration in water quality and flow regime is not addressed alongside habitat loss, sedimentation and possible toxic contaminants from industrial and business activities, during the proposed development of Nkosi City, it is expected that there will be a continued decrease in biotic integrity. Of importance would be to ensure that development located close to the unnamed tributary of the Nsikazi River flowing along the southern boundary is kept to a minimum and highly regulated.

For more recommendations and mitigation measures refer to full text.

Abbreviations

ASPT	Average score per taxon
CBAs	Critical Biodiversity Areas
DEA	Department of Environmental Affairs
DO	Dissolved Oxygen
DWA	(former) Department of Water Affairs
DWAF	(former) Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EMPr	Environmental Management Programme
ESAs	Ecological Support Areas
FEPA	Freshwater Ecosystem Priority Area
FSA	Fish Support Area
GSM	Gravel, Sand and Mud
GPS	Global Positioning System
IHAS	Integrated Habitat Assessment System
IWULA	Integrated Water Use Licence Application
IWWMP	Integrated Water and Waste Management Plan
ISS	Iggdrasil Scientific Services
KNP	Kruger National Park
mamsl	Metres above mean sea level
MBCP	Mpumalanga Biodiversity Conservation Plan
MBSP	Mpumalanga Biodiversity Sector Plan
MTPA	Mpumalanga Tourism and Parks Agency
NEMA	National Environmental Management Act 107 of 1998
NFEPA	National Freshwater Ecosystem Priority Areas
NCCPA	Nkosi City Communal Property Association
NWA	National Water Act 36 of 1998
PES/C	Present Ecological State/Category
RHP	River Health Programme
RIVCON	River Condition
RWQO	Receiving Water Quality Objective
SASS5	South African Scoring System version 5
SAWQG	South African Water Quality Guideline
TDS	Total Dissolved Salts
TWQR	Target Water Quality Range
UP	University of Pretoria
VEGRAI	Riparian Vegetation Response Assessment Index
WMA	Water Management Area
WWTW	Waste Water Treatment Works

Definitions

TERM	DEFINITION
Aquatic Ecosystems	Aquatic ecosystems are defined as the abiotic (physical and chemical) and biotic components, habitats and ecological processes contained within rivers and their riparian zones, reservoirs, lakes and wetlands and their fringing vegetation.
Aquatic Biomonitoring	Aquatic biomonitoring is the science of inferring the ecological condition of rivers and streams by examining the types of organisms that live there, such as invertebrates, algae, aquatic and non-aquatic vegetation, fish, or amphibians. The method is based on the principle that different aquatic organisms have different tolerances to pollutants, and that certain organisms will appear under conditions of pollution, while others will disappear. The assessment of biota in freshwater ecosystems is a widely recognised means of determining the condition, or 'health' of the ecosystem.
Benthic	Relating to or characteristic of the bottom of a water body, or the animals and plants that live there.
Bioaccumulation	The accumulation of a harmful substance in an organism that forms part of the food chain.
Biota	The animal and plant life of a particular region, habitat, or geological period.
Ecoregions	Regions that share similar ecological characteristics and are based on the understanding that ecosystems and their biota display regional patterns that mirror causal factors such as climate, soils, geology, physical land surface and vegetation.
FRAI	An assessment index based on the environmental intolerances and preferences of the reference fish assemblages and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers.
FROC	An index which has determined the frequency of occurrence for reference fish in a particular ecologically defined reach of a river. The FROC ratings are derived from conditions at the particular site as well as the available habitats for species expected under reference conditions.
Macroinvertebrates	Invertebrates include all animals without backbones. In rivers this includes aquatic insects, larvae of insects with terrestrial (often flying) adult forms, as well as mussels, clams, snails and worms that are aquatic throughout their life cycle.
Recruitment	The arrival and establishment of new individuals into populations or communities.
River	A linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water.
Riparian	Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.
Spruit	A small tributary stream or watercourse that is usually non-perennial
Trophic level	The position an organism occupies on the food chain. Examples include omnivores, herbivores, insectivores, planktivores, and piscivores.
Vegetation	Plants of an area or region.
VEGRAI	A model which determines the response of vegetation to impacts in a way which can be defended by sound scientific methods.
Wetlands	Land which is transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface or the land is periodically covered with shallow water and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils.

Table of Contents

List of Tables

List of Figures

1. Introduction

1.1. Orientation and Context

The proposed Nkosi City development is located approximately 20 km North-East of Nelspruit and approximately 5 km West of the Kruger National Park (KNP) in the Mpumalanga Province of South Africa. The proposed Nkosi City, further referred to as the study area in this report, is located just South-East of residential areas Clau Clau and North-East of Daantjie. The study area, falls within the X24B and X24C quaternary catchments and within the Inkomati Water Management Area (WMA 5).

There are several non-perennial, unnamed tributaries of the Nsikazi River which flow through the study area. The Nsikazi River is a tributary of the Crocodile River. The Nsikazi River flows into the Crocodile River approximately 16 kilometres South of the study area, after which the Crocodile River becomes the Southern Border of the Kruger National Park.

1.2. Project Brief

Iggdrasil Scientific Services (Pty) Ltd ("ISS"), an independent ecological specialist company based in Pretoria, Gauteng, was commissioned by Bokamoso to conduct the 2018 baseline aquatic assessment for the proposed development of the Nkosi City Township, Mpumalanga Province, South Africa.

The project has one main deliverable namely a 2018 baseline aquatic report after completion of the site visit. Peter Kimberg (Pr.Sci.Nat Aquatic Science) of The Biodiversity Company and Kimberley Perry [M.Sc. Water Resource Management (UP], and SASS5 accredited by the Department of Water and Sanitation ("DWS")] of ISS conducted the 2018 baseline aquatic assessment for the proposed development of Nkosi City.

1.2.1. Proposed activities

The proposed development associated with Nkosi City will include the construction and installation of the following (Dovetail Properties and NCCPA, 2017) (Figure 1):

Residential (5018 houses and apartments):

- RDP (2510);
- Social Housing (apartments: 966);
- Bonded Housing (1486);
- Urban Farms (332 Ha).

Education:

- 12 Preschools;

- 4 Primary Schools;
- 2 Secondary Schools;
- FET College;
- Agricultural training centre;
- Dovetail Foundation training centre.

Medical:

- Provincial hospital and clinic;
- SPCA.

Offices:

- Institutional and commercial offices;
- Typical Hi-Street mixed use;
- Ground floor offices and apartments;
- Second floor apartments;
- Emergency Services;
- Police Station, etc.;
- Post Office.

Retail:

- 40 000 m^2 Shopping centre;
- Fresh produce market;
- Entertainment and restaurants;
- Filing station and fitment centre;
- CBD with national and local tenants.

Hospitality and Tourism:

- A lodge with travelling opportunities into KNP;
- Other hospitality and B&B facilities.

Light Industrial:

- Farmyard with packing facility and Primary Co-op.;
- Industrial area.

Public Transport:

- Bus terminus and taxi rank.

Infrastructure:

- Electrical HV sub-station, MV mini-substations and LV reticulation;
- Roads and storm water;

- Water reticulation and purification plant;
- Sewer reticulation and treatment plant;
- Water Reservoirs for consumption and irrigation;
- Telecommunications reticulation and Wi-Fi.;
- Nkosi City radio and television stations;
- Renewable energy power plant.

Sport:

- Multi sports facilities at secondary schools;
- Multi-sport stadium (phase 2).

Community:

- Community Centre and Public swimming pool;
- Recreational areas (dam).

Other:

- Abundant parks and recreational areas;
- 950 Ha dam with hydroelectric plant;
- Roughly 1000 Ha additional agricultural development – joint venture with subsistence farmers.

Urban farm Concept:

- Each stand min 2500m^2 intensive agriculture;
- Smallest economically viable agricultural land parcel;
- Large stands – less streets and infrastructure;
- Flanked by two bonded and two RDP houses;
- Provides food security for community and others;
- Afrigrow will train community in intensive farming;
- Offtake agreements from major supermarket groups;
- Treated as security residential farm estate;
- Access control;
- Perimeter security fence.

Figure 1: The preliminary layout (November 2017) of the proposed Nkosi City Township situated on the farm Nkosi City 1002-JU

1.3. Purpose, Approaches and Methodologies for Aquatic Biomonitoring

Aquatic ecosystems are defined as "*the abiotic (physical and chemical) and biotic components, habitats and ecological processes contained within rivers and their riparian zones, reservoirs, lakes and wetlands and their fringing vegetation*" (DWAF 1996). Terrestrial biota, other than humans dependent on aquatic ecosystems for survival are included in this definition. Humankind depends on many "services" provided by healthy aquatic ecosystems, including:

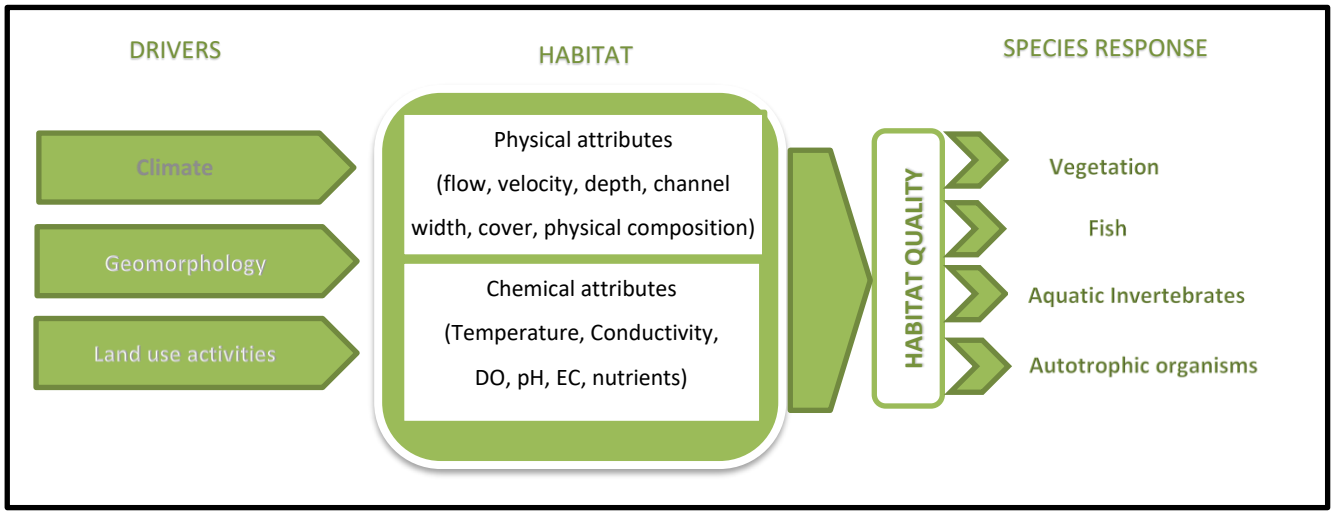
- Maintaining the assimilative capacity of water bodies for certain wastes through self-purification;
- Providing an aesthetically pleasing environment;
- Serving as a resource used for recreation;
- Providing a livelihood to communities dependent on water bodies for food;
- Maintaining biodiversity and providing habitats to that biota dependent on aquatic ecosystems; and
- Industrial and domestic uses.

Aquatic ecosystems, as a resource base, must therefore be effectively protected and managed to ensure that South Africa's water resources remain fit for agricultural, domestic, recreational and industrial uses on a sustained basis (DWAF 1996). Despite being South Africa's most important ecosystems, aquatic ecosystems are the most impacted by anthropogenic activities (Ferrar and Lötter 2007). A land-use activity, such as a colliery, can have a detrimental effect on the health of aquatic ecosystems (in rivers, lakes, streams, and wetlands) which cannot be indicated through chemical monitoring alone.

Aquatic Biomonitoring is an integral component of ecological risk assessment, and is the science of determining the condition, or 'health' of an aquatic ecosystem by examining the organisms that live there, including their habitats, occurrence and composition. It is based on the principle that different aquatic organisms have different responses to stressors to their habitats, and that certain organisms will appear under conditions of stress, while others will disappear. **Stressors** include aspects such as increased or decreased flow (resulting from the abstraction of water, or the discharge of clean stormwater); changes in water quality (resulting from the discharge of stormwater or the introduction of contaminants through the discharge and disposal of effluents or seepage, and littering); bed and channel modification; changes in vegetation (resulting from the reduction of indigenous riparian plants and the presence of invasive alien plants and fauna).

A variety of aquatic organisms require specific habitat types and habitat conditions for at least part of their life cycles. The availability and diversity of suitable habitats for aquatic biota will therefore determine the presence and species composition of the organisms living in the aquatic ecosystem. Habitat conditions for aquatic biota are influenced by drivers such as climate, geomorphology, and land use. The disturbance of the habitats of aquatic biota will result in stress to the aquatic population,

which can affect the occurrence and species composition of the organisms living in the aquatic ecosystem (species response).
These relationships can be depicted as follows (adapted from Kleynhans and Louw, 2008):



Impacts on freshwater ecosystems can be measured by determining the presence or absence of certain indicator species of an aquatic ecosystem (riparian vegetation, fish, and invertebrates), and recording the species composition over time in order to determine changes in species composition, and to relate any observed changes to changes in the habitats of these species, taking cognisance of the drivers that influence the habitats in the first place. The occurrence and composition of species of flora and fauna in aquatic ecosystems therefore reflect both the present and history of the water resource at a particular site, allowing detection of disturbances that might otherwise be missed.

During a typical biomonitoring survey at a specific location in an aquatic ecosystem, both the physical and chemical attributes of the **aquatic habitat**, as well as the **species response** of different types of aquatic biota, are therefore evaluated. Two aspects are of importance in this regard, namely the **methods** used for the evaluation of the physical and chemical attributes of the habitat, as well as for the determination of the species response of different types of aquatic biota at a specific survey site, and the **selection** of biomonitoring sampling points.

These aspects are discussed in more detail below.

1.3.1. Methods for Conducting Biomonitoring Surveys

Because biological communities integrate the effects of physical and chemical changes to the environment in the long-term, different methods, typically based on **assessment indices,** are used as indicators of changes in habitat quality, as well as indicators of species responses (Ferreira and Graca 2008).

The current methods used for the evaluation of the **physical and chemical attributes** of the habitat at a specific biomonitoring survey site can be summarised as follows:

- **Evaluation of the physical attributes of the aquatic habitat:** The physical attributes of the instream and riparian habitat has a direct influence on the occurrence and composition the aquatic community. Physical habitat features such as colour, anthropogenic disturbances and riparian vegetation, as well as stream hydrology, average width and depth are established by means of and evaluated with both the **Integrated Habitat Assessment System ("IHAS")** and the **Index of Habitat Integrity ("IHI").** IHAS was developed in 1998 by McMilan, and version 2 is the currently used assessment index and IHI was developed in 2008 by Kleynhans *et al*.

- **Evaluation of the chemical attributes of the aquatic habitat:** Although available water quality monitoring data on variables such as pH, salinity (EC or TDS) and nutrients will give an indication of the influence of these variables on the aquatic ecosystem, variables such as Temperature, Dissolved Oxygen ("DO"), and Turbidity need to be determined *in situ*, as these variables cannot be established away from the survey site.

The standardised, quantitative and replicable methods currently used for the **species response of the different aquatic organisms** at a specific survey site can be summarised as follows:

- The **South African Scoring System, version 5 ("SASS5")** is a rapid bio-assessment method used to identify changes in species composition of aquatic invertebrates (e.g. snails, crabs, worms, insect larvae, mussels, beetles). As most invertebrate species are fairly short-lived and have limited migration patterns or are not free-moving during their aquatic life phase, they are good indicators of localised conditions in a river over the short term, and can be used to assess site-specific impacts (Dickens and Graham, 2002).

- Vegetation is a readily observable expression of the ecology and relationships as well as a series of interactions between biotic organisms and their abiotic environment, and thus provide a physical representation of the health of an ecosystem. Healthy riparian vegetation zones maintain channel form and serve as filters for light, nutrients and sediment. Changes in the structure and function of riparian vegetation commonly result from changes in the flow regime of a river, flooding, exploitation for firewood, mining, or use of the riparian zone for grazing or ploughing. The **Riparian Vegetation Response Assessment Index ("VEGRAI")** is a model developed by the DWS for the qualitative assessment of the response of riparian vegetation to

impacts (Kleynhans *et al.,* 2007). It must be noted that there is a distinct difference between a VEGRAI and the evaluation of vegetation as part of the IHAS, as the IHAS merely records vegetation as one of the physical attributes of the aquatic habitat, while VEGRAI evaluates and assigns a rating to indicate species composition and diversity. As vegetation can undergo rapid changes, for example due to flooding, veld fires or overgrazing, the VEGRAI-method will record such changes in species composition, which will not be determined by the IHAS method.

- Fish are good indicators of long-term (several years) effects and broad habitat conditions, and changes in the available habitat conditions (Karr, 1981). This is because fish are "top of the food chain," relatively long-lived and mostly highly mobile. Fish bio-accumulate the effects of anthropogenic activities on lower trophic levels; thus, fish assemblage structures are indicative of the integrated health of the aquatic ecosystem. Assemblages include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). The **Fish Response Assessment Index ("FRAI")** is a rule-based model developed by the DWS based on the environmental intolerances and preferences of reference fish assemblages and the response of the species of the assemblage to particular groups of environmental determinants or drivers. Intolerance and preference attributes are categorized into metric groups with constituent metrics that relate to the environmental requirements and preferences of individual species. Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation. Reference conditions with regard to expected fish species and species compositions have been published for most of South Africa (Kleynhans, 2007).

For this 2018 baseline aquatic assessment the **Integrated Habitat Assessment System ("IHAS"), Index of Habitat Integrity ("IHI")**, **South African Scoring System, version 5 ("SASS5"), Riparian Vegetation Response Assessment Index ("VEGRAI")** and the **Fish Response Assessment Index ("FRAI")** methodologies will be used to assess the biotic integrity of the study area.

1.4. Objective of this Report

The objective of this 2018 baseline aquatic report is to determine the aquatic health of the watercourses within the proposed Nkosi City study area during the 2018 wet season survey and to comply with the requirements of the Mpumalanga Tourism and Parks Agency (MTPA). The wet season survey was conducted from the 1st to the 3rd of March 2018 and the 12th to the 13th of March 2018, at the proposed project area.

1.5. Report Structure

This Report is structured as follows:

- Section 1 – this section – describes the project brief, the approaches and methodologies followed for aquatic biomonitoring, the objective of this report, and the report structure;
- Section 2 discusses the **background** situation at the study area in order to determine the **drivers** influencing local habitat conditions, including its location, land use activities, abiotic factors such as climate and geomorphology, expected biotic conditions, as well as any governance requirements for biomonitoring that applies to the area, including national and provincial biodiversity conservation planning initiatives and statutory requirements;
- In Section 3, the **selection of sampling points** for the 2018 baseline aquatic assessment at the study area is described, followed by a discussion of the **results** obtained during this **2018 baseline aquatic survey**, both with regard to the evaluation of **habitat conditions** and disturbances, as well as the **species response** of aquatic biota by determining their occurrence and composition;
- Section 4 contains the **impact assessment** for the proposed Nkosi City Township development, and describes mitigation measures for the project;
- Section 5 contains **conclusions** and makes **recommendations** for the study area in terms of future surveys; and
- Section 6 contains the professional opinion of the specialist.

2. Background: Drivers & Governance Requirements for the study area

This section discusses the **background situation** at the study area in order to determine the **drivers** influencing local habitat conditions, including agricultural activities and other land uses, abiotic factors such as climate and geomorphology, expected biotic conditions, including national and provincial biodiversity conservation planning initiatives, and statutory requirements. A locality map of the study area is provided in Figure 2.

2.1. The Abiotic Environment

The abiotic environment is summarised in Table 1 below.

Table 1: Summary of the Abiotic Environment

ABIOTIC FACTOR	SUB FACTOR	DESCRIPTION
CLIMATE[1]	TEMPERATURE	FOR NELSPRUIT ▪ Wet season is warm and partly cloudy, and dry season is clear; ▪ The highest temperatures are found during February (average of 20°C); ▪ The coldest month is July (average of 12°C).
	RAINFALL	FOR NELSPRUIT ▪ 773 mm of rain per annum; ▪ Majority of the rainfall during midsummer; ▪ The wettest month is December (average of 147.4mm).
	FROST AND MIST	MIST ▪ Occurs infrequently at higher altitudes; FROSTS ▪ Occurs infrequently at higher altitudes.
TOPOGRAPHY AND DRAINAGE	TOPOGRAPHY (SEE FIGURE 3)	▪ The study area slopes from approximately 400 mamsl to approximately 800 mamsl.; ▪ There are hillslopes around the study area.
	DRAINAGE (SEE FIGURE 4)	QUATERNARY CATCHMENTS ▪ X24B and X24C; UNNAMED TRIBUTARIES OF THE NSIKAZI RIVER ▪ The Nsikazi River is a tributary of the Crocodile River which flows South of the study area.
SURROUNDING LAND USE		NEARBY USES ▪ Informal Settlements; ▪ National Parks (KNP) and Game Reserves (Mthethomusga Game Reserve); ▪ National Road (N4); ▪ Sewer systems; and ▪ Agricultural. CLOSEST RESIDENTIAL AREA ▪ Daanjie and Clau-Clau.

[1] Mucina and Rutherford 2006

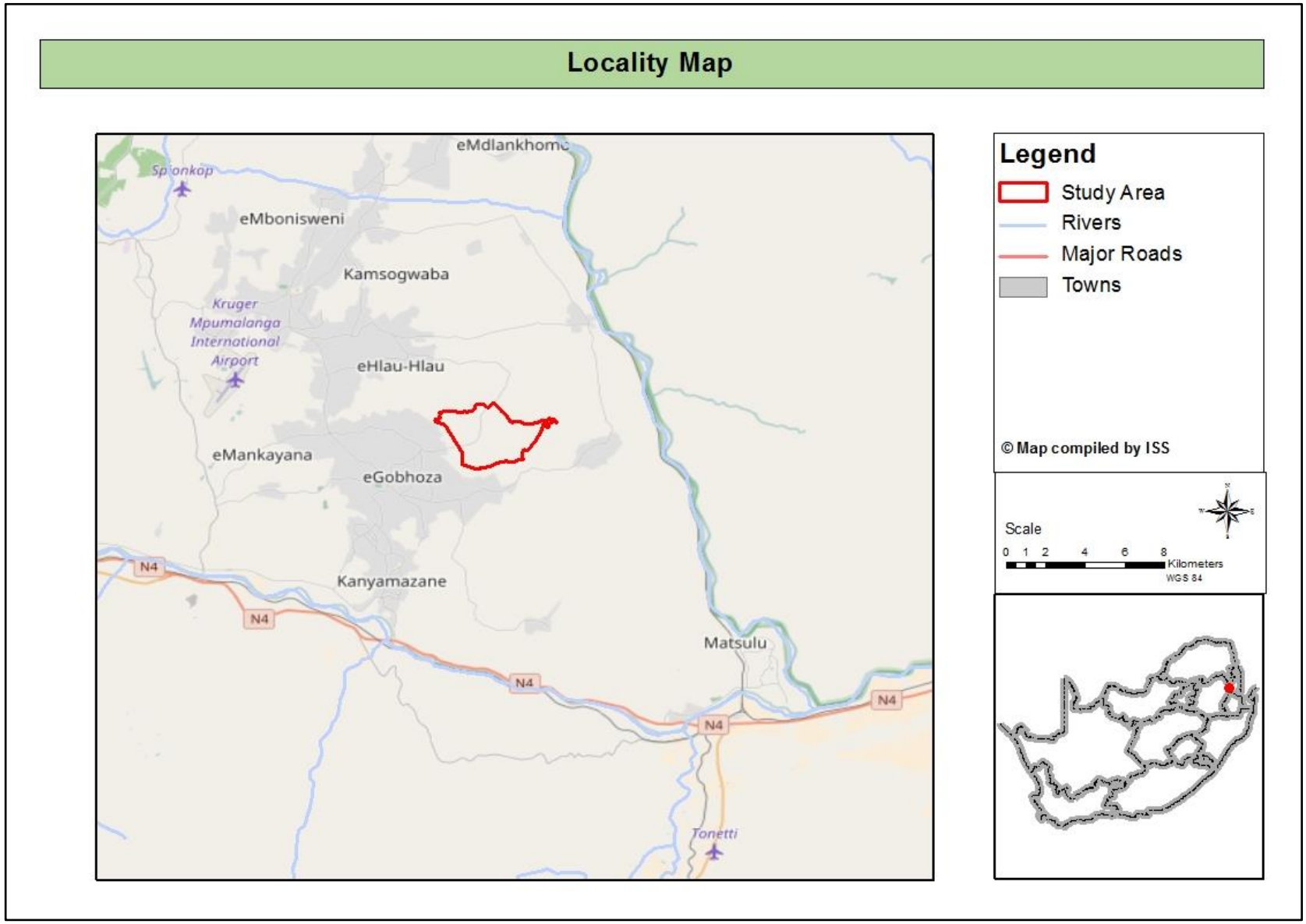


Figure 2: Nkosi City (study area) located in the Mpumalanga Province of South Africa

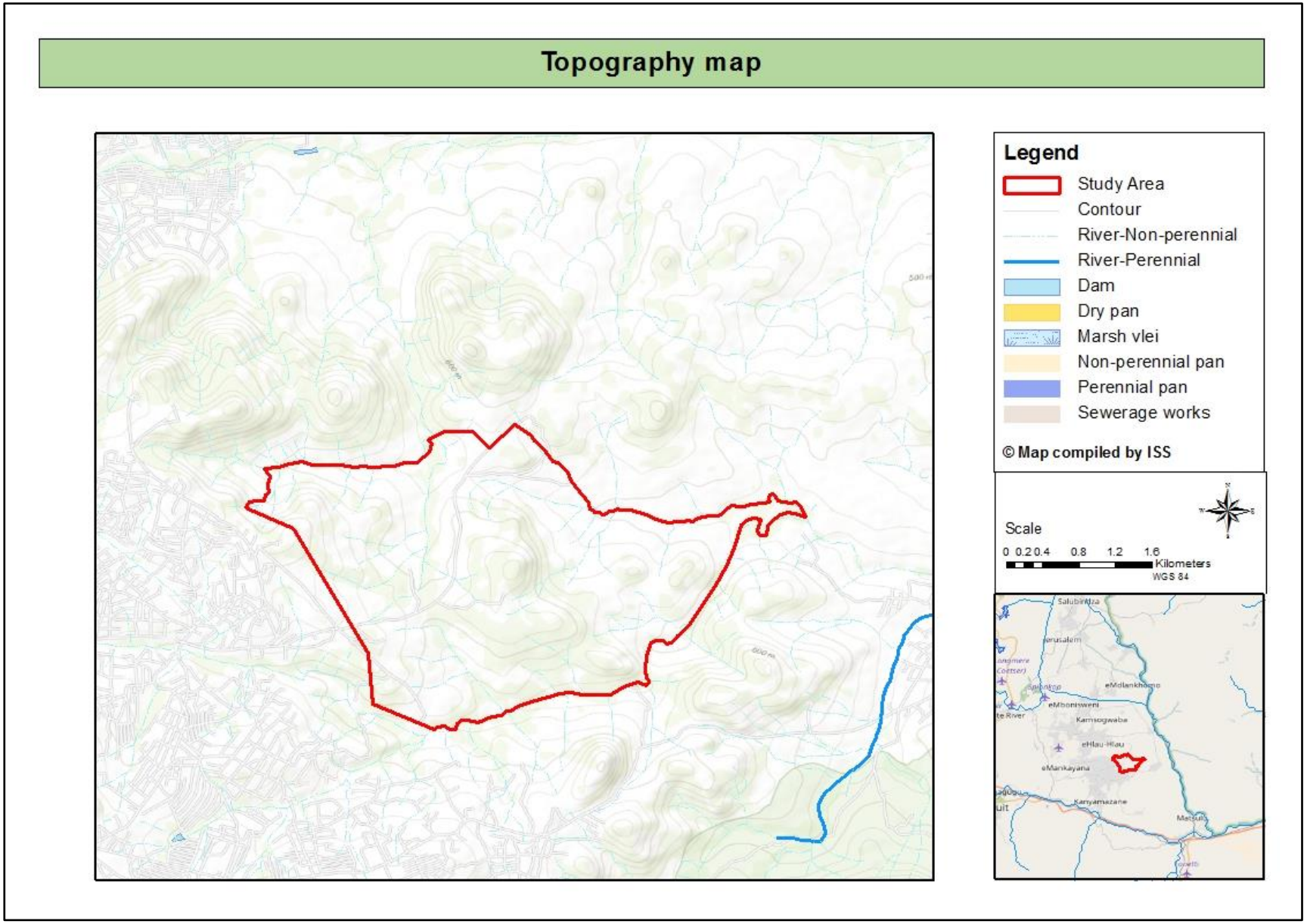


Figure 3: Topography of the study area

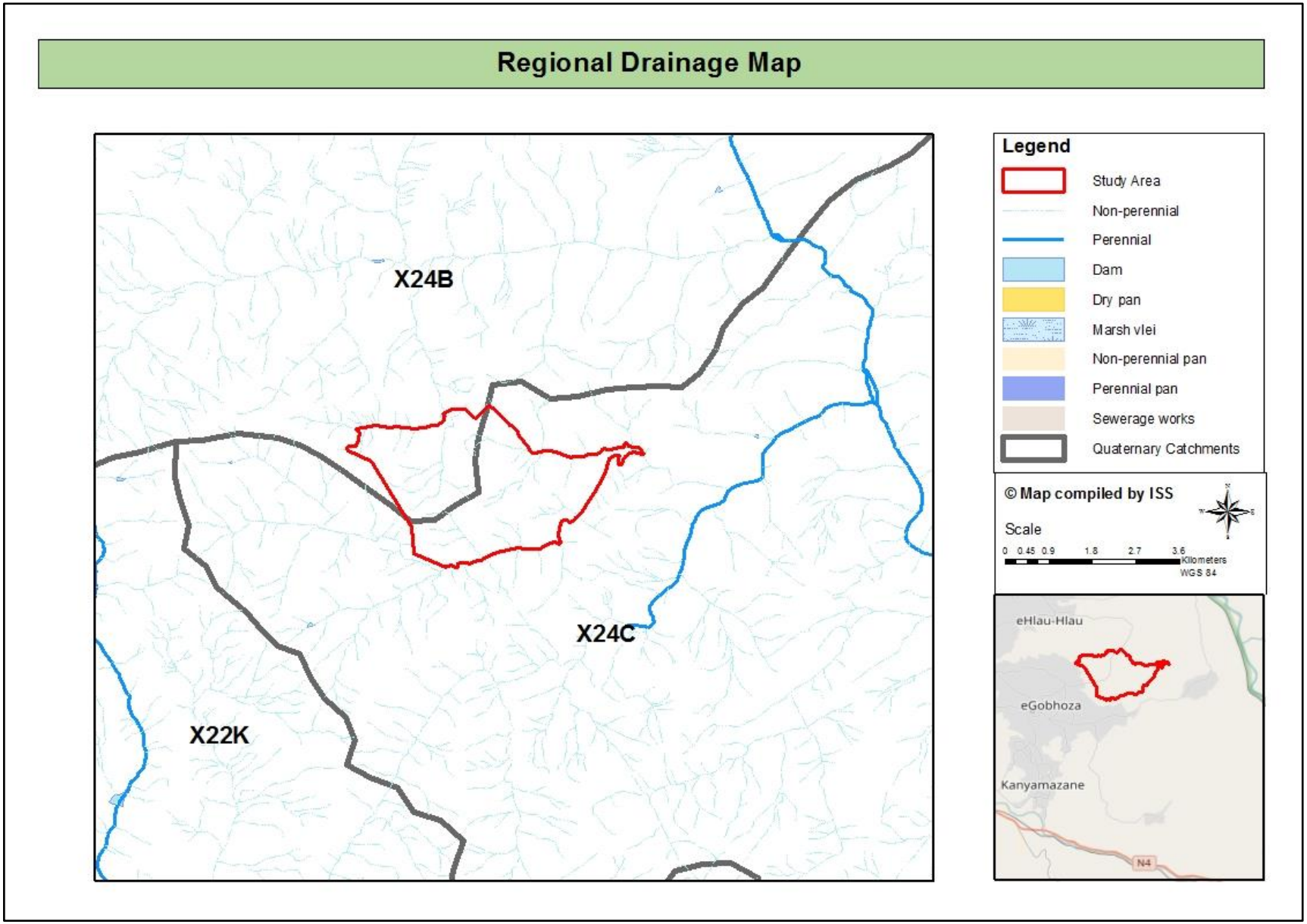


Figure 4: Regional drainage for the study area.

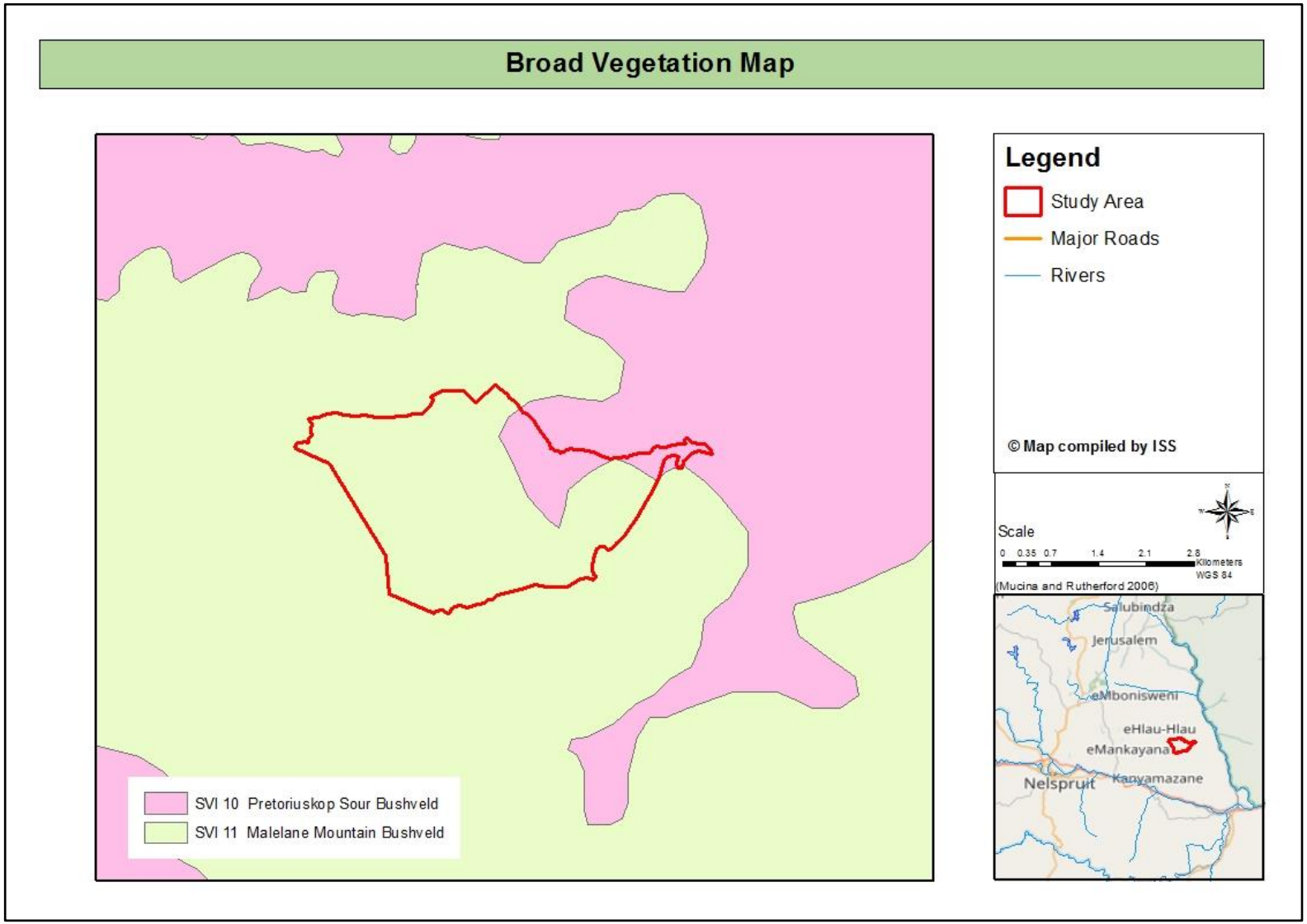


Figure 5: Broad Vegetation Map for the Study Area

The Study Area Falls within the Pretoriuskop Sour Bushveld and the Malelane Mountain Bushveld.

2.2. The Biotic Environment

The vegetation, aquatic ecosystems, the ecoregion and the ecological importance of the area are described below.

2.2.1. Vegetation

The study area transverses the *Savanna Biome.* In terms of the new vegetation map constructed under the editorship of Mucina and Rutherford (2006) the study area falls within the **Pretoriuskop Sour Bushveld (SVl 10)** and the **Malelane Mountain Bushveld (SVl 11)** (see Figure 5).

The **Pretoriuskop Sour Bushveld (SVl 10)** occurs from around Hazeyview and Pretoriuskop Camp in the southwestern part of the Kruger National Park to the Malekutu area. It also occurs in the Crocodile Estates area between Nelspruit and Crocodile Gorge. Important taxa occurring in this area include tall trees such as *Sclerocarya birrea subsp. caffra (d)*, small trees such as *Combretum apiculatum (d)* and *C. zeyheri (d)*, tall shrubs such as *Dichrostachys cinerea (d)* and *Gymnosporia senegalensis (d)*, low shrubs such as *Agathisanthemum bojeri*, succulent shrubs such as *Aloe petricola*, woody climbers such as *Bauhinia galpinii*, graminoids such as *Aristida congesta (d)* and herbs such as *Chamaecrista mimosoides* and *Tricliceras glanduliferum*. Alien invasive plants which may occur in the area include *Opuntia stricta* and *Lantana camara.* Erosion is very low to moderate. The **Pretoriuskop Sour Bushveld (SVl 10)** is **not listed** as a threatened or protected ecosystem in GN 1002 (GG 34809 of 9 December 2011) published under the National Environmental Management: Biodiversity Act 10 of 2004 ("NEM:BA").

The **Malelane Mountain Bushveld (SVl 11)** occurs in high-lying areas north of Malelane and Kaapmuiden including the Berg-en-Dal Rest Camp and as far north as the area of the hill Sithongwane in the KNP. This is a heterogeneous landscape that leads to different micro-habitats. Important taxa include tall trees such as *Pterocarpus angolensis,* small trees such as *Senegalia caffra (d)* and *Vachellia davyi (d)*, succulent trees such as *Euphorbia cooperi*, tall shrubs such as *Searsia pentheri* and *Acalypha glabrata*, low shrubs such as *Barleria rotundifolia* and *Diospyros galpinii*, succulent shrubs such as *Aloe spicata*, woody climbers such as *Bauhinia galpinii*, woody succulent climber such as *Senecio pleistocephalus*, herbaceous climber such as *Coccinia rehmannii*, graminoids such as *Themeda triandra* and *Bothriochloa radicans (d)*, geophytic herbs such as *Drimia altissima*, succulent herb such as *Plectranthus cylindraceus*, epiphytic succulent herbs such as *Ansellia Africana*. Scattered alien plants can include *Lantana camara, Melia azedarach* and *Jacaranda mimosifolia*. Erosion is generally very low to low. The **Malelane Mountain Bushveld (SVl 11)** is **not listed** as a threatened or protected ecosystem in GN 1002 (GG 34809 of 9 December 2011) published under NEM:BA.

2.2.2. Aquatic Ecosystems and their Importance

Aquatic ecosystems are defined as "*the abiotic (physical and chemical) and biotic components, habitats and ecological processes contained within rivers and their riparian zones, reservoirs, lakes and wetlands and their fringing vegetation*" (DWAF 1996). Terrestrial biota, other than humans, dependent on aquatic ecosystems for survival are included in this definition. Despite being South Africa's most important ecosystems, aquatic ecosystems are the most impacted (Ferrar and Lötter 2007).

Humankind depends on many "services" provided by healthy aquatic ecosystems, including:

- Maintaining the assimilative capacity of water bodies for certain wastes through self-purification;
- Providing an aesthetically pleasing environment;
- Serving as a resource used for recreation;
- Providing a livelihood to communities dependent on water bodies for food;
- Maintaining biodiversity and providing habitats to that biota dependent on aquatic ecosystems;
- Domestic and industrial uses.

Aquatic ecosystems, as a resource base, must be effectively protected and managed to ensure that South Africa's water resources remain fit for agricultural, domestic, recreational and industrial uses on a sustained basis (DWAF 1996).

Wetlands are defined in the National Water Act 36 of 1998 ("NWA") as "*land which is transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils*."

Wetlands are protected by the NWA because of their importance and their vulnerability to damaging impacts (Ferrar and Lötter 2007).

Wetlands are important because they:

- Provide hydrological control which helps prevent soil erosion (attenuate floods, store and release water slowly);
- Recharge groundwater sources;
- Purify water by trapping many pollutants, including sediment, heavy metals and disease-causing organisms;
- Are very productive since they supply nutrients and water in a stable environment for rapid plant growth and thus can be used as grazing areas if done on a sustainable basis; and
- Are one of the most biodiverse ecosystems, providing life support for a wide variety of species, some totally reliant on wetlands for their survival (Davies and Day 1998; DWA 2005).

Wetlands are among some of the most threatened habitats in the world. In some catchments in South Africa, studies have revealed that over 50% of the wetlands have already been destroyed. Altering the water flow and quality may destroy or damage wetlands, and continued wetland destruction will result in less pure water, less reliable water supplies, increased severe flooding, lower agricultural productivity, and more endangered species (DWAF 2005). Mining activities, agriculture, and other sources of contamination are among the causes of impacts on this habitat.

2.2.3. Ecoregions and Ecological Importance

Ecoregions are regions that share similar ecological characteristics and according to Ferrar and Lötter (2007) this characterisation is "*based on the understanding that ecosystems and their biota display regional patterns that mirror causal factors such as climate, soils, geology, physical land surface and vegetation*."

The study area lies within the **Lowveld (3) Level 1 Ecoregion** and the **North Eastern Highlands (4) Level 1 Ecoregion** (according to the delineation provided by Kleynhans *et al.* 2005). The **Lowveld (3) Level 1 Ecoregion** is a hot and dry area characterised by characterised by plains with a low to moderate relief and vegetation consisting mostly of Lowveld Bushveld types. Open hills with high relief and low mountains with high relief are present towards the west on the boundary with the North Eastern Highlands. The **North Eastern Highlands (4) Level 1 Ecoregion** is a mountainous area characterised by closed hills and mountains with moderate to high relief and vegetation comprising North-Eastern Highveld Grassland and Lowveld Bushveld types. Patches with Afromontane Forest are scattered throughout the region.

2.3. Provincial Biodiversity Conservation Planning Initiatives: MBCP and MBSP

The Mpumalanga Biodiversity Conservation Plan ("MBCP") maps the distribution of the known aquatic biodiversity sub-catchments in the province into five categories. These are ranked according to ecological and biodiversity importance and their contribution to meeting the quantitative targets set for each biodiversity feature (Ferrar and Lötter 2007). The categories are:

- *Protected areas* – already protected and managed for conservation;
- *Irreplaceable areas* – protection crucial, no other options available to meet targets;
- *Highly Significant areas* – protection needed, very limited choice for meeting targets;
- *Important and Necessary areas* – protection needed, greater choice in meeting targets;
- *Ecosystem Maintenance* – transformed/modified areas.

According to the MBCP, the study area is located in an area for which the aquatic biodiversity sub-catchments are categorised as **Ecosystem Maintenance** (Figure 9). Sub-catchments characterised in the *Ecosystem Maintenance* category has lost most of their biodiversity and ecological functioning. In the remnants of natural habitat that occur between cultivated lands and along drainage lines and ridges, residual biodiversity features and ecological processes do survive. These remnants are however

biologically impoverished, highly vulnerable to damage and have limited likelihood of being able to persist. Maintenance of the ecosystem is needed in these areas to ensure that they are reconnected with areas which form part of other categories and improve local ecological function and processes (Ferrar and Lötter 2007).

In 2014, the Mpumalanga Parks and Tourism Agency developed the **Mpumalanga Biodiversity Sector Plan ("MBSP")**. In essence the MBSP is a map guiding areas of conservation concern for the Mpumalanga Province. Two maps have been developed, namely one for terrestrial biodiversity, and the other for freshwater biodiversity. The MBSP maps the freshwater ecosystems of Mpumalanga into the following categories:

- *Critical Biodiversity Areas ("CBAs")* – areas of high biodiversity value, needed to meet biodiversity targets. These areas should be maintained in natural or near natural state;
- Ecological Support Areas – these areas support CBAs, but are not essential for meeting conservation targets;
- Other Natural Areas – these areas have natural characteristics but have not been earmarked as priority areas for conservation but perform a range of biological as well as ecological functions;
- Heavily Modified Areas – Areas which have been impacted and have had a significant or complete loss of natural habitat and ecological function.

According to the MBSP, the study area comprises two categories of the MBSP namely Other Natural Area, and Heavily Modified (Figure 10, Lötter *et al*., 2014).

2.4. National Freshwater Ecosystem Priority Areas

The **National Freshwater Ecosystem Priority Areas** ("NFEPA") project is a multi-partner project between the CSIR, the Water Research Commission, the South African National Biodiversity Institute, the Department of Environmental Affairs, the South African Institute of Aquatic Biodiversity and South African National Parks.

The project responds to the reported degradation of freshwater ecosystem condition and associated biodiversity, both globally and in South Africa. It uses systematic conservation planning to provide strategic spatial priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development.

The project has three inter-related components:

- A technical component to identify a national network of freshwater conservation areas;
- A national governance component to align DEA and DWA policies and approaches for conserving freshwater ecosystems; and
- A sub-national governance and management component that conducts case studies to demonstrate how NFEPA outcomes can be implemented (CSIR 2010).

River Condition ("RIVCON") is a classification used by the NFEPA programme. *RIVCON A* and *B* are considered intact rivers that are able to contribute towards river ecosystem targets. All the unnamed non-perennial tributaries flow eventually into the Nsikazi River. According to NFEPA data, the Nsikazi River is classified as **RIVCON D** indicating that the river system is largely modified and then further down the reach the Nsikazi River is classified as **RIVCON C** indicating that the river system is moderately modified (Figure 6). There are no **Wetland FEPAs** in close proximity to the study area, as indicated in Figure 8.

Within the X24C; quaternary catchment the Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) per Sub Quaternary Reaches for Secondary Catchments in South Africa were determined for the Nsikazi River. The Nsikazi River is found to have a PES of A, EI of High and ES of High according to PES SQ Reach X24B-928. Further down the reach the Nsikazi River has a PES of B, EI of High and ES of High according to PES SQ Reach X24C-978 (Figure 7) (Department of Water and Sanitation, 2014).

The study area transverses an upstream FEPA (Figure 8).

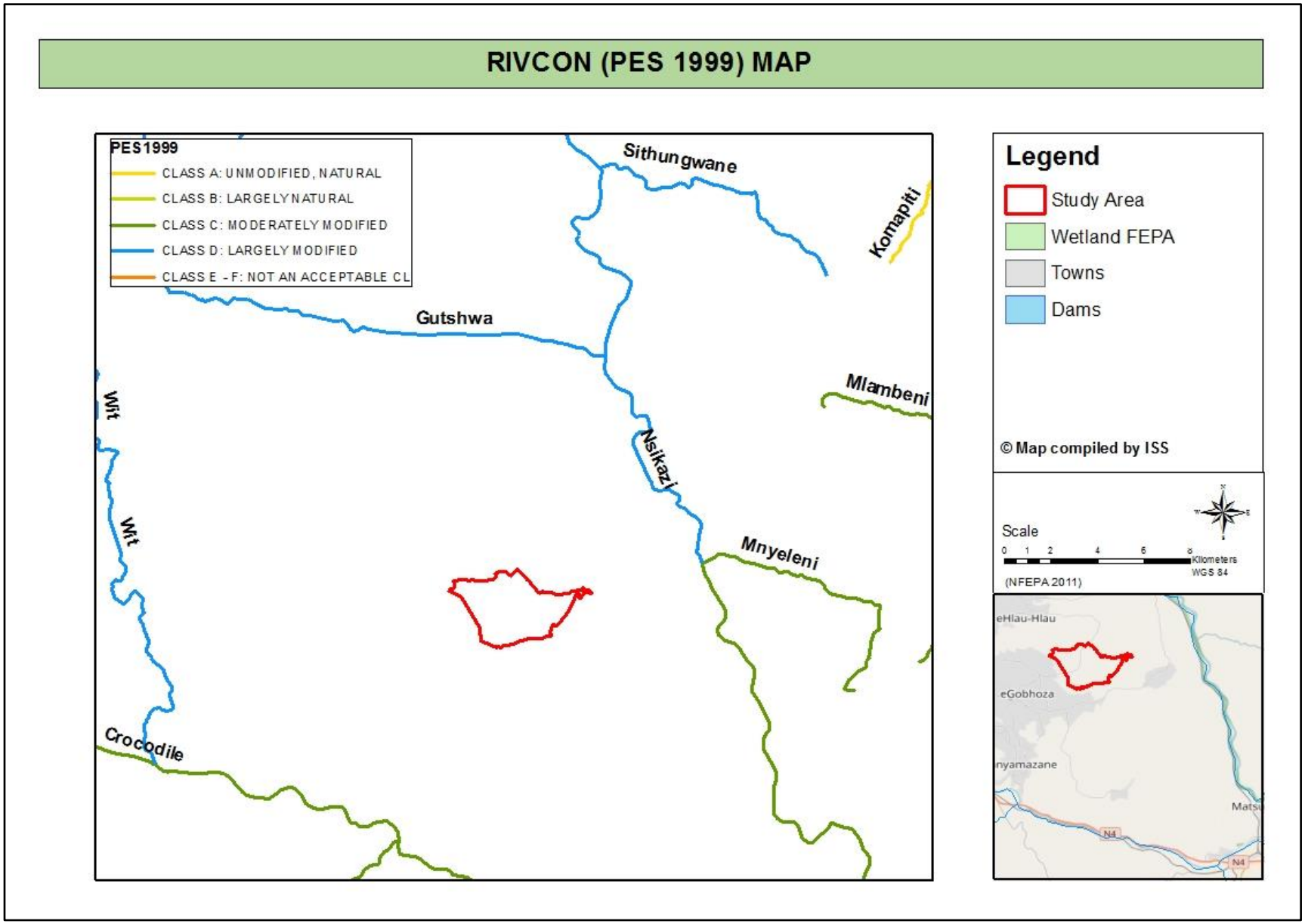


Figure 6: RIVCON (PES 1999) Map for the study area

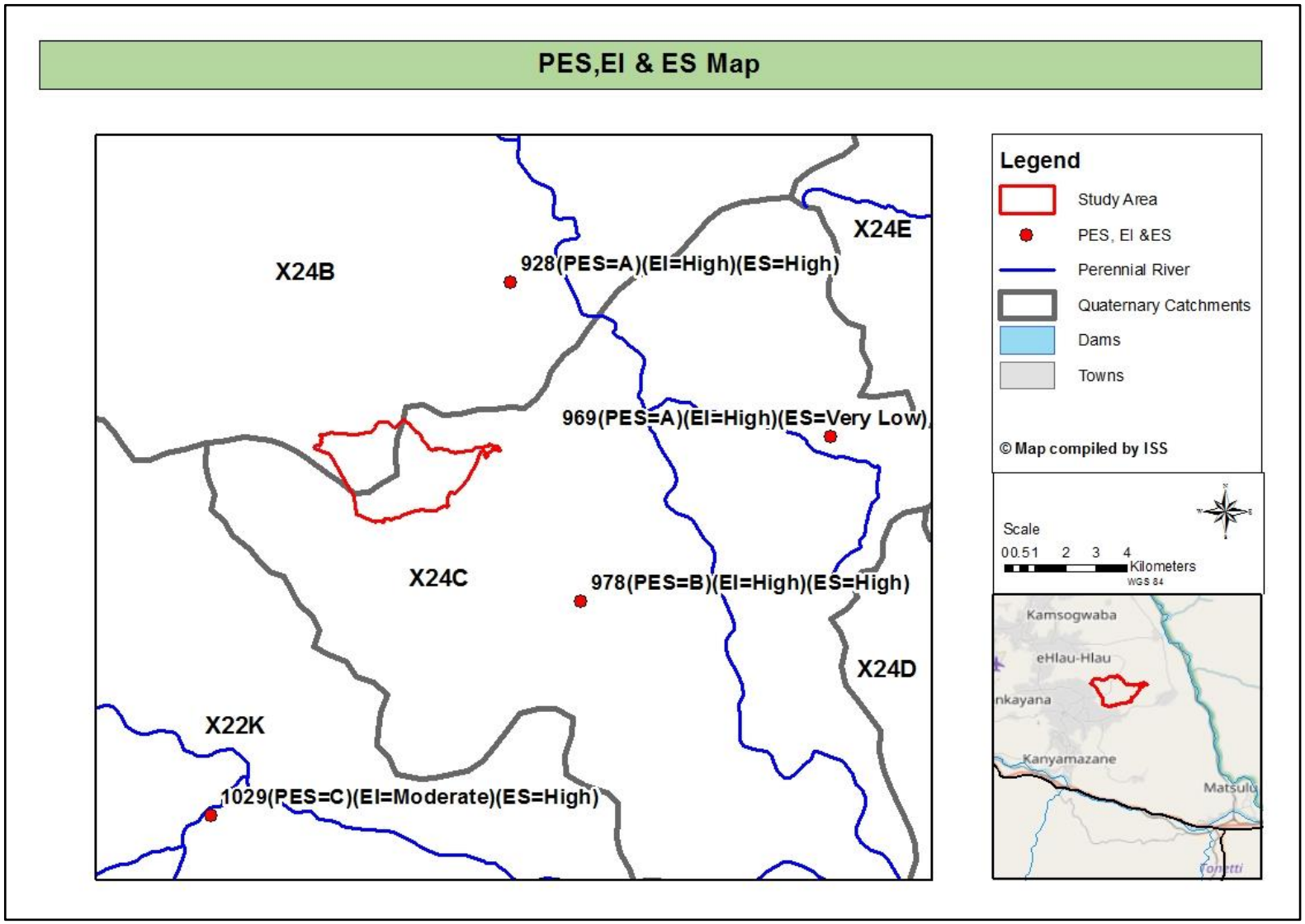


Figure 7: 2014 PES, EI and ES Map for the study area

The Nsikazi River has a PES of A, EI of High and ES of High according to PES SQ Reach X24B-928. The Nsikazi River has a PES of B, EI of High and ES of High according to PES SQ Reach X24C-978.

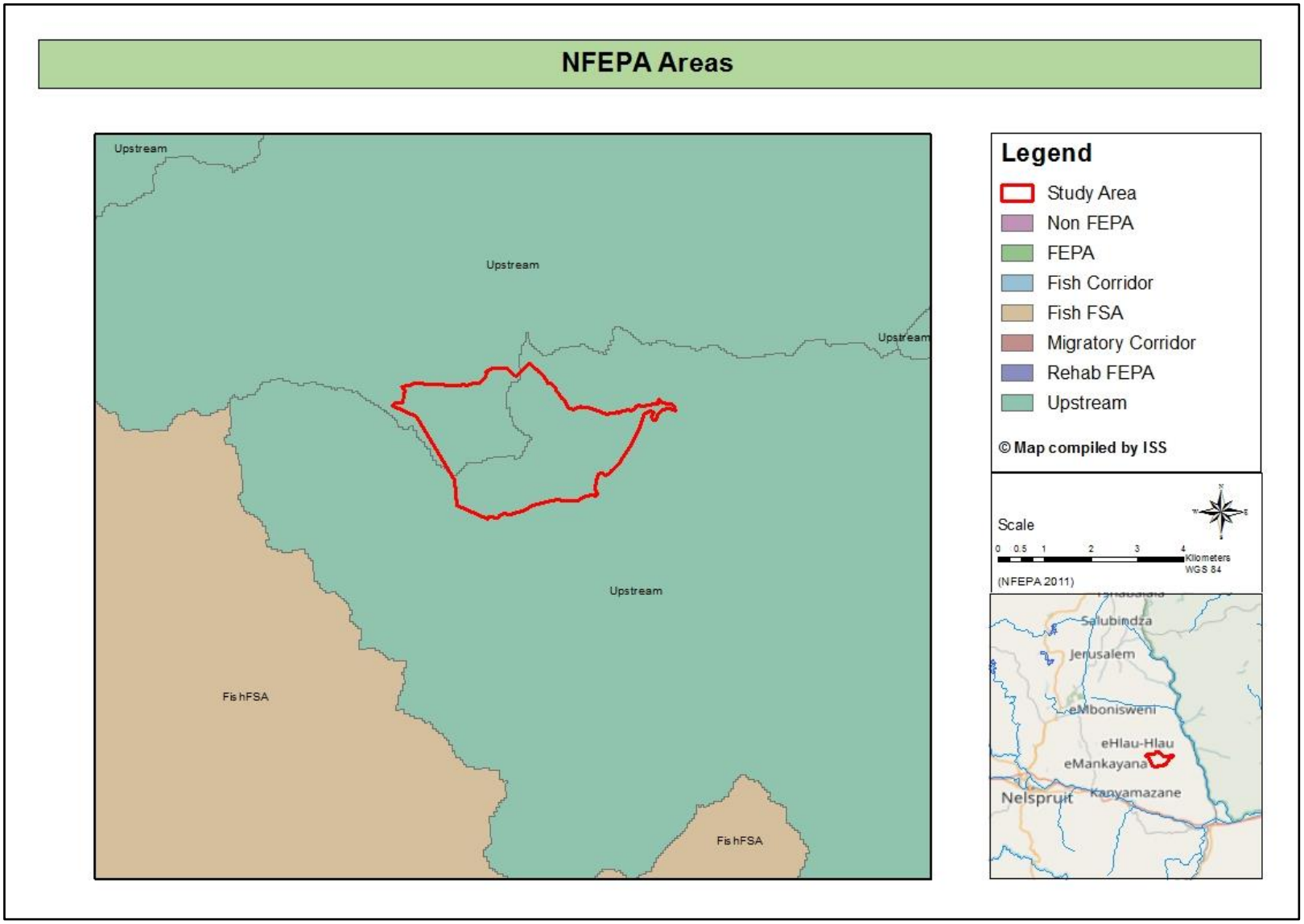


Figure 8: NFEPA Map for the study area

The study area traverses an Upstream FEPA.

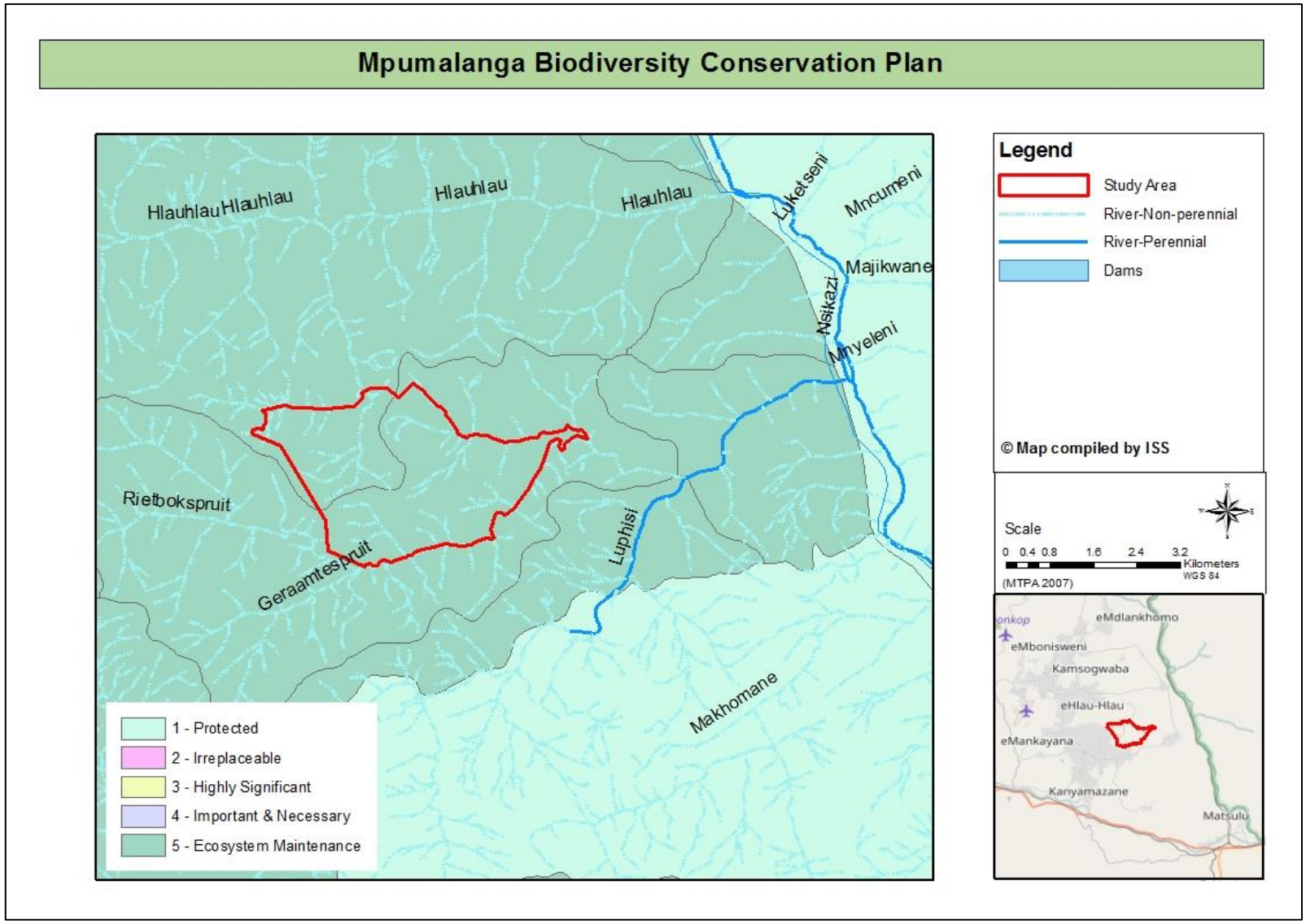


Figure 9: The Aquatic Biodiversity Sub-Catchment Map for the study area (from the MBCP)

*The study area transverses one of the aquatic biodiversity sub-catchment categories in the Mpumalanga Biodiversity Conservation Plan, namely **Ecosystem Maintenance**.*

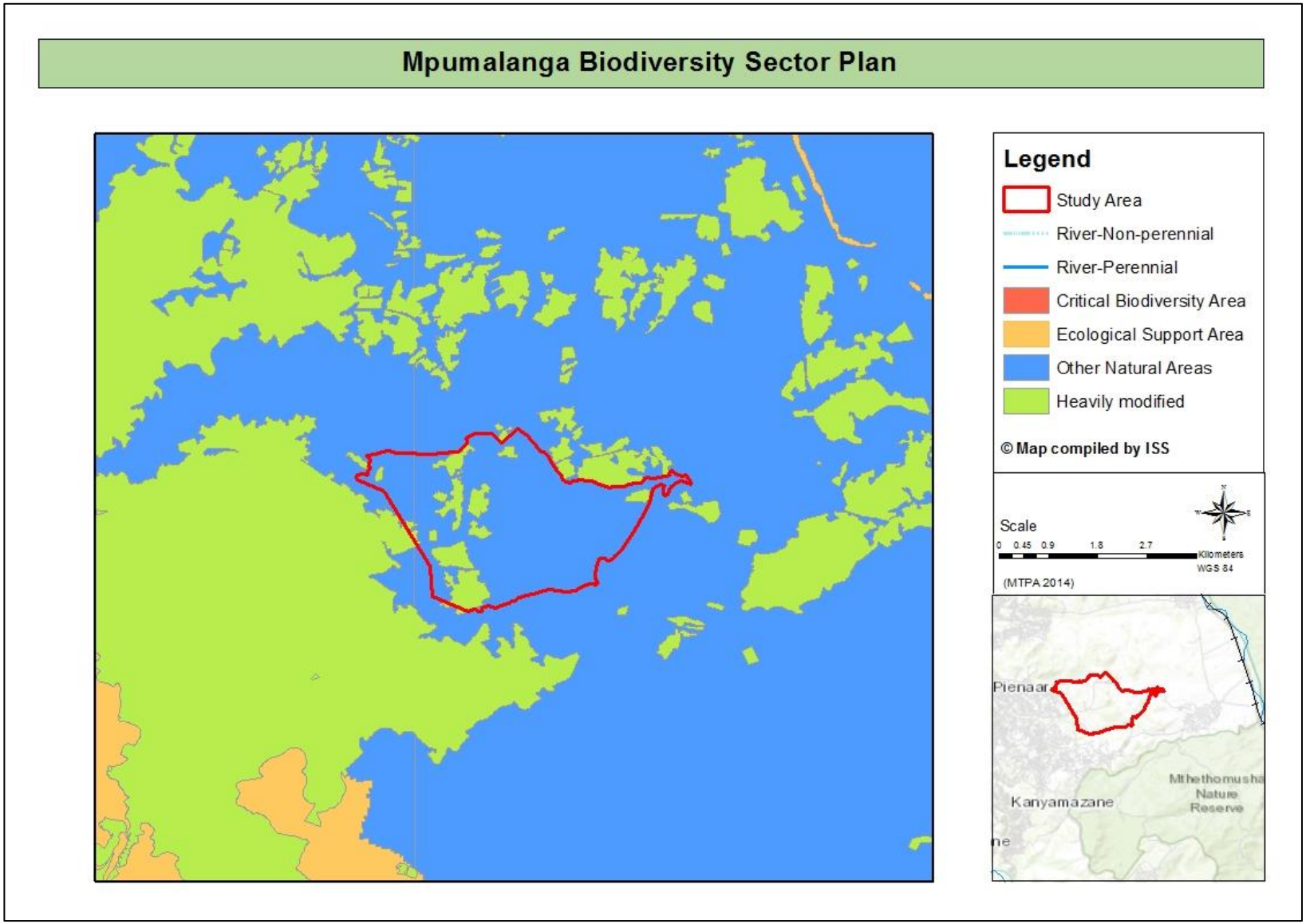


Figure 10: Mpumalanga Biodiversity Sector Plan Map for the study area (from the MBSP)

The study area transverses all four MBSP categories (Heavily Modified and Other Natural Area).

3. Discussion and Evaluation of Results

In this section, the **selection of sampling points** for the 2018 baseline aquatic assessment is firstly described, followed by a discussion of the **results** obtained, both with regard to the evaluation of **habitat conditions** and disturbances, as well as the **species response** of aquatic biota by determining their occurrence and composition at the sampling points described below.

3.1. Selection of Sampling Points for the 2018 Baseline Aquatic Assessment

With regard to the **selection of sampling points for biomonitoring**, it is important to note that biomonitoring surveys can only be conducted in flowing water (streams and rivers), and not in wetlands, as the results will be inaccurate due to the fact that most biomonitoring assessment methods (including SASS5) were designed to assess river health, and are not applicable to wetland communities or habitats (Dickens and Graham 2002; Kleynhans 2007; Kleynhans *et al*. 2007).

Two sets of data are required in order to interpret the results of biomonitoring surveys, namely data from a "**reference condition site**", where habitat conditions are expected to be relatively undisturbed, and data from an "**affected condition site**" (or "**affected site**"), where the influences resulting from a land-use is expected to have created stressors in the habitats of the aquatic biota.

A total of ten (10) sampling points were selected for the baseline aquatic assessment conducted in 2017. Table 2 over the page indicates the number, GPS coordinates, and a description of each of the sampling points. For this current 2018 baseline aquatic assessment NK1 was not visited as there was no access to this site.

The locations of these sampling points are illustrated in Figure 11 on page 23.

Table 2: Sampling points for the baseline aquatic assessment at Nkosi City

SURVEY SITE	LATITUDE	LONGITUDE	SITE DESCRIPTION
NK1	25°23'37.40" S	31°11'25.256"E	UPSTREAM/REFERENCE SAMPLING POINT ▪ In the headwaters of an unnamed tributary of the Nsikazi River. ▪ Assess impacts of study area on the unnamed tributary flowing into the Nsikazi River. ▪ Site was inaccessible.
NK2	25°23'29.13" S	31°12'54.928"E	DOWNSTREAM/AFFECTED SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi River. ▪ Assess impacts of study area on the unnamed tributary flowing into the Nsikazi River.
NK3	25°24'3.477" S	31°12'56.2"E	UPSTREAM/REFERENCE SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi River. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River.
NK4	25°23'58.38" S	31°14'2.341"E	UPSTREAM/REFERENCE SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi river. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River.
NK5	25°23'56.48" S	31°14'56.399"E	DOWNSTREAM/AFFECTED SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi river. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River.
NK6	25°24'2.205" S	31°15'0.215"E	DOWNSTREAM/AFFECTED SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi river. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River.
NK7	25°25'0.715" S	31°14'11.881"E	DOWNSTREAM/AFFECTED SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi river. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River.
NK8	25°25'22.33" S	31°13'13.372"E	UPSTREAM/REFERENCE SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi river. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River. Also measures impacts of Daantjie Residential area on unnamed tributary flowing into the Nsikazi River.
NK9	25°25'19.15" S	31°12'54.292"E	UPSTREAM/REFERENCE SAMPLING POINT ▪ In the unnamed tributary of the Nsikazi river. ▪ Measures impacts of study area on the unnamed tributary flowing into the Nsikazi River. Also measures impacts of Daantjie Residential area on unnamed tributary flowing into the Nsikazi River.
NK10	25°21'48.015" S	31°13'35.631"E	DOWNSTREAM/AFFECTED SAMPLING POINT ▪ Sampling point was requested by client ▪ Assess impacts of Clau Clau and Newscom Residential areas on the unnamed tributary of the Nsikazi River.

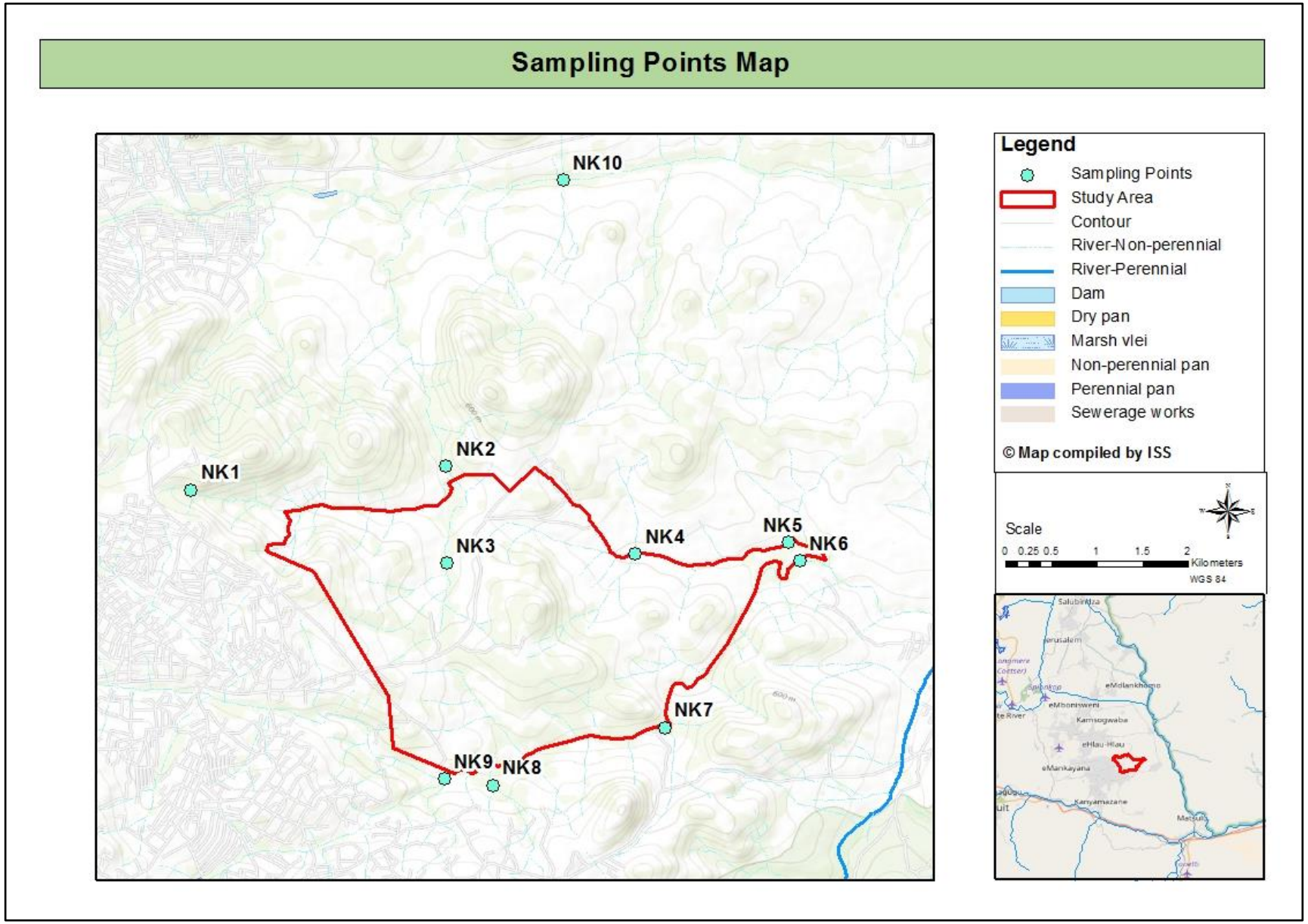


Figure 11: Sampling points for the proposed Nkosi City development

Figure 12: Sampling points that occur in the preliminary layout (November 2017) of the proposed Nkosi City Township

Table 3: Evaluation of Suitability and Impacts at each sampling point

SAMPLING POINT	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK2**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Downstream of the dam located in the study area. ▪ River bed consisted of isolated pools with no flow.	▪ Road and bridge crossing upstream. ▪ Dam upstream. ▪ Riparian vegetation located close to river bed. ▪ Limited alien vegetation present. ▪ Natural habitat typical of Savanna vegetation.
	SITE SAMPLED	No Isolated pools			
	SUITABLE FOR FUTURE SAMPLING	Yes			
 **NK3**	SITE VISITED	Yes	UPSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Situated upstream of the dam located in the study area. ▪ River bed consisted of isolated pools with no flow.	▪ Road and bridge crossing downstream. ▪ Dam located downstream. ▪ Riparian vegetation located close to river bed. ▪ Limited alien vegetation present. ▪ Natural habitat.
	SITE SAMPLED	No Isolated pools			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SAMPLING POINT	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK4**	SITE VISITED	Yes	UPSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ River bed consisted of isolated pools with no flow. ▪ Situated on northern the boundary of the study area.	▪ Riparian vegetation located close to river bed. ▪ Natural habitat typical of Savanna vegetation. ▪ Limited impacts observed at the sampling point.
	SITE SAMPLED	No Isolated pools			
	SUITABLE FOR FUTURE SAMPLING	Yes			
 **NK5**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Sampling point consisted of large, shallow, isolated pool of water. ▪ Turbid water. ▪ Habitat consisted of majority GSM, and limited amount of Stones.	▪ Natural habitat typical of Savanna vegetation. ▪ Small amount of subsistence agriculture in surrounding area. ▪ Limited impacts from surrounding area.
	SITE SAMPLED	Yes			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SAMPLING POINT	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK6**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Habitat consists of large boulders, bedrock, small cobbles and GSM.	▪ Natural habitat typical of Savanna vegetation. ▪ Small amount of subsistence agriculture and livestock (cattle) present in surrounding area. ▪ Limited impacts from surrounding area and at the sampling point although the sampling point may be affected by upstream residential area Daantjie.
	SITE SAMPLED	Yes			
	SUITABLE FOR FUTURE SAMPLING	Yes			
 **NK7**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Dense vegetation present at sampling point. ▪ Marginal vegetation. ▪ Habitat consists largely of GSM, as well as some large and small stones and bedrock.	▪ Natural habitat typical of Savanna vegetation. ▪ Rubbish present at the sampling point. ▪ The sampling point may be affected by upstream residential area Daantjie.
	SITE SAMPLED	Yes			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SAMPLING POINT	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK8**	SITE VISITED	Yes	UPSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Dense vegetation present at sampling point. ▪ Marginal vegetation was limited for sampling. ▪ Flow was low. ▪ Habitat consisted mostly of large boulders, with some GSM, small cobbles and bedrock was present.	▪ Natural habitat typical of Savanna vegetation. ▪ Water pipeline present at site. ▪ Dirt road present. ▪ Some residential areas in surrounding area. ▪ Sampling point may be affected by upstream residential area Daantjie.
	SITE SAMPLED	Yes but flow levels were low			
	SUITABLE FOR FUTURE SAMPLING	Yes			
 **NK9**	SITE VISITED	Yes	UPSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Site located downstream of a road crossing. ▪ Habitat consists of GSM and small cobbles, to a lesser extent large boulders and bedrock.	▪ Foot path crossing the sampling point. ▪ Alien and invasive plant species. ▪ Natural habitat typical of Savanna vegetation. ▪ Sampling point may be affected by upstream residential area Daantjie.
	SITE SAMPLED	Yes			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SAMPLING POINT	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK10**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY AND CLAU-CLAU RESIDENTIAL AREA ▪ On an unnamed tributary of the Nsikazi River.	▪ Site located downstream at a road crossing. ▪ Habitat consists of GSM and small cobbles, to a lesser extent large boulders and bedrock.	▪ Dirt road crossing. ▪ Sand mining present just upstream of the site. ▪ Alien and invasive plant species. ▪ Natural habitat typical of Savanna vegetation. ▪ Sampling point may be affected by upstream residential area Clau-Clau and Newscom.
	SITE SAMPLED	Yes			
	SUITABLE FOR FUTURE SAMPLING	Yes			

3.2. Conducting the 2018 Baseline Aquatic Assessment

The 2018 baseline aquatic assessment was conducted by Kimberley Perry and Peter Kimberg, and all the sampling points listed in Table 2 were visited between the 1st to the 3rd of March 2018, as well as the 12th to the 13th of March 2018. The **habitats** at all sampling points were firstly evaluated by means of observations with regard to their surroundings, possible causes of stressors or disturbances on aquatic ecosystems, and the suitability of each site for future biomonitoring surveys, as summarised in **Table 3 on page 25**.

The outcome of this evaluation indicated that sampling methods could not be applied at sampling points **NK2, NK3, and NK4** as they consisted of small, isolated pools of water. *In situ* water quality parameters were measured at these sites. This implied that **NK5, NK6, NK7, NK8, NK9, and NK10** could be further assessed by means of the sampling methods described in paragraph 1.3.1 on page 3 (a detailed description of how these methods are executed, and how results obtained from each of these methods are interpreted, is contained in **Annexure "A"**. Sampling point **NK5** had no flow and therefore it was sampled for invertebrate species composition records only and the SASS5 EC could not be determined for this sampling point. *In situ* water quality parameters were measured at all of the sampling points that were sampled. Fish sampling was only conducted at sites **NK6, NK7, NK9** and **NK10** due to the lack of flow and suitable habitat at the remainder of the sites.

The following methods were used in this baseline aquatic survey at these sampling points:

- **Habitat evaluations:**
  - Observations regarding possible impacts and effects at each survey site (see Table 3 on page 25);
  - IHAS evaluation (see **Annexure A.1**);
  - IHI evaluation (see **Annexure A.2**); and
  - Measuring relevant *in-situ* water quality parameters and comparing the results obtained with the TWQRs for aquatic ecosystems (see **Annexure A.3**).

- **Species Response evaluations:**
  - Aquatic Invertebrate response evaluation, making use of SASS5 (see **Annexure A.4**);
  - Riparian Vegetation response evaluation, making use of VEGRAI (see **Annexure A.5**); and
  - Fish response evaluation, making use of FRAI (see **Annexure A.6**).

The results obtained from the *in situ* measurement of temperature, pH, Electrical Conductivity, and DO are summarised in **Annexure "B".** The results obtained from the IHAS-scorecards are attached as **Annexure "C".** The SASS5 Score-sheets are attached as **Annexure "D"**, the VEGRAI data interpretation is attached as **Annexure "E"**, and the FRAI results are attached as **Annexure "F".**

The results obtained during this 2018 wet season aquatic assessment and the 2017 dry season aquatic assessment at these sites are discussed below.

3.3. Results of the Baseline Aquatic Assessment at downstream site NK5

NK5 is located in an unnamed tributary of the Nsikazi River, downstream of sampling point NK4. Surrounding land use includes a small amount of subsistence farming.

Table 4 contains an overview of the conditions observed at NK5. The drivers and biotic responses observed at NK5 is summarised in Table 7.

Table 4: Overview of conditions observed at downstream site NK5

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	**Pretoriuskop Mountain Bushveld**	**X24C**

Table 5: Drivers and biotic responses at downstream site NK5

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td>IN SITU WATER QUALITY</td><td>The visual appearance of the water prior to sampling was brown. The in situ chemical parameters measured (Annexure B) were within the TWQRs for aquatic ecosystems with the exception of DO. Do levels at NK5 were below TWQRs (72%) however above being considered sub-lethal.</td></tr>
<tr><td>HABITAT</td><td>There was no flow at this sampling point. Habitats could be affected by trampling from livestock. Habitat consisted of mostly GSM, and Stones was limited. Annexure C contains the IHAS Score Sheets. The IHAS score was 52%, which indicates a habitat that is insufficient for supporting a diverse macroinvertebrate community.</td></tr>
<tr><td colspan="2">SPECIES RESPONSE</td></tr>
<tr><td>INVERTEBRATES</td><td>The SASS5 evaluation sheets are contained in Annexure D. The SASS5 results obtained during this survey can be summarised as follows:
<table>
<tr><th></th><th>March 2018</th></tr>
<tr><td>SASS5 score</td><td>66</td></tr>
<tr><td>Number of Taxa</td><td>15</td></tr>
<tr><td>ASPT</td><td>4.4</td></tr>
</table>
Taxa present at this sampling point in high abundances (10-100 individuals) during the 2018 wet season include Coenagrionidae. Other taxa present include Gomphidae, Libellulidae, Hydrometridae, Vellidae, Dytiscidae, Chironomidae, and Culicidae.</td></tr>
<tr><td>VEGETATION</td><td>The VEGRAI 3 evaluation is attached as Annexure E, which indicates a VEGRAI Ecological Category of D. The vegetation on the L downstream bank had been cleared down to the water’s edge for cultivation of crops.

Terrestrial vegetation surrounding the survey site is gallery forest.

Some instream vegetation is present, but it is limited. Marginal vegetation was mainly wetland species such as Juncus effuses and Cyperus spp. Aquatic plants included, and Persicaria species.

Non-marginal vegetation was sparse mostly due to excessive trampling and scouring of the river banks. There was more than one individual of NEMBA listed category 1B Lantana camara present.</td></tr>
<tr><td>FISH</td><td>No fish sampling was conducted at this site due to the lack of flow.</td></tr>
</table>

3.4. Results of the Baseline Aquatic Assessment at downstream site NK6

NK6 is located in an unnamed tributary of the Nsikazi River, downstream of sampling points NK7, NK8, and NK9. Impacts upstream from the site include residential areas Daantjie and Msogwaba. Surrounding land use includes a small amount of subsistence farming.

Table 6 contains an overview of the conditions observed at NK6. The drivers and biotic responses observed at NK6 is summarised in Table 7.

Table 6: Overview of conditions observed at downstream site NK6

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	**Pretoriuskop Mountain Bushveld**	**X24C**

Table 7: Drivers and biotic responses at downstream site NK6

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td>IN SITU WATER QUALITY</td><td>The visual appearance of the water prior to sampling was clear. The in situ chemical parameters measured (Annexure B) for this current 2018 wet season are within the TWQRs for aquatic ecosystems. During the 2017 dry season, the in situ chemical parameters measured were within the TWQRs for aquatic ecosystems with the exception of DO which was in excess of 100% (126.5%). This was super saturated and could be indicative of eutrophication. The pH at the site was also slightly elevated (8.50 and 8.59) indicating a more alkaline environment during the 2017 dry season.</td></tr>
<tr><td>HABITAT</td><td>The flow was moderate. Habitats could be affected by trampling from livestock. Habitat consists of large boulders, small cobbles and GSM, whilst a small amount of bedrock is present. Annexure C contains the IHAS Score Sheets. The IHAS score was 77, which indicates a habitat that is highly sufficient for supporting a diverse macroinvertebrate community. The IHAS score for the 2017 dry season was 85 (also indicating a habitat that is highly sufficient for supporting a diverse macroinvertebrate community).</td></tr>
<tr><td colspan="2">SPECIES RESPONSE</td></tr>
<tr><td>INVERTEBRATES</td><td>The SASS5 evaluation sheets are contained in Annexure D. The SASS5 results obtained can be summarised as follows:
<table>
<tr><th></th><th>March 2018</th><th>May 2017</th></tr>
<tr><td>SASS5 EC</td><td>B</td><td>C</td></tr>
<tr><td>SASS5 score</td><td>128</td><td>131</td></tr>
<tr><td>Number of Taxa</td><td>23</td><td>25</td></tr>
<tr><td>ASPT</td><td>5.56</td><td>5.24</td></tr>
</table>
Taxa present at this sampling point in high abundances (10-100 individuals) during the 2018 wet season include Baetidae, Caenidae, Coenagrionidae, Gomphidae, Hydropsychidae, Chironomidae, and Simuliidae. Thiaridae was present in very high abundances (100- 1000). Taxa present at this sampling point in high abundances (10-100 individuals) during the 2017 dry season included Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, Vellidae, Gyrinidae, Chironomidae, and Simuliidae.</td></tr>
<tr><td>VEGETATION</td><td>The VEGRAI evaluation is attached as Annexure E, which indicates a VEGRAI Ecological Category of C. The riparian vegetation at this site was largely intact although alien invasive plant species were present.

There was more than one individual of NEMBA listed category 1B Lantana camara present.</td></tr>
<tr><td>FISH</td><td>The FRAI assessment is attached as Annexure F. Based on the FRAI results the fish community at site NK6 was in a seriously modified state (FRAI Category E) at the time of the survey. Only 3 of the 14 expected fish species were recorded during the survey. The fish community was comprised of species that are rated as moderately tolerant or tolerant of modified water quality and flow indicating that water quality and flow related impacts have been significant limiting factors of the fish assemblage.</td></tr>
</table>

3.5. Results of the Baseline Aquatic Assessment at downstream site NK7

NK7 is located in an unnamed tributary of the Nsikazi River, downstream of sampling points NK8 and NK9. Impacts upstream from the site include residential areas Daantjie and Msogwaba. Surrounding land use includes a small amount of subsistence farming.

Table 8 contains an overview of the conditions observed at NK7. The drivers and biotic response observed at NK7 is summarised in Table 9.

Table 8: Overview of conditions observed at downstream site NK7

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	**Malelane Mountain Bushveld**	**X24C**

Table 9: Drivers and biotic responses at downstream site NK7

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td>IN SITU WATER QUALITY</td><td>The visual appearance of the water prior to sampling was clear. The in situ chemical parameters measured (Annexure B) were all within the TWQR's for aquatic ecosystems. During the 2017 dry season the DO levels at this site were in excess of 100% (106%). This was super saturated and could be indicative of eutrophication. Calcium levels were slightly higher than TWQRs for domestic water use at this site. Faecal coliforms were present in water samples (count of 2419.6) as well as E. coli (count of 613.1)</td></tr>
<tr><td>HABITAT</td><td>The flow is moderate, but probability of artificial flow is high due to WWTW upstream. Habitat consists largely of GSM, as well as some large and small stones and bedrock. A large amount of fringing vegetation is present. Annexure C contains the IHAS Score Sheets. The IHAS score was 76, which indicates a habitat that is highly suitable for supporting a diverse macroinvertebrate community. The IHAS score during the 2017 baseline assessment was 85 also indicative of a habitat that is highly suitable for supporting a diverse macroinvertebrate community.</td></tr>
<tr><td colspan="2">SPECIES RESPONSE</td></tr>
<tr><td>INVERTEBRATES</td><td>The SASS5 evaluation sheets are contained in Annexure D. The SASS5 results obtained can be summarised as follows:
<table>
<tr><th></th><th>March 2018</th><th>May 2017</th></tr>
<tr><td>SASS5 EC</td><td>B</td><td>C</td></tr>
<tr><td>SASS5 score</td><td>126</td><td>124</td></tr>
<tr><td>Number of Taxa</td><td>24</td><td>23</td></tr>
<tr><td>ASPT</td><td>5.25</td><td>5.39</td></tr>
</table>
Taxa present at this sampling point in high abundances (10-100 individuals) during the 2018 wet season include Baetidae, Caenidae, Coenagrionidae, Gomphidae, Belostomatidae, and Thiaridae. Taxa present at this sampling point in high abundances (10-100 individuals) during the 2017 dry season included Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, Chironomidae, and Simuliidae.</td></tr>
<tr><td>VEGETATION</td><td>The VEGRAI evaluation is attached as Annexure E, which indicates a VEGRAI Ecological Category of C.

Terrestrial vegetation surrounding the survey site consists of savannah bushveld. Due to the relative remoteness of the site terrestrial vegetation was still largely intact although the upstream urbanization has contributed to the presence of alien invasive plant species.</td></tr>
<tr><td>FISH</td><td>The FRAI assessment is attached as Annexure F. Based on the FRAI results the fish community at site NK7 was in a seriously modified state (FRAI Category E) at the time of the survey. Only 3 of the 14 expected fish species were recorded at this site during the March 2018 survey. The observed fish community was comprised of species that are rated as moderately tolerant or tolerant to modified water quality and flow indicating that water quality and flow related impacts have been a significant limiting factors of the fish assemblage.</td></tr>
</table>

3.6. Results of the Baseline Aquatic Assessment at upstream site NK8

NK8 is located in an unnamed tributary of the Nsikazi River, upstream of sampling points NK7 and NK6. Impacts upstream from the site include residential areas Daantjie and Msogwaba. Surrounding land use includes a small residential area and a dirt road.

Table 10 contains an overview of the conditions observed at NK8. The drivers and biotic response observed at NK8 is summarised in Table 11.

Table 10: Overview of conditions observed at upstream site NK8

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	**Malelane Mountain Bushveld**	**X24C**

Table 11: Drivers and biotic responses at upstream site NK8

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td>IN SITU WATER QUALITY</td><td>The visual appearance of the water prior to sampling was opaque. The in situ chemical parameters measured (Annexure B) were all within the TWQR's for aquatic ecosystems during both the 2018 wet season survey as well as the 2017 dry season survey.</td></tr>
<tr><td>HABITAT</td><td>The flow was low at this site. Habitat consisted mostly of large boulders, with some GSM, small cobbles and bedrock was present. Marginal vegetation was limited at this site due to low flow levels. Annexure C contains the IHAS Score Sheets. The IHAS score was 69, which indicates a habitat that is acceptable for supporting a diverse macroinvertebrate community. The IHAS score during the 2017 dry season survey was 73, also indicative of a habitat that is acceptable for supporting a diverse macroinvertebrate community.</td></tr>
<tr><td colspan="2">SPECIES RESPONSE</td></tr>
<tr><td>INVERTEBRATES</td><td>The SASS5 evaluation sheets are contained in Annexure D. The SASS5 results obtained can be summarised as follows:
<table>
<tr><th></th><th>March 2018</th><th>May 2017</th></tr>
<tr><td>SASS5 EC</td><td>D</td><td>C</td></tr>
<tr><td>SASS5 score</td><td>98</td><td>140</td></tr>
<tr><td>Number of Taxa</td><td>20</td><td>24</td></tr>
<tr><td>ASPT</td><td>4.9</td><td>5.83</td></tr>
</table>
Taxa present at this sampling point in high abundances (10-100 individuals) during the 2018 wet season survey include Potamonautidae, Baetidae, Caenidae, Leptophlebiidae, Coenagrionidae, Gomphidae, Philopotamidae, Dytiscidae, and Thiaridae. Taxa present at this sampling point in high abundances (10-100 individuals) during the 2017 dry season survey included Baetidae, Caenidae, Leptophlebiidae, Coenagrionidae, Gomphidae, Libellulidae, Corixidae, Gerridae, Notonectidae, Vellidae, Gyrinidae, and Chironomidae.</td></tr>
<tr><td>VEGETATION</td><td>The VEGRAI evaluation is attached as Annexure E, which indicates a VEGRAI Ecological Category of D.

Due to the proximity to the urban edge and the associated harvesting of resources this site showed a higher degree of disturbance than the downstream sites NK6 and NK7.</td></tr>
<tr><td>FISH</td><td>No fish sampling was conducted at this site due to the limited flow and the steep gradient.</td></tr>
</table>

3.7. Results of the Baseline Aquatic Assessment at upstream site NK9

NK9 is located in an unnamed tributary of the Nsikazi River, upstream of sampling points NK7 and NK6. Impacts upstream from the site include residential areas Daantjie and Msogwaba. Surrounding land use includes a small road crossing and alien vegetation plant species.

Table 12 contains an overview of the conditions observed at NK9. The drivers and biotic response observed at NK9 is summarised in Table 13.

Table 12: Overview of conditions observed at upstream site NK9

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	**Malelane Mountain Bushveld**	**X24C**

Table 13: Drivers and biotic responses at upstream site NK9

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td>IN SITU WATER QUALITY</td><td>The visual appearance of the water prior to sampling was clear. The in situ chemical parameters measured (Annexure B) were all within the TWQR's for aquatic ecosystems for both the 2018 wet season survey as well as the 2017 dry season survey. Calcium levels were slightly higher than TWQRs for domestic water use at this site. Faecal coliforms were present in water samples (count of 2419.6) as well as E. coli (count of 1732.9)</td></tr>
<tr><td>HABITAT</td><td>The flow was moderate. Habitat consists of GSM and small cobbles, to a lesser extent large boulders and bedrock. Annexure C contains the IHAS Score Sheets. The IHAS score was 73, which indicates a habitat that is suitable for supporting a diverse macroinvertebrate community. The IHAS score during the 2017 dry season survey was 76, also indicating a habitat that is highly suitable for supporting a diverse macroinvertebrate community.</td></tr>
<tr><td colspan="2">SPECIES RESPONSE</td></tr>
<tr><td>INVERTEBRATES</td><td>The SASS5 evaluation sheets are contained in Annexure D. The SASS5 results obtained can be summarised as follows:
<table>
<tr><th></th><th>March 2018</th><th>May 2017</th></tr>
<tr><td>SASS5 EC</td><td>D</td><td>C</td></tr>
<tr><td>SASS5 score</td><td>86</td><td>107</td></tr>
<tr><td>Number of Taxa</td><td>18</td><td>23</td></tr>
<tr><td>ASPT</td><td>4.77</td><td>4.65</td></tr>
</table>
Taxa present at this sampling point in high abundances (10-100 individuals) during the 2018 wet season survey include Potamonautidae, Baetidae, Caenidae, Coenagrionidae, Gomphidae, Chironomidae, and Thiaridae. Taxa present in very high abundances (100 – 1000 individuals) include Simuliidae. Taxa present at this sampling point in high abundances (10-100 individuals) during the 2017 dry season survey included Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, Simuliidae, Chironomidae, and Thiaridae.</td></tr>
<tr><td>VEGETATION</td><td>The VEGRAI evaluation is attached as Annexure E, which indicates a VEGRAI Ecological Category of D. This site is situated in close proximity to the urban environment and a large degree of removal of riparian vegetation has occurred along with the associated encroachment of alien invasive vegetation especially Lantana camara, a NEMBA category 1b species.

Despite the increased level of disturbance, some elements of the expected indigenous vegetation community was still present.</td></tr>
<tr><td>FISH</td><td>The FRAI assessment is attached as Annexure F. Based on the FRAI results the fish community at site NK9 was in a seriously modified state (FRAI Category E) at the time of the survey. Only 3 of the 14 expected fish species were recorded at this site during the March 2018 survey. These fish species were also present in low abundances. The observed fish community was comprised of species that are rated as moderately tolerant or tolerant to modified water quality and flow indicating that water quality and flow related impacts have been a significant limiting factors of the fish assemblage.</td></tr>
</table>

3.8. Results of the Baseline Aquatic Assessment at the control site NK10

NK10 is located in an unnamed tributary of the Nsikazi River, downstream of sampling points NK2 and NK3. Impacts upstream from the site include residential areas Clau-Clau and Newscom. Surrounding land use includes a road crossing and alien vegetation plant species.

Table 14 contains an overview of the conditions observed at NK10. The drivers and biotic response observed at NK10 is summarised in Table 15.

Table 14: Overview of conditions observed at control site NK10

GEOMORPHOLOGICAL ZONE	VEGETATION	QUATERNARY CATCHMENT
Lower	**Pretoriuskop Mountain Bushveld**	**X24B**

Table 15: Drivers and biotic responses at control site NK10

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td>IN SITU WATER QUALITY</td><td>The visual appearance of the water prior to sampling was clear. The in situ chemical parameters measured (Annexure B) were all within the TWQR's for aquatic ecosystems. During the 2017 dry season the in situ chemical parameters measured were all within the TWQR's for aquatic ecosystems, with the exception of DO levels. DO levels at NK10 were below TWQRs for aquatic ecosystems (75%) but still above sub lethal limits during the 2017 dry season survey.</td></tr>
<tr><td>HABITAT</td><td>The flow was moderate. Road crossing was present as well as alien vegetation. Habitat consists of GSM and small cobbles, to a lesser extent large boulders and bedrock. Annexure C contains the IHAS Score Sheets. The IHAS score was 69, which indicates a habitat that is acceptable for supporting a diverse macroinvertebrate community. The IHAS score during the 2017 dry season survey was 72, also indicating a habitat that is acceptable for supporting a diverse macroinvertebrate community.</td></tr>
<tr><td colspan="2">SPECIES RESPONSE</td></tr>
<tr><td>INVERTEBRATES</td><td>The SASS5 evaluation sheets are contained in Annexure D. The SASS5 results obtained can be summarised as follows:
<table>
<tr><th></th><th>March 2018</th><th>May 2017</th></tr>
<tr><td>SASS5 EC</td><td>C</td><td>D</td></tr>
<tr><td>SASS5 score</td><td>123</td><td>115</td></tr>
<tr><td>Number of Taxa</td><td>24</td><td>23</td></tr>
<tr><td>ASPT</td><td>5.12</td><td>5.00</td></tr>
</table>
Taxa present at this control point in high abundances (10-100 individuals) during the 2018 wet season survey include Baetidae, Coenagrionidae, Belostomatidae, Veliidae, and Chironomidae. Taxa present at this control point in high abundances (10-100 individuals) during the 2017 dry season survey included Baetidae, Coenagrionidae, Gomphidae, Libellulidae, Gerridae, Hydroptilidae, Chironomidae, Planorbinae, and Thiaridae.</td></tr>
<tr><td>VEGETATION</td><td>The VEGRAI evaluation is attached as Annexure E, which indicates a VEGRAI Ecological Category of E. The impact of ongoing sand mining adjacent to the site has had a significant negative impact on the riparian vegetation community of this site.</td></tr>
<tr><td>FISH</td><td>The FRAI assessment is attached as Annexure F. Based on the FRAI results the fish community at site NK10 was in a largely/seriously modified state (FRAI Category D/E) at the time of the survey. Only 4 of the 14 expected fish species were recorded at this site during the March 2018 survey. The observed fish community was comprised of species that are rated as moderately tolerant or tolerant to modified water quality and flow indicating that water quality and flow related impacts have been a significant limiting factor of the fish assemblage.</td></tr>
</table>

3.9. Results of IHI Analysis

This model refers to the maintenance of a balanced composition of *physico*-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). An assessment was undertaken for the non-perennial tributaries of the Nsikazi River associated with the study area (Table 16).

Table 16: The IHI for the non-perennial tributaries of the Nsikazi River

INSTREAM IHI		
CRITERIA	**WEIGHTING**	**SCORE**
WATER QUALITY	15	5
SOLID WASTE DISPOSAL	13	4.5
WATER ABSTRACTION	13	4.5
FLOW MODIFICATION	12	4.5
BED MODIFICATION	12	4.5
CHANNEL MODIFICATION	12	4.5
EXOTIC MACROPHYTES	9	4.5
EXOTIC FAUNA	7	4.0
INUNDATION	7	4.0
Total		**40 (Largely Modified)**
RIPARIAN IHI		
CRITERIA	**WEIGHTING**	**SCORE**
WATER QUALITY	15	5
BANK EROSION	13	5
CHANNEL MODIFICATION	13	5
WATER ABSTRACTION	13	5
FLOW MODIFICATION	12	5
INDIGENOUS VEGETATION REMOVAL	12	5
EXOTIC VEGETATION ENCROACHMENT	12	4.0
INUNDATION	10	4.0
Total		**38 (Seriously Modified)**

The Instream IHI was classed largely modified. The surrounding townships in the area will negatively affect the water quality of the system which is seen to be the largest impact. There are numerous river crossings located within the non-perennial tributaries of the Nsikazi River, as well as instream dams which have altered the natural flow regime. Abstraction is also taking place within the reach used for residential housing, and irrigation.

The Riparian IHI was classed seriously modified, this is mainly due to the surrounding expansion of residential areas such as Daantjie and Clau-Clau. This leads to decreased water quality, clearing of indigenous vegetation, bank erosion and channel modification.

3.10. Determination of SASS5 Ecological Category

For the purposes of this 2018 baseline aquatic assessment at the proposed Nkosi City development, it was possible to determine the SASS5 Ecological Category *(EC)* at **NK6, NK7, NK8, NK9, and NK10. Habitat integrity** was determined by means of visual observations, IHAS, IHI, and *in situ* water quality. **Species response** was determined by making use of SASS5, VEGRAI, and FRAI indices.

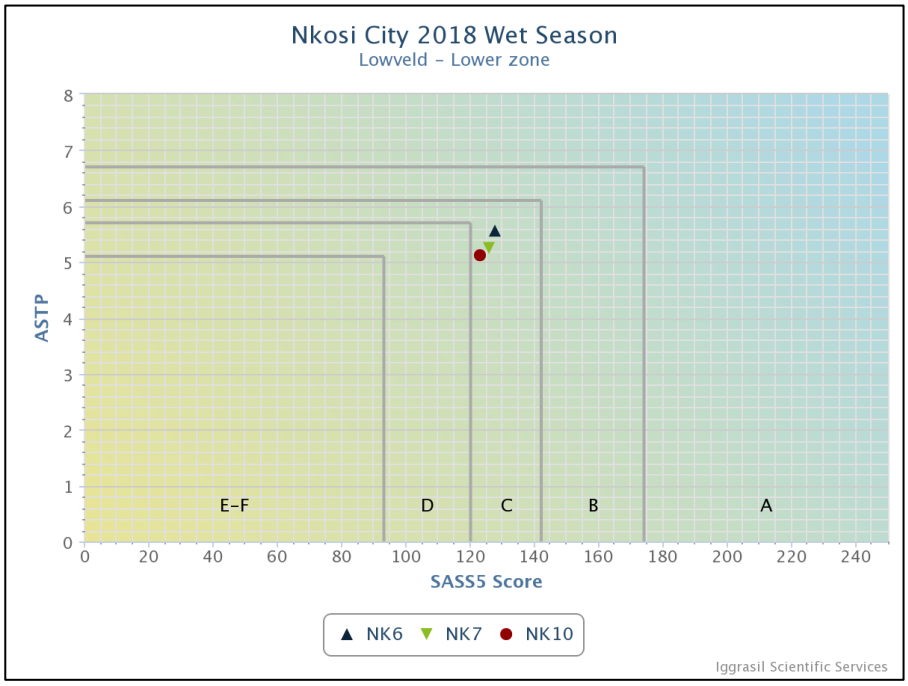


Figure 13: SASS5 Score and ASPT Plot for sampling points at Nkosi City

The SASS5 Score and ASPT for the 2018 wet season aquatic survey at the proposed Nkosi City site in comparison to the biological bands for the Lowveld Ecoregion (Lower zone) (Dallas 2007)

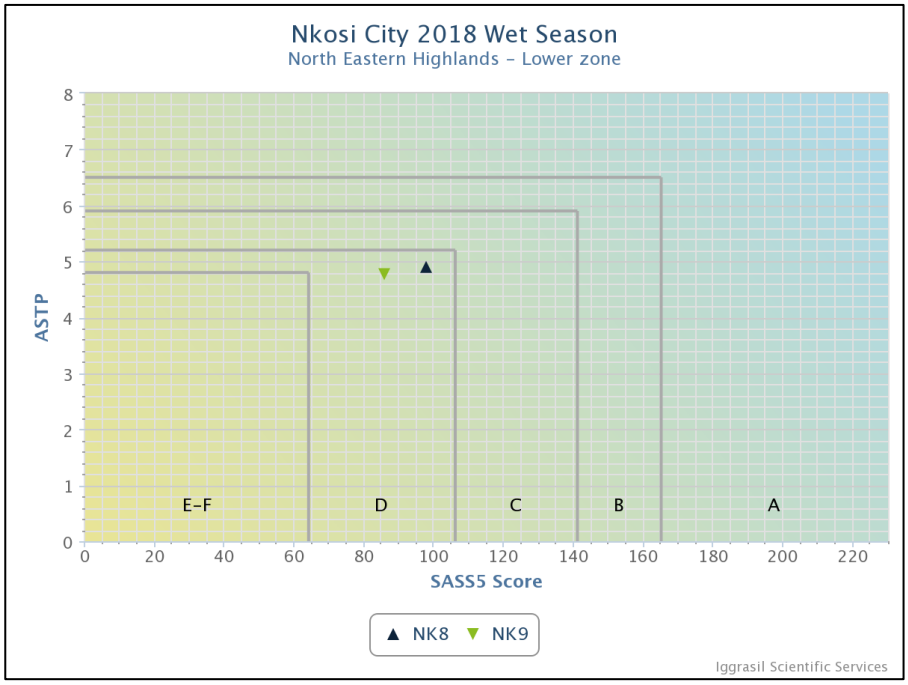


Figure 14: SASS5 Score and ASPT Plot for sampling points at Nkosi City

The SASS5 Score and ASPT for the 2018 wet season aquatic survey at the proposed Nkosi City site in comparison to the biological bands for the North Eastern Highlands Ecoregion (Lower zone) (Dallas 2007)

At upstream sites NK8 and NK9 the SASS5 EC was determined to be D (Figure 14). At downstream sites NK6 and NK7 the SASS5 EC was determined to be B, whilst the control site NK10 had a SASS5 EC of C (Figure 13).

4. Impact Assessment and suggested mitigation measures

The impacts described in this report are limited to the aquatic ecosystems that will be affected by the proposed activities. These activities include, but are not limited, to those described in the "Proposed activities" section on page 1 and the preliminary layout plan from November 2017 (Figure 1).

The largest impacts which currently face the proposed study area are water quality and flow alteration. The change of natural habitat (as the system is now) to a city which comprises of 5018 houses and apartments, as well as all associated services and infrastructure, will cause a major change in the water quality, availability and runoff patterns in the area. The impacts of the proposed activities could only be assessed with the information at hand as described in section 1.2.1.

From conceptual designs (Dovetail Properties and NCCPA, 2017) which were made available for consideration when assessing the potential risks, and from the preliminary layout obtained in November 2017 (Figure 1), the majority of the industrial and business activities are proposed to be located in the centre of the study area, along one of the unnamed tributaries of the Nsikazi River which was dry at the time of the 2017 dry season survey and consisted of isolated pools during the 2018 wet season survey. Along the southern boundary of the proposed Nkosi City development there is another unnamed tributary of the Nsikazi River which was sampled and found to be in relatively good condition during both the 2017 dry season and 2018 wet season surveys, although already impacted by Daantjie residential areas. According to proposed plans there will be farming land, some housing, and a Primary and Secondary School along this particular unnamed tributary (Figure 1). The unnamed tributary in the North-Eastern boundary of the study area is expected to have Bonded Housing built. The assessment therefore follows the precautionary principle and assumed that activities would take place in the watercourse and riparian habitat and that infrastructure would be placed in some areas of the watercourses and riparian habitat. The confidence level with which the impact assessment was done is **high.**

The proposed Nkosi City development will have several impacts on the surrounding environment and particularly on aquatic ecosystems. However, if mitigation measures to address the possible impacts are implemented, the significance of potential impacts can be mitigated and reduced. These mitigation measures have been listed in Table 19. It is important that any mitigation be implemented in the context of an Environmental Management Programme (EMPr) in order to ensure accountability and ultimately the success of the mitigation.

4.1. Impact Assessment Matrix

The impact assessment table significance of potential impacts is presented in Table 17.

Table 17: Impact Assessment Table

EXTENT THE PHYSICAL AND SPATIAL SCALE OF THE IMPACT.	Footprint	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
	Site	The impact could affect the whole, or a significant portion of the site.
	Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
	National	The impact could have an effect that expands throughout the country (South Africa).
	International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
DURATION THE LIFETIME OF THE IMPACT, THAT IS MEASURED IN RELATION TO THE LIFETIME OF THE PROPOSED DEVELOPMENT.	Short Term	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.
	Short-Medium Term	The impact will be relevant through to the end of a construction phase.
	Medium Term	The impact will last up to the end of the development phases, where after it will be entirely negated.
	Long Term	The impact will continue or last for the entire operational lifetime of the development, but will be mitigated by direct human action or by natural processes thereafter.
	Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY IS THE IMPACT DESTRUCTIVE OR BENIGN, DOES IT DESTROY THE IMPACTED ENVIRONMENT, ALTERS ITS FUNCTIONING, OR SLIGHTLY ALTER THE ENVIRONMENT ITSELF?	Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
	Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
	High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY THE LIKELIHOOD OF THE IMPACTS ACTUALLY OCCURRING. THE IMPACT MAY OCCUR FOR ANY LENGTH OF TIME DURING THE LIFE CYCLE OF THE ACTIVITY, AND NOT AT ANY GIVEN TIME.	Improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0%).
	Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25%.
	Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50%.
	Highly Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75%.
	Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100%.

Mitigation – The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

Determination of Significance – Without Mitigation **–** Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required. Where the impact is positive, significance is noted as "positive". Significance will be rated on the following scale:

No significance: The impact is not substantial and does not require any mitigation action;

Low: The impact is of little importance, but may require limited mitigation;

Medium: The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels; and

High: The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

Determination of Significance – With Mitigation – Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation will be rated on the following scale:

No significance: The impact will be mitigated to the point where it is regarded as insubstantial; Low: The impact will be mitigated to the point where it is of limited importance;

Low to medium: The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels;

Medium: Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw;

Medium to high: The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels; and

High: The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

***Assessment Weighting* –** Each aspect within an impact description was assigned a series of quantitative criteria. Such criteria are likely to differ during the different stages of the project's life

cycle. In order to establish a defined base upon which it becomes feasible to make an informed decision, it will be necessary to weigh and rank all the identified criteria.

Ranking, Weighting and Scaling – For each impact under scrutiny, a scaled weighting factor will be attached to each respective impact. The purpose of assigning such weightings serve to highlight those aspects considered the most critical to the various stakeholders and ensure that each specialist's element of bias is taken into account. The weighting factor also provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspect criteria.

Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high value will score a relatively higher weighting than that which is of lower importance (See Figure 15 below: Weighting description).

Extent	Duration	Intensity	Probability	Weighting Factor (WF)	Significance Rating (SR)	Mitigation Efficiency (ME)	Significance Following Mitigation (SFM)
Footprint 1	Short term 1	Low 1	Probable 1	Low 1	Low 0-19	High 0,2	Low 0-19
Site 2	Short to medium 2		Possible 2	Low to medium 2	Low to medium 20-39	Medium to high 0,4	Low to medium 20-39
Regional 3	Medium term 3	Medium 3	Likely 3	Medium 3	Medium 40-59	Medium 0,6	Medium 40-59
National 4	Long term 4		Highly Likely 4	Medium to high 4	Medium to high 60-79	Low to medium 0,8	Medium to high 60-79
International 5	Permanent 5	High 5	Definite 5	High 5	High 80-100	Low 1,0	High 80-100

Figure 15: Description of bio-physical assessment parameters with its respective weighting

Identifying the Potential Impacts Without Mitigation Measures (WOM) – Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned weightings, resulting in a value for each impact (prior to the implementation of mitigation measures).

Equation 1: Significance Rating (WOM) = (Extent + Intensity + Duration + Probability) x Weighting Factor

Identifying the Potential Impacts with Mitigation Measures (WM) – In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it will be necessary to re-evaluate the impact.

Mitigation Efficiency (ME) – The most effective means of deriving a quantitative value of mitigated impacts is to assign each significance rating value (WOM) a mitigation effectiveness (ME) rating. The

allocation of such a rating is a measure of the efficiency and effectiveness, as identified through professional experience and empirical evidence of how effectively the proposed mitigation measures will manage the impact.

Thus, the lower the assigned value the greater the effectiveness of the proposed mitigation measures and subsequently, the lower the impacts with mitigation.

Equation 2: Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency

Or

WM = WOM x ME

***Significance Following Mitigation (SFM)* –** The significance of the impact after the mitigation measures is taken into consideration. The efficiency of the mitigation measure determines the significance of the impact. The level of impact will, therefore, be seen in its entirety with all considerations taken into account.

Table 18: Risk assessment of impacts and calculation of significance prior to and after mitigation measures

Threat	Extent	Intensity	Duration	Probability	Weighting factor	Significance rating	Mitigation efficiency	Significance following mitigation
Altering the flow regime of the watercourse.	Regional	High	Permanent	Definite	High	High	Medium – Low	Medium - High
	3	5	5	5	5	90	0.8	72
Altering the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount).	Site	Medium	Long term	Likely	Medium	Medium	Medium	Low - Medium
	2	4	4	3	3	45	0.6	27
Alteration of water quality – increasing the amounts of nutrients (phosphate, nitrite, nitrate).	Regional	High	Permanent	Highly likely	High	High	Medium	Medium - High
	3	5	5	4	5	85	0.6	51
Alteration of water quality – toxic contaminants (including toxic metal ions (e.g. copper, lead, zinc) and hydrocarbons.	Regional	Medium	Permanent	Highly likely	Medium – High	Medium - High	Medium to High	Low - Medium
	3	4	5	4	4	64	0.4	25.6
Changing the physical structure within a water resource (habitat).	Site	Medium	Short	Highly likely	Medium	Medium	Medium to high	Low
	2	3	2	4	3	33	0.4	13.2
Loss of aquatic biota	Regional	Medium	Medium	Highly likely	Medium-High	Medium	Medium to high	Low - Medium
	3	3	3	4	4	52	0.4	20.8

Table 19: Impacts and suggested management procedures relevant to the proposed development (modified from Macfarlane et al, 2010)

THREAT/IMPACT	SOURCE OF THE THREAT	PRIMARY MANAGEMENT PROCEDURE
Altering the flow regime of the watercourse.	*Construction:* Development within water resources e.g. infrastructure footprint within the wetland area or riparian area, thereby diverting or impeding flow. Lack of adequate rehabilitation resulting in colonization by invasive plants.	No unlicensed activities should take place in the watercourses and associated buffer zone. Any activities within 500 m of riparian areas are subject to authorization by means of a water use license. Construction in and around watercourses must be restricted to the dryer winter months. A temporary fence or demarcation must be erected around the works area to prevent access to sensitive environments. The works areas generally include the servitude, construction camps, areas where material is stored and the actual footprint of the infrastructure. Prevent pedestrian and vehicular access into the riparian areas and buffer areas. Formalise access roads and make use of existing roads and tracks where feasible, rather than creating new routes through naturally vegetated areas. Planning of the construction site must include eventual rehabilitation/restoration of indigenous vegetative cover in footprint area Alien plant eradication and follow-up control activities prior to construction, to prevent spread into disturbed soils, as well as follow-up control during construction, operation and closure. The amount of vegetation removed should be limited. Rehabilitation of damage/impacts that arise as a result of construction must be implemented immediately upon completion of construction.
	Operational: Vehicles driving in/through watercourses. Damage to vegetated areas.	Maintenance activities should not take place within watercourses or buffer zones. Where unavoidable, the footprint needed for maintenance must be kept to a minimum. This is subjected to authorization by means of a Water Use License. Where possible, maintenance within watercourses must be restricted to the drier winter months. Maintenance activities should not impact on rehabilitated areas. Maintenance workers should respect and also maintain fences that are in place to prevent livestock from entering rehabilitated areas, until such time that monitoring found that rehabilitation is successful and the fences removed. Maintenance should not impact on natural vegetation. Maintenance vehicles must stay on dedicated roads/servitudes.

THREAT/IMPACT	SOURCE OF THE THREAT	PRIMARY MANAGEMENT PROCEDURE
Altering the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount).	*Construction:* Earthwork activities. Clearing of surface vegetation will expose the soils, which in rainy events would wash down into wetlands, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soils. Disturbance of soil surface. Disturbance of slopes through creation of roads and tracks. Changes in runoff characteristics. Erosion (e.g. gully formation, bank collapse).	Construction in and around watercourses must be restricted to the dryer winter months. A temporary fence or demarcation must be erected around the works area to prevent water runoff and erosion of the disturbed or heaped soils into wetland areas. Access roads and bridges should span the wetland area, without impacting on the permanent or seasonal zones. Formalise access roads and make use of existing roads and tracks where feasible, rather than creating new routes through naturally vegetated areas. Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction/earthworks in that area (DWAF, 2005). A vegetation rehabilitation plan should be implemented. Untransformed indigenous vegetation can be removed as sods and stored. The sods must preferably be removed during the winter months and be replanted by latest springtime. The sods should not be stacked on top of each other or within sensitive environs. Once construction is completed, these sods should be used to rehabilitate the disturbed areas from where they have been removed. In the absence of timely rainfall, the sods should be watered well after planting and at least twice more over the next two weeks. Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover. Rehabilitation plans must be submitted and approved for rehabilitation of damage during construction and that plan must be implemented immediately upon completion of construction. Cordon off areas that are under rehabilitation as no-go areas using danger tape and steel droppers. If necessary, these areas should be fenced off to prevent vehicular, pedestrian and livestock access. During the construction phase, measures must be put in place to control the flow of excess water so that it does not impact on the surface vegetation. Protect all areas susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas. Runoff from roads must be managed to avoid erosion and pollution problems. Implementation of best management practices. Source-directed controls. Buffer zones should be maintained to trap sediments.

THREAT/IMPACT	SOURCE OF THE THREAT	PRIMARY MANAGEMENT PROCEDURE
Altering the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount).	*Operational:* Vehicles impacting on surface vegetation.	Rehabilitated vegetation should not be impacted on by maintenance. Maintenance vehicles must remain on dedicated roads and servitudes. Maintenance activities should not take place within watercourses or buffer zones. Where unavoidable, the footprint needed for maintenance must be kept to a minimum. This is subjected to authorization by means of a Water Use License. Where possible, maintenance within watercourses must be restricted to the drier winter months. Maintenance activities should not impact on rehabilitated areas and where soil or vegetation disturbances took place, this should be rehabilitated immediately.
Alteration of water quality – increasing the amounts of nutrients (phosphate, nitrite, nitrate).	*Construction* Disposal or discharge of human (including partially treated and untreated) sewage during the construction phase of the development.	Provision of adequate sanitation facilities located outside of the wetland/riparian area or its associated buffer zone. Establishment of buffer zones to reduce nutrient inputs in diffuse flow.
	Operational: Disposal or discharge of human (including partially treated and untreated) sewage during the operational phase (maintenance) of the development.	Provision of adequate sanitation facilities located outside of the wetland/riparian area or its associated buffer zone.
Alteration of water quality – toxic contaminants (including toxic metal ions (e.g. copper, lead, zinc) and hydrocarbons.	*Construction* Runoff from road surfaces. Discharge of solvents, and other industrial chemicals.	After construction, the land must be cleared of rubbish, surplus materials, and equipment, and all parts of the land shall be left in a condition as close as possible to that prior to use. Maintenance of construction vehicles. Control of waste discharges. Guidelines for implementing Clean Technologies. Maintenance of buffer zones to trap sediments with associated toxins.

THREAT/IMPACT	SOURCE OF THE THREAT	PRIMARY MANAGEMENT PROCEDURE
Alteration of water quality – toxic contaminants (including toxic metal ions (e.g. copper, lead, zinc) and hydrocarbons.	*Operational:* Runoff from road surfaces. Discharge of solvents, and other industrial chemicals.	Ensure that maintenance work does not take place haphazardly, but according to a fixed plan, from one area to the other. After maintenance, the land must be cleared of rubbish, surplus materials, and equipment, and all parts of the land shall be left in a condition as close as possible to that prior to use. Ensure maintenance vehicles are in proper order and well maintained. Control of waste discharges – particularly industries and residential areas along riparian areas of the Township. Guidelines for implementing Clean Technologies. Maintenance of buffer zones to trap sediments with associated toxins.
Changing the physical structure within a water resource (habitat).	*Construction:* Deposition of wind-blown sand. Loss of fringing vegetation and erosion. Alteration in natural fire regimes. Alteration of flow	Other than approved and authorized structure, no other development or maintenance infrastructure is allowed within the delineated wetland and riparian areas or their associated buffer zones. All recommendations included in the wetland specialist report should be considered; Linear developments (e.g. roads) should span the watercourse. Weed control in buffer zone. Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance of the proposed infrastructure and take immediate corrective action where invasive species are observed to establish. Design of wetland rehabilitation should limit alterations in flow and allow sufficient release of water during no flow periods.
	Operational: Loss of vegetation. Loss of hydrological flow classes Loss of biodiversity	Where possible, maintenance within watercourses must be restricted to the drier winter months. Maintenance activities should not impact on rehabilitated or naturally vegetated areas. The design of the wetland rehabilitation should limit fragmentation and isolation of sections of the non-perennial tributaries.

THREAT/IMPACT	SOURCE OF THE THREAT	PRIMARY MANAGEMENT PROCEDURE
Loss of aquatic biota	*Construction:* Loss of instream habitat Deposition of wind-blown sand. Loss of fringing vegetation and erosion. Alteration in natural fire regimes and subsequent loss of non-marginal and marginal vegetation. Increase in invasive species due to disturbance. Change in water quality Changes in flow	Ensure that no additional vegetation is removed, No fires should be allowed in natural veld – demarcated areas for cooking should be allowed for workers in construction camp. Avoid unnecessary river crossing - limit work within the stream, river or wetland. Other than approved and authorized structure, no other development or maintenance infrastructure is allowed within the delineated wetland and riparian areas or their associated buffer zones. Mark all areas which don't form part of the proposed weir and dam development within wetlands and riparian areas as no-go areas. Weed control in buffer zone. Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance of the proposed infrastructure and take immediate corrective action where invasive species are observed to establish. All management procedures listed above for the change in water quality. It is essential that the ecological reserve of the two non-perennial tributaries should be determined prior to impoundment.
	Operational: Loss of instream habitat Loss of flow	Maintenance activities should not take place within watercourses or buffer zones. Where unavoidable, the footprint for maintenance must be kept to a minimum. This is subjected to authorization by means of a Water Use License. Where possible, maintenance within watercourses must be restricted to the drier winter months. Maintenance activities should not impact on rehabilitated or naturally vegetated areas.

5. Conclusions and Recommendations

The 2018 baseline aquatic assessment at the proposed Nkosi City development was conducted on the 1st to the 3rd of March 2018 and the 12th to the 13th of March 2018. The habitats at all sampling points were firstly evaluated by means of observations with regard to their surroundings, possible causes of impacts or disturbances on aquatic ecosystems, and their suitability for future biomonitoring surveys. The outcome of this evaluation indicated that biomonitoring sampling methods could not be applied at sampling points **NK2, NK3, and NK4** as they consisted of small, isolated pools of water. *In situ* water quality parameters were measured at these sites.

This implied that **NK5, NK6, NK7, NK8, NK9, and NK10** could be further assessed by means of the sampling methods, although **NK5** had no flow and therefore it was sampled for species composition records only. *In situ* water quality parameters were measured at all of the sampling points that were sampled.

5.1. Conclusions

In terms of national and provincial planning the study area is not situated in an area currently earmarked for conservation in a near future. The study area is not deemed critical for meeting national or provincial conservation targets.

The IHI results indicate that the tributaries of the Nsikazi River flowing through the proposed Nkosi City development are largely and seriously modified in terms of instream and riparian conditions respectively. A number of anthropogenic activities have been identified at each individual site that could be detrimental to local habitats for aquatic biota, most notably upstream residential areas, invasive aliens, trampling by livestock, etc., as well as road crossings and impoundments, which causes sedimentation and bank erosion.

For this baseline aquatic report it was found that at upstream sites NK8 and NK9, those located closest to townships such as Daantjie, the SASS5 EC was determined to be D. At downstream sites NK6 and NK7 the SASS5 EC was determined to be B, whilst site NK10 had a SASS5 EC of C. The IHAS scores at all the sites – although varied – indicated suitability to support a diverse macroinvertebrate community. The impacts related to residential areas located upstream of the proposed Nkosi City development – particularly Daantjie - could potentially explain the poorer results at sampling points **NK8** and **NK9** as compared to sampling points **NK6 and NK7** which are located further downstream.

Based on the Fish Response Assessment Index (FRAI) the state of fish communities ranged from a Class E (seriously modified) at sites **NK9, NK7** and **NK6** to a class D/E (largely/seriously modified) at site **NK10**. The observed fish species are all regarded as tolerant or moderately tolerant of water quality

impairment and flow modifications. Therefore, water quality and flow related impacts are likely to have been a significant limiting factor on the fish assemblages.

Based on the results of the level 3 Vegetation Response Assessment Index (VEGRAI) assessment, the state of riparian vegetation communities in the project area ranged from Class D in the upper reaches and in close proximity to the urban areas (**NK8** and **NK9**) to Class D in the more remote and inaccessible downstream areas (**NK6** and **NK7**). The vegetation at site **NK10** has been severely degraded by ongoing sand mining activities and was categorised as being in a Class E.

If alteration in water quality and flow regime is not addressed alongside habitat loss, sedimentation and possible toxic contaminants from industrial and business activities, during the proposed development of Nkosi City, it is expected that there will be a continued decrease in biotic integrity. Of importance would be to ensure that development located close to the unnamed tributary of the Nsikazi River flowing along the southern boundary is kept to a minimum and highly regulated.

5.2. Recommendations

The proposed Nkosi City is located approximately 5 kilometres away from the Kruger National Park (KNP) and hence water quality should not be affected by the proposed development to avoid both aquatic and terrestrial species losses within the KNP. The Nsikazi River is a tributary of the Crocodile River which flows along the southern boundary of the KNP. It is recommended that all mitigation measures are strictly adhered to should the development commence. During the construction period, aquatic biomonitoring should be conducted on a quarterly basis. This assessment should include the latest version of SASS, IHAS, MIRAI, VEGRAI, FRAI and additionally diatoms should be considered as a biomonitoring tool. During the operational phase, it is recommended that biomonitoring should be conducted on a bi-annual basis. Biomonitoring of the control point NK10 during the proposed development of Nkosi City will potentially indicate effects of the development on the study area.

6. Professional opinion

A professional opinion is required as per the NEMA regulations with regards to the proposed development. The aquatic ecosystems in and around the study area were moderately modified, with the system along the southern boundary of the proposed development area seen to be in relatively good condition. However, they were not earmarked for conservation on a national or provincial planning level and hence are not critical for meeting conservation goals. It is therefore recommended that the proposed development should be considered with caution for approval, with the condition that all the recommendation and mitigation measures be strictly adhered to.

References

ACOCKS J. P. H., 1988. Veld types of South Africa. Memoirs of the Botanical Survey of South Africa.

BALLANCE A., HILL, L. ROUX, D., SILBERBAUER, M. AND STRYDOM W. 2001. State of the rivers report: Crocodile, Sabie-Sand and Olifants River Systems, Resource Quality Services, DWAF, Pretoria, South Africa (www.csir.co.za/rhp).

BRAUN-BLANQUET, J. 1932. Plant Sociology. Translated by Fuller, G.D. & Conrad, H.S. McGraw-Hill, New York.

CSIR, 2010. National Freshwater Ecosystem Priority Areas (NFEPA) CSIR, Pretoria, South Africa (http://gsdi.geoportal.csir.co.za/projects/national-freshwater-ecosystem-priority-areas-nfepa-project/).

DALLAS, H.F. 2005. Volume 2 – Maps of national RHP monitoring sites – per water management area *In:* Inventory of national river health programme monitoring sites. Report prepared for Environmentek (CSIR) and Resource Quality Services, Department of Water Affairs and Forestry.

DALLAS, H.F. 2007. River Health Programme: South African Scoring System (SASS) data interpretation guidelines. Report prepared for Institute of Natural Resources and Department of Water Affairs and Forestry.

DAVIES, B. AND DAY, J. 1998. Vanishing Waters. Cape Town: University of Cape Town Press.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY. 1996. South African Water Quality Guidelines (second edition). Volume 1: Domestic Use. Volume 4: Agricultural Use: Irrigation. Volume 5: Agricultural Use: Livestock Watering. Volume 7: Aquatic Ecosystems. Pretoria: Department of Water Affairs and Forestry.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Pretoria: Department of Water Affairs and Forestry.

DICKENS, C.W.S. AND GRAHAM, P.M. 2002. The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science 27*:* 1-10

DOVETAIL PROPERTIES AND NKOSI CITY COMMUNAL PROPERTY ASSOCIATION (NCCPA). 2017. Presentation on Nkosi City - An integrated human settlement in Daantjie, Mpumalanaga.

FERRAR, A.A. AND LÖTTER, M.C. 2007. Mpumalanga Biodiversity Conservation Plan Handbook. Nelspruit: Mpumalanga Tourism and Parks Agency.

KARR, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

KLEYNHANS, C. J. AND KEMPER, N. 2000. Overview of the river and assessment of habitat integrity. Chapter 8. In: JM King, RE Tharme and MS de Viliers (Ed.). Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology. WRC report No: TT 131/00.

KLEYNHANS CJ, 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu river (Limpopo system, South Africa). Journal of Aquatic Ecosystem Health 5: 41-54.

KLEYNHANS, CJ, THIRION, C AND MOOLMAN, J 2005. A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

KLEYNHANS, C. J. 2007. Module D: Fish Response Assessment Index (FRAI) in River Ecoclassification: Manual for Ecostatus Determination (Version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC report nr: TT330/08.

KLEYNHANS C.J., LOUW M.D. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. TT330/08

KLEYNHANS, C.J. MACKENZIE, J. AND LOUW, M.D. 2007. Riparian Vegetation Response Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC report nr: TT333/08.

KLEYNHANS, C.J. LOUW M.D. AND GRAHAM, M. 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical Manual). Joint Water Research Commission and Department of Water Affairs and Forestry report. TT377-08.

LÖTTER, M.C., CADMAN, M.J. AND LECHMERE-OERTEL, R.G. 2014. Mpumalanga biodiversity sector plan handbook. Mpumalanga Tourism and Parks Agency, Mbombela (Nelspruit).

MUCINA, L. AND RUTHERFORD, M.C. (eds.) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute.

MCMILAN, P.H. (1998). An Integrated Habitat Assessment System (IHAS v2) for the Rapid Biological Assessment of Rivers and Streams. A CSIR research project. Number ENV-P-I 98132 for the water resources management programme. CSIR.

THIRION, C. 2007. Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report.

Limitations

It is acknowledged that the knowledge of the aquatic specialist could be limited and there could be gaps in the information provided in this Biomonitoring report.

Findings, recommendations and conclusions provided in this report are based on the authors' best scientific and professional knowledge and information available at the time of compilation. The methods used for biomonitoring often require the author to make a predicted estimation based on prior knowledge and learning. These are however the methods as requested by the client and also accepted methods in the field of aquatic ecology.

In order to obtain a comprehensive understanding of the dynamics of the aquatic ecosystem in an area, ecological assessments should always consider investigations at different time scales (across seasons/years) and through replication, as river systems are in constant change.

Assumptions

- All information provided to ISS was accurate and up to date.
- The position of study area was accurate.

Copy right

Annexure A: Methods

A.1: Physical Habitat Assessment: The IHAS Method

The quality of the instream and riparian habitat has a direct influence on the aquatic community. Evaluating the structure and functioning of an aquatic ecosystem must therefore take into account the physical habitat to assess the ecological integrity. The IHAS sampling protocol, of which version 2 is currently used, was developed by McMillan in 1998 for use in conjunction with the SASS5 protocol to determine which habitats are present for aquatic macroinvertebrates.

IHAS consists of a scoring sheet that assists to determine the extent of each of the instream habitats, together with the physical parameter of the stream. For example, the proportion of stones in current and stones out of current will be compared with the presence of instream vegetation. This sampling protocol assists with the interpretation of the SASS5 data.

Data recorded during the site visit concerning sampling habitat and stream condition is uploaded into an excel spreadsheet. The results are then interpreted according to the categories supplied by McMillan:

IHAS SCORE	INTERPRETATION
<65%	Insufficient for supporting a diverse aquatic macro invertebrate community
65%-75%	Acceptable for supporting a diverse aquatic macroinvertebrate community
75%	Highly suitable for supporting a diverse aquatic macroinvertebrate community

A.2: Physical Habitat Assessment: The IHI Method

This model refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The assessment of habitat integrity is approached from an instream and riparian zone perspective (Kleynhans *et al.,* 2008). Both are formulated according to metric groups (such as Hydrological Modification and Bank Structure Modification). Each metric group has a number of metrics that then enable the assessment of habitat integrity based on an interpretation of deviation from the reference condition (Kleynhans *et al.,* 2008). Metrics are rated according to the following:

IMPACT/SEVERITY CLASS	DESCRIPTION	RATING
None: reference	No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity and variability is very small.	0.5-1.0
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity and variability are limited	1.5-2.0

Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity and variability. Large areas are not influenced.	2.5-3.0
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	3.5-4.0
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	4.5-5.0

The index of habitat integrity assessment is primarily concerned with the attributes of different river types and determining the weights of metrics within metric groups for both the in-stream and riparian zone. In order of consideration these are: (Kleynhans & Kemper, 2000):

- Perennial or non-perennial;
- Longitudinal geomorphic zone: Source, mountain stream, foothill and lowland; and
- River size (width): <5m, 5-15m and >15m.

The IHI takes a look at the study area holistically and categorises the in-stream habitat and the riparian zone. The in-stream-habitat is categorised according to the following components (each one is summed and expressed as a percentage):

- Hydrological modification;
- Physico-chemical modification;
- Bed modification;
- Bank modification; and
- Connectivity modification.

The Riparian zone is categorised according to three metric groups which are also weighed according to their overall impact and expressed as a percentage:

- Hydrological modification;
- Bank structure modification; and
- Riparian zone connectivity.

These two indices are then paired and comparisons are drawn in order to finally rate the study area according to the categories listed below:

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% OF TOTAL)
A	Unmodified, natural	90-100
B	Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged.	80-89

C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. The loss of natural habitat, biota and basic ecosystem function is extensive.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically/Extremely modified	0-19

A.3: Chemical Habitat Assessment: In Situ Water Quality

Water quality has a direct influence on in stream biota, and can fluctuate, depending on site-specific conditions. The biological monitoring of especially macroinvertebrates and fish thus need to be augmented with the *in situ* measurement of basic water quality indicator parameters (DWAF 1996), namely:

- **Temperature**, which plays an important role in water by affecting the rates of chemical reactions and therefore the metabolic rates of organisms. Temperature is one of the major factors controlling the distribution of aquatic organisms. The temperatures of inland waters in South Africa generally range from 5 – 30°C. Natural variations in water temperature occur in response to seasonal and diel cycles and organisms use these changes as cues for activities such as migration, emergence and spawning. Artificially-induced changes in water temperature can thus impact on individual organisms and on entire aquatic communities.

- **pH**, which gives an indication of the level of hydrogen ions in water, as calculated by the expression: $pH = -\log_{10}[H^+]$, where $[H^+]$ is the hydrogen ion concentration. The pH of pure distilled water (that is, water containing no other soluble chemicals) at a temperature of 24°C is 7.0, implying that the number of H^+ and OH^- ions are equal and the water is therefore electrochemically neutral. As the concentration of hydrogen ions increases, pH decreases and the solution becomes more acidic. As $[H^+]$ decreases, pH increases and the solution becomes more alkaline. For natural surface water systems, pH values typically range between 4 and 11, and depends on the availability of carbonate and bicarbonate, which influences the buffer capacity of the water, and which are determined by geological and atmospheric circumstances.

- **Electrical Conductivity ("EC")** is the measurement of the ease with which water conducts electricity (in milli-Siemens/meter – mS/m) and can also be used to estimate the total dissolved salts ("TDS"): EC in mS/mx 7 ≈ TDS in mg/ℓ. Changes in the EC values provide useful and rapid estimates of changes in the TDS concentration, which indicates the quantity of all compounds dissolved in the water that carry an electrical charge. Natural waters contain varying concentrations of TDS as a consequence of the dissolution of minerals in rocks, soils and decomposing plant material. TDS thus depends on the characteristics of the geological

formations which the water has been in contact with, and on physical processes such as rainfall and evaporation. Plants and animals possess a wide range of physiological mechanisms and adaptations to maintain the necessary balance of water and dissolved ions in cells and tissues. Changes in EC can affect microbial and ecological processes such as rates of metabolism and nutrient cycling. The effect on aquatic organisms depend more on the rate of change than absolute changes in concentrations of salts.

- **Dissolved Oxygen** ("DO") is the measurement of the percentage saturation of water with gaseous oxygen, which is generated by aquatic plants during photosynthesis, or which dissolved into the water from the atmosphere. Gaseous oxygen is moderately soluble in water, and the saturation solubility varies non-linearly with temperature, salinity, atmospheric pressure (and thus altitude), and other site-specific chemical and physical factors. In unpolluted surface waters, dissolved oxygen concentrations are usually close to 100% saturation. Concentrations of less than 100% saturation indicate that DO has been depleted from the theoretical equilibrium concentration. Results in excess of 100% saturation (super-saturation of oxygen) usually indicate eutrophication in a water body. Typical oxygen saturation concentrations at sea level, and at TDS values below 3,000 mg/ℓ, are at around 13 mg/ℓ (@5 °C); 10 mg/ℓ (@15 °C); and 9 mg/ℓ (@20 °C). High water temperatures combined with low dissolved oxygen levels can compound stress effects on aquatic organisms. There is a natural diel (24 hour cycle) variation in DO, associated with the 24-hour cycle of photosynthesis and respiration by aquatic biota. Concentrations decline through the night to a minimum near dawn, then rise to a maximum by mid-afternoon. Seasonal variations arise from changes in temperature and biological productivity. The maintenance of adequate DO saturation levels in water is critical for the survival and functioning of aquatic biota, because it is required for the respiration of all aerobic organisms. Therefore, the DO saturation levels provides a useful measure of the health of an aquatic ecosystem (DWAF 1996). Measuring DO is measuring a dissolved gas, and is thus best measured in situ, to prevent de-oxygenation or oxygenation during transportation.

It should be noted that the *in situ* measurement of these water quality parameters does not represent the general water quality at the sampling points or the streams. It is not a laboratory analysis of water quality, and does not measure macro anions and cations, metals or organic contaminants, nutrients or pesticides. The *in situ* measurements of these parameters provide a snapshot of the water quality at the survey site **at the time the biological samples were taken**, and thus can provide valuable insight into the characteristics at a survey site that could have an influence on the aquatic biota at that site, and at the time of conducting the sampling for biomonitoring.

In situ measurements of pH, temperature (in °C), and EC (in µS/cm) were taken by means of a calibrated hand-held instrument (Hanna - HI 991300) in the main flow of the river or stream sampled, both prior to conducting the sampling for biomonitoring as well as after the completion of conducting the sampling for biomonitoring.

The EC measurements in µS/cm were converted to mS/m (10 µS/cm = 1 mS/m) by dividing with a factor of 10.

Receiving water quality objectives ("RWQOs") based on the water quality requirements for different users, are contained in a set of documents first published by DWAF in 1993, and revised in 1996 (DWAF, 1996). These documents are collectively known as the "South African Water Quality Guidelines" ("SAWQGs") and contain guidelines for specific types of water users, namely:

- SAWQG Volume 1: Domestic Water Use
- SAWQG Volume 2: Recreational Water Use
- SAWQG Volume 3: Industrial Water Use
- SAWQG Volume 4: Agricultural Water Use: Irrigation
- SAWQG Volume 5: Agricultural Water Use: Livestock Watering
- SAWQG Volume 6: Agricultural Water Use: Aquaculture
- SAWQG Volume 7: Aquatic Ecosystems

These guidelines provide useful information on the effects of various chemical substances on water resource quality, and establish objectives for the management of the water resource based on the requirements of the different users of the water resource. The water quality requirements for protecting and maintaining the health of aquatic ecosystems differ from those of other water uses. It is difficult to determine the effects of changes in water quality on aquatic ecosystems, as the cause-effect relationships are not well understood. Therefore, water quality guidelines have to be derived indirectly through extrapolation of the known effects of water quality on a very limited number of aquatic organisms. Certain quality ranges are required to protect and maintain aquatic ecosystem health. For each constituent, guideline ranges are specified, including the No Effect Range (Target Water Quality Range or "TWQR"), Minimum Allowable Values, Acceptable Range, and, for some parameters, Intolerable levels.

The SAWQGs for aquatic ecosystems that are applicable to the *in situ* measurements of water quality, as well as additional general water quality parameter measurements are summarised below (DWAF 1996):

PARAMETER	UNIT	TARGET WATER QUALITY RANGE	MINIMUM ALLOWABLE VALUES
Temperature	°C	Should not vary from the background average daily water temperature considered to be normal for that specific site and time of day, by > 2 °C, **or** by > 10 %, whichever estimate is the more conservative	
EC	mS/m	Should not be changed by > 15 % from the normal cycles of the water body	
pH	pH units	Variation from background pH limited to <0.5 of a pH unit, or < 5%, whichever is the more conservative estimate	
DO	% saturation	80 – 120	> 60 (sub lethal) > 40 (lethal)
Suspended Solids	mg/R	Any increase in TSS concentrations must R be limited to < 10 % of the background TSS concentrations (< 100 mg/R for all aquatic ecosystems)	
Inorganic Nitrogen	mg/R	Inorganic nitrogen concentrations should not be changed by more than 15 % from that of the water body under local unimpacted conditions at any time of the year	
Inorganic Phosphorus	Fg/R	Inorganic phosphorus concentrations should not be changed by > 15 % from that of the water body under local, unimpacted conditions at any time of the year	

Data collected during the *in situ* measurements were compared against these SAWQGs for aquatic ecosystems.

The SAWQGs for domestic water use that are applicable to general water quality parameter measurements are summarised below (DWAF 1996):

PARAMETER	UNIT	TARGET WATER QUALITY RANGE	MINIMUM ALLOWABLE VALUES
Chloride	mg/R	0 - 100	200- 1200 (Salty taste; likelihood of rapid corrosion in domestic appliances) > 1 200 (disturbance of the electrolyte balance can occur)
Sulphate	mg/R as SO_4	0 - 200	200 – 400 (Tendency to develop diarrhoea in sensitive and some non-adapted individuals) 400 – 600 (Diarrhoea in most non-adapted individuals) 600 - 1 000 (Diarrhoea in most individuals) > 1 000 (Diarrhoea in all individuals)
Nitrate	mg/R	0 - 6	10 – 20 (Methaemoglobinaemia may occur in infants) > 20 (Methaemoglobinaemia occurs in infants)
Calcium	mg/R	0 - 32	32 – 80 (No health effects) > 80 (No health effects. Severe scaling problems Lathering of soap severely impaired)

A.4: Species Response: Aquatic Invertebrates & the SASS5 Method

SASS5 is a rapid bio-assessment method used to identify changes in species composition of aquatic invertebrates to indicate relative water quality (Dickens and Graham 2002). SASS5 requires the identification of invertebrates to a family level in the field.

SASS5 is based on the principle that some invertebrate taxa are more sensitive than others to pollutants. In particular, macroinvertebrate assemblages are good indicators of localized conditions in rivers. Many macroinvertebrates have limited migration patterns or are not free-moving, which makes them well-suited for assessing site specific impacts with upstream/downstream studies. Benthic macroinvertebrates are abundant in most streams. Even small streams (1st and 2nd order) which may have a limited fish population will support a diverse macroinvertebrate fauna. These groups of species constitute a broad range of trophic levels and pollution tolerances. Thus, SASS5 is a useful method for interpreting the cumulative effects of impacts on aquatic environments.

Using a 'kick net', the SASS5 sampling method entails prescribed time-periods and spatial areas for the kicking of in-current and out-current stones and bedrock; sweeping of in-current and out-current marginal and aquatic vegetation, as well as of gravel, stones and mud ("GSM"); followed by visual observations and hand-picking. The results of each biotope are kept separate, until all observations are noted. The entire sample is then returned to the river, retained alive, or preserved for further identification.

In SASS5 analysis, species abundance are recorded on an SASS5 data sheet which weighs the different taxons common to South African rivers from 1 (pollutant tolerant) to 15 (pollution sensitive). The SASS5 score will be high at a particular site if the taxa are pollution sensitive and low if they are mostly pollution tolerant.

The SASS5 Score, the number of taxa observed, and the average score per taxon ("ASPT") are calculated for all of the biotopes combined. Dallas (2007) used available SASS5 Score and ASPT values for each eco-region in South Africa to generate biological bands on standardised graphs that are used as a guideline for interpreting any data obtained during the study. The meaning of each *SASS5 Ecological Category* is as follows (Dallas 2007).

EC	ECOLOGICAL CATEGORY	DESCRIPTION
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

A.5: Species Response: Vegetation and the VEGRAI Method

Vegetation is a readily observable expression of the ecology and relationships as well as a series of interactions between the biotic organisms and their abiotic environment and hence is a physical representation of an ecosystem. **VEGRAI** is a spreadsheet model developed by the DWA (Kleynhans *et al*. 2007) for the qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitatively defensible results. In other words, it is a model which determines the response of vegetation to impacts in a way which can be defended by sound scientific methods.

VEGRAI Level 3 Analysis Diagram:
The metrics in the VEGRAI model can be used to compare an affected site with a reference condition site to give a measure of vegetative response to impacts.

The VEGRAI spreadsheet model is composed of a series of metric groups (non-woody vs. woody) and metrics (abundance, cover requirement, species composition and population structure) each of which is rated in the field. The vegetative *Ecological Category* is determined by examining the marginal, lower and upper zones of riparian vegetation and evaluating the metrics for the following metric groups in each zone:

- Non-woody vegetation in terms of cover, abundance and species composition; and
- Woody vegetation in terms of cover, abundance, species composition and population structure.

In a VEGRAI level 3 analysis, the riparian zone is divided into only marginal and non-marginal zones. The marginal zone includes vegetation of the area from the water level at low or basal flow, if present

to those features that are hydrologically activated for the greater part of the year. The non-marginal zone is subdivided into the lower and upper zones.
The lower zone consist of geomorphic features that are hydrologically activated on a seasonal basis either yearly during high flow periods or every two to three years. The lower zone extends from the marginal zone and ends where a marked increase in lateral elevation occurs. The upper zone extends from the lower zone to the end of the riparian corridor.

The upper zone consists of geomorphic features that are hydrologically activated on an ephemeral basis, less than every 3 years. The vegetative composition of the upper zone comprises of both terrestrial and riparian species (Kleynhans *et al.* 2007).

The **VEGRAI sampling methodology** entails the following:

- Gather an overview of the section of the river at the selected monitoring station by walking up and downstream, observing general characteristics, flow, geomorphic morphology, substrata, elevation, vegetation structure and species as well as any impacts on these features;
- Take photographs of features, both up and downstream, as well as of the non-marginal vegetation;
- Compile a list of key/indicator/dominant species that are observed, indicating in which zone the species occur and whether it is an exotic species;
- Assess the vegetation observed, and divide the vegetation into woody and non-woody components;
- Estimate the relative proportion, as well as abundance, of vegetative cover;
- If exotic species are present, estimate the proportion of exotic species cover present on site.

If two sides of a river bank are markedly different in respect of these aspects, each river bank should be treated as a separate site.

Data is interpreted with the VEGRAI spreadsheet model, and the results are used to establish the *VEGRAI Ecological Category*. VEGRAI ecological category is determined based on the following (Kleynhans *et al.,* 2007).

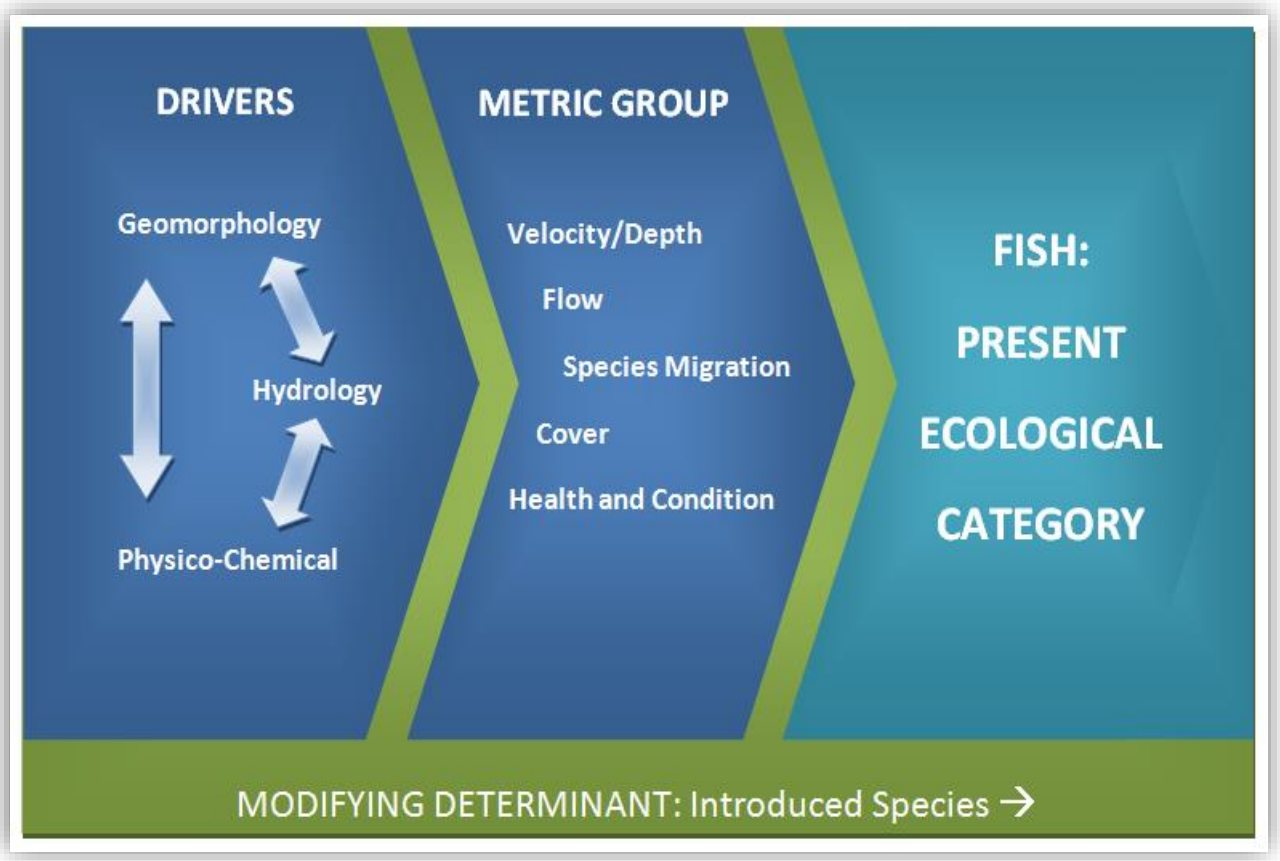
ECOLOGICAL CATEGORY	DESCRIPTION OF SCORE	PERCENTAGE OF TOTAL
A	Unmodified, natural	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In	0-19

	the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	

A.6: Species Response: Fish and the FRAI Method

Fish are good indicators of long-term (several years) effects and broad habitat conditions, and changes in the available habitat conditions (Karr 1981). This is because fish are "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). Fish bioaccumulate the effects of anthropogenic activities on lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health.

FRAI is a rule-based model recently developed by DWA (Kleynhans 2007) and is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers. Intolerance and preference attributes are categorized into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species. Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation and to determine the *Present Ecological Category* ("PEC") of the fish assemblage.



Fish Present Ecological Category Diagram
*Fish **Present Ecological Category** is determined by an interaction of the ecological drivers and metric groups with the major determining factor being species not native to the system.*

The purpose of FRAI is to provide a habitat-based and cause-effect evaluation to interpret the deviation of the assemblage to the reference condition. 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

Fish are sampled using a 10 mm-mesh scoop-net connected to a SAMUS 725MP electrofisher. Electrofishing shocking is highly effective and entails the use of an electronic device to rapidly catch fish in wadeable sections of a river or stream.

The sampling of fish by using an electrofisher 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 are identified and anomalies and general age structure will be recorded. Sampling should be kept to about 60 minutes.

Collected data is interpreted in the FRAI spreadsheet model, and the results are used to establish the FRAI Ecological Category.

Fish habitat is evaluated against the following parameters:

- velocity depth classes,
- cover,
- flow modifications,
- physico-chemical conditions,
- constraints on migration upstream.

The FRAI spreadsheet model also measures the effect of introduced fish species to the system.

A.6.1: Expected Fish Species List

An expected fish species list for the SQR was obtained from the following sources: Skelton (2001) and DWS (2014).

Based on the sources mentioned above, 25 fish species are expected to occur in quaternary catchments X24B-0928 and X24C-0978. However, it should be noted that these expected species lists are compiled on a quaternary catchment basis and that it would be very unlikely to collect all these species at every site with habitat availability being the primary determinant. Therefore, the list was assessed and redacted to a list of 14 species that could be expected in the project area based on their specific habitat preferences and the types of habitats observed in the project area during the March 2018 survey. The list of expected fish species is provided in Table 20. Table 20 should be viewed as a list of potential species rather than an expected species list.

No introduced or alien invasive fish species are expected to occur in the project area.

Table 20: Fish species that may potentially occur in the project area, their IUCN status and their preferred habitat (DWS, 2014; IUCN, 2018; Skelton, 2001)

Species	Common Name	IUCN (2018)	Habitat preferences (IUCN, 2018; Skelton, 2001)
Anguilla mossambica	Longfin eel	LC	Demersal, catadromous eel. Spending the majority of its life in both quiet and fast flowing freshwater, brackish and coastal habitat,
Clarias gariepinus	Sharptooth catfish	LC	Wide range of habitats
Coptodon rendalli	Redbreast tilapia	LC	Prefers quiet, well-vegetated water along river littorals or backwaters, floodplains and swamps
Enteromius annectens	Broadstriped barb	LC	Prefers slower flowing, often vegetated sections of rivers and streams.
Enteromius eutaenia	Orangefin barb	DD	Small streams and tributaries
Enteromius paludinosus	Straightfin barb	LC	Hardy species, preferring quiet, well-vegetated waters in lakes, and marshes or marginal areas of larger rivers and slow-flowing streams
Enteromius toppini	Eastcoast barb	LC	Common in quiet streams
Enteromius trimaculatus	Threespot barb	LC	Commonly occurs in a wide variety of habitats, especially where there is vegetation.
Enteromius viviparus	Bowstripe barb	LC	Quiet, usually vegetated sections of rivers and lakes in the low-veld, coastal plains
Labeo cylindricus	Redeyed labeo	LC	Favours clear, running waters in rocky habitats of small and large rivers
Mesobola brevianalis	River sardine	LC	It prefers well-aerated, open water of flowing rivers
Micralestes acutidens	Silver robber	LC	Common in water with fringing vegetation
Oreochromis mossambicus	Mozambique tilapia	NT	Occurs in all but fast-flowing waters; thrives in standing waters
Pseudocrenilabrus philander	Southern mouthbrooder	Unlisted	Marginal vegetation in streams and rivers
Number of expected fish species			**14**

A.6.2: Presence of Species of Conservation Importance

The conservation statuses of the indigenous fish species were assessed in terms of the IUCN Red List of Threatened Species (IUCN, 2018). Based on this assessment 1 fish species of conservation concern was expected to occur in the project area namely *Oreochromis mossambicus* (Mozambique tilapia). *Oreochromis mossambicus* is listed as Near Threatened (NT) in the IUCN Red List (2018) due to the threat of hybridization with the closely related introduced fish species *Oreochromis niloticus* (Nile tilapia). *Oreochromis niloticus* has been introduced into southern Africa by the aquaculture industry and escapees from these facilities now threaten the genetic purity of *O. mossambicus*. Hybrids between these 2 species have been recorded in the northern portion of *O. mossambicus'* distribution including the Zambezi and portions of the Limpopo catchment.

A.6.3: Fish Response Assessment Index (FRAI)

The FRAI 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 (Kleynhans, 2007) (Figure 16).

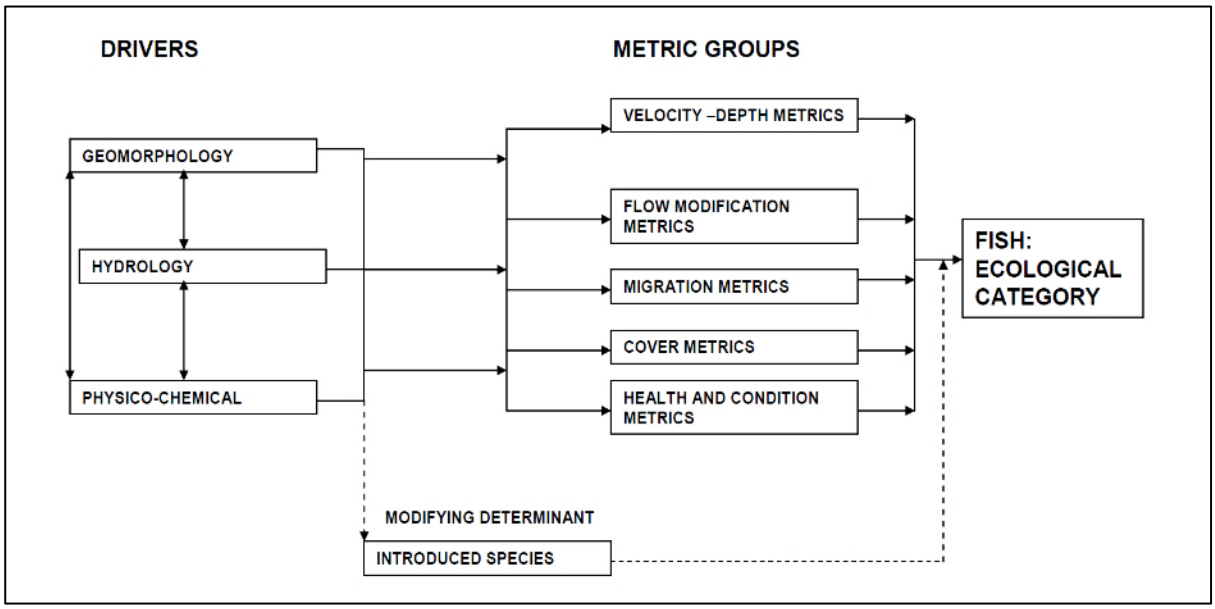


Figure 16: The relationship between drivers and fish metric groups (Kleynhans, 2007)

The steps and procedures for calculation of the Present Ecological State (PES) based on the FRAI are presented in Table 21 below.

Table 21: Steps and procedures for calculation of Present Ecological State (PES) based on FRAI

STEP	PROCEDURE
	Use historical data & expert knowledge
	Model: use ecoregional and other environmental information

Determine reference fish assemblage: species and frequency of occurrence	Use expert fish reference frequency of occurrence database if available
Determine present state for drivers	Hydrology
	Physico-chemical
	Geomorphology
	Index of habitat integrity
Select representative sampling sites	Field survey in combination with other survey activities
Determine fish habitat condition at site	Assess fish habitat potential
	Assess fish habitat condition
Representative fish sampling at site or in river section	Sample all velocity depth classes per site if feasible
	Sample at least three stream sections per site
Collate and analyse fish sampling data per site	Transform fish sampling data to frequency of occurrence ratings
Execute FRAI model	Rate the FRAI metrics in each metric group
	Enter species reference frequency of occurrence data
	Enter species observed frequency of occurrence data
	Determine weights for the metric groups
	Obtain FRAI value and category
	Present both modelled FRAI & adjusted FRAI.

The purpose of the FRAI is to provide a habitat-based cause-and-effect underpinning to interpret the deviation of the fish assemblage from the reference condition (Kleynhans, 2007). The interpretation of the FRAI results is based on the habitat integrity classes defined by Kleynhans (1996) and can be seen in Table 22. Each class gives a description of generally expected conditions for a specific FRAI class.

Table 22: Descriptions of conditions associated with specific FRAI classes

CLASS	DESCRIPTION
A	Unmodified, or approximate natural conditions closely
B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification.
C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class.
D	Largely modified. A clearly lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class.
E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become evident.
F	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a complete loss of species at the lower limit of the class. Impairment of health generally very evident.

Annexure B: Results –Water Quality

The chemical characteristics were determined by the *in situ* measurement of temperature, pH, Electrical Conductivity and Dissolved Oxygen at each sampling point, and the results are summarised below.

Comparison of *in situ* water quality results for the 2018 wet season aquatic assessment

SAMPLING POINT	NK2	NK3	NK4	NK5	NK6	NK7	NK8	NK9	NK10
IHAS Score	NA	NA	NA	52%	77%	76%	69%		
IHAS Class description	NA	NA	NA	Unsuitable	Highly suitable	Highly suitable	Suitable	Suitable	Suitable
Visual appearance of water prior to sampling	Clear	Clear	Clear	Brown	Clear	Clear	Opaque	Clear	Clear
Date	2018/03/01	2018/03/01	2018/03/02	2018/03/02	2018/03/02	2018/03/03	2018/03/03	2018/03/03	2018/03/03
Time (hh:mm)	17:42	16:57	16:36	12:39	10:16	11:02	14:40	9:01	12:31
Temperature (°C)	26.9	29.1	30.2	28.5	27.0	24.9	23.6	21.5	25.6
pH	**5.79**	6.59	**5.88**	7.05	7.69	8.01	7.48	7.94	7.72
EC (mS/m)	16.8	27.7	23.2	9.9	61.8	58.4	51.2	60.1	44
DO (%)	**15.2**	**46.1**	**50.2**	72	96.3	97	84	111.3	98.1

Additional water quality parameter results were obtained by Waterlab. Faecal coliforms and *E. coli* results were obtained from Bokamoso Environmental Consultants. The results are summarised below:

General water quality results for the 2018 wet season aquatic assessment

SAMPLING POINT	NK7 (DOWNSTREAM)	NK9 (UPSTREAM)
pH – value at 25°C	8	8.4
Electrical Conductivity in mS/m at 25°C	69.1	69.3
Suspended Solids at 105°C	72	5.6
Total Alkalinity as $CaCO_3$	220	220
Chloride as Cl	71	71
Sulphate as SO_4	57	59
Nitrate as N	1.0	1.4
Ortho Phosphate as P	<0.1	<0.1
Calcium as Ca	**46**	**46**
Faecal Coliforms	2419.6	2419.6
E. coli	**613.1**	**1732.9**

Annexure C: IHAS Score Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK5**					
Date: 2018/03/02	version 2.2 peter mac 1/2001					
SCORE	0	1	2	3	4	5
SAMPLING HABITAT						
Stones in current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	**none**	0-1	>1-2	*>2-3*	>3-5	>5
Total length of submerged stones in current (run) (in metres)	**none**	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	**1**	2-3	4-5	6+	
Average stone size's kicked (cm's)(<2 or >20 is '<2>20')(gravel is <2; bedrock is >20)	none	<2>20	**2-10**	11-20	2-20	
Amount of stone surface clear (of algae, sediment etc.) (in percent %)*	n/a	**0-25**	26-50	51-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes)(gravel/bedrock = 0 min)	0	<1	>1-2	**2**	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC SCORE (Max. 20)					**7**	
Vegetation						
Length of fringing vegetation sampled (river banks) (PROTOCOL - in metres)	none	0-½	>½-1	>1-2	**2**	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	none	**0-½**	>½-1	>1		
Fringing vegetation sampled in: ('still'=pool/still water only; 'run'=run only)	none		run	**still**		mix
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49%)	none		1-25	**26-50**	51-75	>75
VEGETATION SCORE (Max. 15)					**11**	
Other Habitat/General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	**0-½**	>½-1	1	>1	
Sand sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	**0-½**	>½-1	1	>1
Mud sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	0-½	½	**>½**	
Gravel sampled: (PROTOCOL – in minutes) (if all gravel, SIC stone size = '<2')**	none	**0-½**	½	>½**		
Bedrock sampled: ('all'=no SIC, sand, or gravel; then SIC stone size ='>20')**	**none**	some			all**	
Algal presence: ('1-2m²'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m²	**rocks**	1-2m²	<1m²	isol.	none
Tray identification: (PROTOCOL – using time: 'corr' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
OTHER HABITAT SCORE (Max.20)					**12**	
HABITAT TOTAL (Max. 55)					**30**	
STREAM CONDITION						
Physical						
River make up: ('pool'=pool/still/dam only; 'run' only; 'rapid' only; '2mix'=2 types etc.)	**pool**		run	rapid	2 mix	3 mix
Average width of stream: (metres)		>10	>5-10	<1	**1-2**	>2-5
Average depth of stream: (metres)	>1	1	>½-1	**½**	<½-¼	<¼
Approximate velocity of stream: ('slow'=<½m/s; 'fast'=>1m/s) (use twig etc. to test).	**still**	slow	fast	med.		mix
Water colour: ('disc.'=discoloured with visible colour but still transparent)	**silty**	opaque		disc.		clear
Recent disturbances due to: ('constr.'=construction; 'fl/dr'=flood or drought) ***	fl/dr	fire	constr.	**other**		none
Bank / riparian vegetation is: ('grass'=includes reeds; 'shrubs'=includes trees)	none		grass	shrubs	**mix**	
Surrounding impacts: ('erosn'=erosion/shear bank; 'farm'=farmland/settlement)***.	erosn.	farm	trees	**other**		open
Left bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
Right bank cover (rocks and vegetation): (in percent %)	0-50	51-75	75-95	**>95**		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (Max. 45)					**22**	
TOTAL IHAS SCORE					**52 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK6**					
Date: 2018/03/02	version 2.2 peter mac 1/2001					
SCORE	0	1	2	3	4	5
SAMPLING HABITAT						
Stones in current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	none	0-1	**>1-2**	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	>2-5	**>5-10**	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	**6+**	
Average stone size's kicked (cm's)(<2 or >20 is '<2>20')(gravel is <2; bedrock is >20)	none	<2>20	2-10	11-20	**2-20**	
Amount of stone surface clear (of algae, sediment etc.) (in percent %)*	n/a	**0-25**	26-50	51-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes)(gravel/bedrock = 0 min)	0	<1	>1-2	**2**	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC SCORE (Max. 20)					**17**	
Vegetation						
Length of fringing vegetation sampled (river banks) (PROTOCOL - in metres)	none	0-½	>½-1	>1-2	**2**	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	none	0-½	**>½-1**	>1		
Fringing vegetation sampled in: ('still'=pool/still water only; 'run'=run only)	none		run	still		**mix**
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49%)	none		**1-25**	26-50	51-75	>75
VEGETATION SCORE (Max. 15)					**13**	
Other Habitat/General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	0-½	**>½-1**	1	>1	
Sand sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	0-½	**>½-1**	1	>1
Mud sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	**under**	0-½	½	>½	
Gravel sampled: (PROTOCOL – in minutes) (if all gravel, SIC stone size = '<2')**	none	0-½	½	**>½****		
Bedrock sampled: ('all'=no SIC, sand, or gravel; then SIC stone size ='>20')**	none	some			**all****	
Algal presence: ('1-2m²'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m²	**rocks**	1-2m²	<1m²	isol.	none
Tray identification: (PROTOCOL – using time: 'corr' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
OTHER HABITAT SCORE (Max.20)					**17**	
HABITAT TOTAL (Max. 55)					**47**	
STREAM CONDITION						
Physical						
River make up: ('pool'=pool/still/dam only; 'run' only; 'rapid' only; '2mix'=2 types etc.)	pool		run	rapid	2 mix	**3 mix**
Average width of stream: (metres)		>10	>5-10	<1	**1-2**	>2-5
Average depth of stream: (metres)	>1	1	**>½-1**	½	<½-¼	<¼
Approximate velocity of stream: ('slow'=<½m/s; 'fast'=>1m/s) (use twig etc. to test).	still	slow	fast	med.		**mix**
Water colour: ('disc.'=discoloured with visible colour but still transparent)	silty	opaque		disc.		**clear**
Recent disturbances due to: ('constr.'=construction; 'fl/dr'=flood or drought) ***	**fl/dr**	fire	constr.	other		none
Bank / riparian vegetation is: ('grass'=includes reeds; 'shrubs'=includes trees)	none		grass	shrubs	**mix**	
Surrounding impacts: ('erosn'=erosion/shear bank; 'farm'=farmland/settlement)***.	erosn.	**farm**	trees	other		open
Left bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
Right bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (Max. 45)					**30**	
TOTAL IHAS SCORE					**77 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK7**					
Date: 2018/03/03	version 2.2 peter mac 1/2001					
SCORE	0	1	2	3	4	5
SAMPLING HABITAT						
Stones in current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	none	**0-1**	>1-2	*>2-3*	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	>2-5	**>5-10**	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	**4-5**	6+	
Average stone size's kicked (cm's)(<2 or >20 is '<2>20')(gravel is <2; bedrock is >20)	none	<2>20	2-10	11-20	**2-20**	
Amount of stone surface clear (of algae, sediment etc.) (in percent %)*	n/a	0-25	**26-50**	51-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes)(gravel/bedrock = 0 min)	0	<1	>1-2	**2**	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC SCORE (Max. 20)					**16**	
Vegetation						
Length of fringing vegetation sampled (river banks) (PROTOCOL - in metres)	none	0-½	>½-1	>1-2	**2**	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	**none**	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still'=pool/still water only; 'run'=run only)	none		run	still		**mix**
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49%)	none		1-25	**26-50**	51-75	>75
VEGETATION SCORE (Max. 15)					**12**	
Other Habitat/General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	0-½	>½-1	**1**	>1	
Sand sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	0-½	**>½-1**	1	>1
Mud sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	**under**	0-½	½	>½	
Gravel sampled: (PROTOCOL – in minutes) (if all gravel, SIC stone size = '<2')**	none	0-½	**½**	>½**		
Bedrock sampled: ('all'=no SIC, sand, or gravel; then SIC stone size ='>20')**	none	**some**			all**	
Algal presence: ('1-2m²'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m²	**rocks**	1-2m²	<1m²	isol.	none
Tray identification: (PROTOCOL – using time: 'corr' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
OTHER HABITAT SCORE (Max.20)					**14**	
HABITAT TOTAL (Max. 55)					**42**	
STREAM CONDITION						
Physical						
River make up: ('pool'=pool/still/dam only; 'run' only; 'rapid' only; '2mix'=2 types etc.)	pool		run	rapid	2 mix	**3 mix**
Average width of stream: (metres)		>10	>5-10	<1	1-2	**>2-5**
Average depth of stream: (metres)	>1	1	**>½-1**	½	<½-¼	<¼
Approximate velocity of stream: ('slow'=<½m/s; 'fast'=>1m/s) (use twig etc. to test).	still	slow	fast	med.		**mix**
Water colour: ('disc.'=discoloured with visible colour but still transparent)	silty	opaque		disc.		**clear**
Recent disturbances due to: ('constr.'=construction; 'fl/dr'=flood or drought) ***	**fl/dr**	fire	constr.	other		none
Bank / riparian vegetation is: ('grass'=includes reeds; 'shrubs'=includes trees)	none		grass	shrubs	**mix**	
Surrounding impacts: ('erosn'=erosion/shear bank; 'farm'=farmland/settlement)***.	erosn.	farm	**trees**	other		open
Left bank cover (rocks and vegetation): (in percent %)	0-50	51-75	75-95	**>95**		
Right bank cover (rocks and vegetation): (in percent %)	0-50	51-75	75-95	**>95**		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (Max. 45)					**34**	
TOTAL IHAS SCORE					**76 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK8**					
Date: 2018/03/02	version 2.2 peter mac 1/2001					
SCORE	0	1	2	3	4	5
SAMPLING HABITAT						
Stones in current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	none	**0-1**	>1-2	*>2-3*	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	**>2-5**	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	**2-3**	4-5	6+	
Average stone size's kicked (cm's)(<2 or >20 is '<2>20')(gravel is <2; bedrock is >20)	none	<2>20	**2-10**	11-20	2-20	
Amount of stone surface clear (of algae, sediment etc.) (in percent %)*	n/a	**0-25**	26-50	51-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes)(gravel/bedrock = 0 min)	0	<1	>1-2	**2**	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC SCORE (Max. 20)					**11**	
Vegetation						
Length of fringing vegetation sampled (river banks) (PROTOCOL - in metres)	none	0-½	>½-1	**>1-2**	2	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	**none**	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still'=pool/still water only; 'run'=run only)	none		**run**	still		mix
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49%)	none		**1-25**	26-50	51-75	>75
VEGETATION SCORE (Max. 15)					**7**	
Other Habitat/General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	**0-½**	>½-1	1	>1	
Sand sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	0-½	**>½-1**	1	>1
Mud sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	**under**	0-½	½	>½	
Gravel sampled: (PROTOCOL – in minutes) (if all gravel, SIC stone size = '<2')**	none	0-½	½	**>½****		
Bedrock sampled: ('all'=no SIC, sand, or gravel; then SIC stone size ='>20')**	none	**some**			all**	
Algal presence: ('1-2m²'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m²	rocks	1-2m²	<1m²	**isol.**	none
Tray identification: (PROTOCOL – using time: 'corr' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
OTHER HABITAT SCORE (Max.20)					**16**	
HABITAT TOTAL (Max. 55)					**34**	
STREAM CONDITION						
Physical						
River make up: ('pool'=pool/still/dam only; 'run' only; 'rapid' only; '2mix'=2 types etc.)	pool		run	rapid	**2 mix**	3 mix
Average width of stream: (metres)		>10	>5-10	<1	1-2	**>2-5**
Average depth of stream: (metres)	>1	1	>½-1	½	<½-¼	**<¼**
Approximate velocity of stream: ('slow'=<½m/s; 'fast'=>1m/s) (use twig etc. to test).	still	slow	fast	med.		**mix**
Water colour: ('disc.'=discoloured with visible colour but still transparent)	silty	**opaque**		disc.		clear
Recent disturbances due to: ('constr.'=construction; 'fl/dr'=flood or drought) ***	fl/dr	fire	constr.	**other**		none
Bank / riparian vegetation is: ('grass'=includes reeds; 'shrubs'=includes trees)	none		grass	shrubs	**mix**	
Surrounding impacts: ('erosn'=erosion/shear bank; 'farm'=farmland/settlement)***.	erosn.	farm	trees	**other**		open
Left bank cover (rocks and vegetation): (in percent %)	0-50	51-75	75-95	**>95**		
Right bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (Max. 45)					**35**	
TOTAL IHAS SCORE					**69 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK9**					
Date: 2018/03/03	version 2.2 peter mac 1/2001					
SCORE	0	1	2	3	4	5
SAMPLING HABITAT						
Stones in current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	none	0-1	**>1-2**	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	**>2-5**	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	**4-5**	6+	
Average stone size's kicked (cm's)(<2 or >20 is '<2>20')(gravel is <2; bedrock is >20)	none	<2>20	2-10	11-20	**2-20**	
Amount of stone surface clear (of algae, sediment etc.) (in percent %)*	n/a	**0-25**	26-50	51-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes)(gravel/bedrock = 0 min)	0	<1	>1-2	**2**	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC SCORE (Max. 20)					**15**	
Vegetation						
Length of fringing vegetation sampled (river banks) (PROTOCOL - in metres)	none	0-½	>½-1	>1-2	**2**	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	none	**0-½**	>½-1	>1		
Fringing vegetation sampled in: ('still'=pool/still water only; 'run'=run only)	none		run	still		**mix**
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49%)	none		**1-25**	26-50	51-75	>75
VEGETATION SCORE (Max. 15)					**12**	
Other Habitat/General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	0-½	>½-1	**1**	>1	
Sand sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	0-½	**>½-1**	1	>1
Mud sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	**0-½**	½	>½	
Gravel sampled: (PROTOCOL – in minutes) (if all gravel, SIC stone size = '<2')**	none	0-½	**½**	>½**		
Bedrock sampled: ('all'=no SIC, sand, or gravel; then SIC stone size ='>20')**	**none**	some			all**	
Algal presence: ('1-2m²'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m²	**rocks**	1-2m²	<1m²	isol.	none
Tray identification: (PROTOCOL – using time: 'corr' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
OTHER HABITAT SCORE (Max.20)					**14**	
HABITAT TOTAL (Max. 55)					**41**	
STREAM CONDITION						
Physical						
River make up: ('pool'=pool/still/dam only; 'run' only; 'rapid' only; '2mix'=2 types etc.)	pool		run	rapid	2 mix	**3 mix**
Average width of stream: (metres)		>10	>5-10	<1	**1-2**	>2-5
Average depth of stream: (metres)	>1	1	>½-1	½	**<½-¼**	<¼
Approximate velocity of stream: ('slow'=<½m/s; 'fast'=>1m/s) (use twig etc. to test).	still	slow	fast	med.		**mix**
Water colour: ('disc.'=discoloured with visible colour but still transparent)	**silty**	opaque		disc.		clear
Recent disturbances due to: ('constr.'=construction; 'fl/dr'=flood or drought) ***	fl/dr	fire	constr.	**other**		none
Bank / riparian vegetation is: ('grass'=includes reeds; 'shrubs'=includes trees)	none		grass	shrubs	**mix**	
Surrounding impacts: ('erosn'=erosion/shear bank; 'farm'=farmland/settlement)***.	erosn.	farm	trees	**other**		open
Left bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
Right bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (Max. 45)					**32**	
TOTAL IHAS SCORE					**73 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK10**					
Date: 2018/03/01	version 2.2 peter mac 1/2001					
SCORE	0	1	2	3	4	5
SAMPLING HABITAT						
Stones in current (SIC)						
Total length of white water rapids (ie: bubbling water) (in metres)	**none**	0-1	>1-2	*>2-3*	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	**>2-5**	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	**6+**	
Average stone size's kicked (cm's)(<2 or >20 is '<2>20')(gravel is <2; bedrock is >20)	none	<2>20	2-10	11-20	**2-20**	
Amount of stone surface clear (of algae, sediment etc.) (in percent %)*	n/a	**0-25**	26-50	51-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes)(gravel/bedrock = 0 min)	0	<1	>1-2	**2**	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
SIC SCORE (Max. 20)					**14**	
Vegetation						
Length of fringing vegetation sampled (river banks) (PROTOCOL - in metres)	none	0-½	>½-1	>1-2	**2**	>2
Amount of aquatic vegetation/algae sampled (underwater) (in square metres)	**none**	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still'=pool/still water only; 'run'=run only)	none		run	still		**mix**
Type of veg. (percent leafy veg. as opposed to stems/shoots) (aq. veg. only=49%)	none		1-25	26-50	**51-75**	>75
VEGETATION SCORE (Max. 15)					**13**	
Other Habitat/General						
Stones Out Of Current (SOOC) sampled: (PROTOCOL - in square metres)	none	**0-½**	>½-1	1	>1	
Sand sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	under	**0-½**	>½-1	1	>1
Mud sampled: (PROTOCOL – in minutes) ('under' = present, but only under stones)	none	**under**	0-½	½	>½	
Gravel sampled: (PROTOCOL – in minutes) (if all gravel, SIC stone size = '<2')**	none	0-½	½	**>½****		
Bedrock sampled: ('all'=no SIC, sand, or gravel; then SIC stone size ='>20')**	**none**	some			all**	
Algal presence: ('1-2m²'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	**>2m²**	rocks	1-2m²	<1m²	isol.	none
Tray identification: (PROTOCOL – using time: 'corr' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
OTHER HABITAT SCORE (Max.20)					**10**	
HABITAT TOTAL (Max. 55)					**37**	
STREAM CONDITION						
Physical						
River make up: ('pool'=pool/still/dam only; 'run' only; 'rapid' only; '2mix'=2 types etc.)	pool		run	rapid	2 mix	**3 mix**
Average width of stream: (metres)		>10	>5-10	<1	**1-2**	>2-5
Average depth of stream: (metres)	>1	1	>½-1	½	**<½-¼**	<¼
Approximate velocity of stream: ('slow'=<½m/s; 'fast'=>1m/s) (use twig etc. to test).	still	slow	fast	**med.**		mix
Water colour: ('disc.'=discoloured with visible colour but still transparent)	silty	opaque		disc.		**clear**
Recent disturbances due to: ('constr.'=construction; 'fl/dr'=flood or drought) ***	fl/dr	fire	constr.	**other**		none
Bank / riparian vegetation is: ('grass'=includes reeds; 'shrubs'=includes trees)	none		grass	shrubs	**mix**	
Surrounding impacts: ('erosn'=erosion/shear bank; 'farm'=farmland/settlement)***.	**erosn.**	farm	trees	other		open
Left bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
Right bank cover (rocks and vegetation): (in percent %)	0-50	51-75	**75-95**	>95		
(*** NOTE: if more than one option, choose the lowest)						
STREAM CONDITIONS TOTAL (Max. 45)					**32**	
TOTAL IHAS SCORE					**69 %**	

Annexure D: SASS Version 5 Score Sheets

SASS5 sampling sheet for Sampling Point: NK5

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3				
ANNELIDA						
Oligochaeta	Earthworms	1				
Hirudinea	Leeches	3				
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3				
Atyidae	Freshwater Shrimps	8				
Palaemonidae	Freshwater Prawns	10				
HYDRACARINA	Mites	8				
PLECOPTERA	Stoneflies					
Notonemouridae		14				
Perlidae		12				
EPHEMEROPTERA	Mayflies					
Baetidae 1sp		4		A		
Baetidae 2 sp		6			A	A
Baetidae > 2 sp		12				
Caenidae	Squaregills/Cainfles	6			A	A
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9				
Oligoneuridae	Brushlegged mayflies	15				
Polymitarcyidae	Pale Burrowers	10				
Prosopistomatidae	Water specs	15				
Teloganodidae SWC	Spiny Crawlers	12				
Tricorythidae	Stout Crawlers	9				
ODONATA	Dragonflies & Damselflies					
Calopterygidae ST,T	Demoiselles	10				
Chlorocyphidae	Jewels	10				
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4		A	A	B
Lestidae	Emerald Damselflies/Spreadwings	8				
Platycnemidae	Stream Damselflies	10				
Protoneuridae	Threadwings	8				
Aeshnidae	Hawkers & Emperors	8				
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6		A		A
Libellulidae	Darters/Skimmers	4	1		1	A
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3				
*Corixidae**	Water boatmen	3	A	1	A	A
*Gerridae**	Pond skaters/Water striders	5		A		A
*Hydrometridae**	Water measurers	6			A	A
*Naucoridae**	Creeping water bugs	7				
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		1	A	A
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5		A		A
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8				
Hydropsychidae 1 sp		4				
Hydropsychidae 2 sp		6				
Hydropsychidae > 2 sp		12				
Philopotamidae		10				
Polycentropodidae		12				
Psychomyiidae/Xiphocentronidae		8				
Cased caddis:						
Barbarochthonidae SWC		13				
Calamoceratidae ST		11				
Glossosomatidae SWC		11				
Hydroptilidae		6				
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6		1		1
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5		A		A
*Elmidae/Dryopidae**	Riffle beetles	8				
*Gyrinidae**	Whirligig beetles	5				
*Haliplidae**	Crawling water beetles	5				
Helodidae	Marsh beetles	12				
*Hydraenidae**	Minute moss beetles	8				
*Hydrophilidae**	Water scavenger beetles	5		A	A	A
Limnichidae	Marsh-Loving Beetles	10				
Psephenidae	Water Pennies	10				

TAXON		QV	S	VEG	GSM	TOTAL
DIPTERA	Flies					
Athericidae	Snipe flies	10				
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5				
Chironomidae	Midges	2		A	1	A
*Culicidae**	Mosquitoes	1		1	1	A
*Dixidae**	Dixid midge	10				
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5				
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5				
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6				
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3				
*Planorbinae**	Orb snails	3				
Thiaridae =Melanidae*		3				
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					66
	No. of Taxa					15
	ASPT					4.4

1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000

Other biota:
Tadpoles in GSM

Comments/Observations:

SASS5 sampling sheet for Sampling Point: NK6

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3	A			A
ANNELIDA						
Oligochaeta	Earthworms	1				
Hirudinea	Leeches	3				
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3				
Atyidae	Freshwater Shrimps	8				
Palaemonidae	Freshwater Prawns	10				
HYDRACARINA	Mites	8				
PLECOPTERA	Stoneflies					
Notonemouridae		14				
Perlidae		12				
EPHEMEROPTERA	Mayflies					
Baetidae 1sp		4	A			
Baetidae 2 sp		6		B	B	
Baetidae > 2 sp		12				B
Caenidae	Squaregills/Cainfles	6	B	A	A	B
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9				
Oligoneuridae	Brushlegged mayflies	15				
Polymitarcyidae	Pale Burrowers	10				
Prosopistomatidae	Water specs	15				
Teloganodidae SWC	Spiny Crawlers	12				
Tricorythidae	Stout Crawlers	9				
ODONATA	Dragonflies & Damselflies					
Calopterygidae ST,T	Demoiselles	10				
Chlorocyphidae	Jewels	10				
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4		B		B
Lestidae	Emerald Damselflies/Spreadwings	8				
Platycnemidae	Stream Damselflies	10				
Protoneuridae	Threadwings	8				
Aeshnidae	Hawkers & Emperors	8				
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6	A	A	B	B
Libellulidae	Darters/Skimmers	4	1			1
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3		A		A
*Corixidae**	Water boatmen	3				
*Gerridae**	Pond skaters/Water striders	5				
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7			1	1
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		A	1	A
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5		A		A
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8	A			A
Hydropsychidae 1 sp		4	B			B
Hydropsychidae 2 sp		6				
Hydropsychidae > 2 sp		12				
Philopotamidae		10	A			A
Polycentropodidae		12				
Psychomyiidae/Xiphocentronidae		8				
Cased caddis:						
Barbarochthonidae SWC		13				
Calamoceratidae ST		11				
Glossosomatidae SWC		11				
Hydroptilidae		6	1	A		A
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6		A		A
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5				
*Elmidae/Dryopidae**	Riffle beetles	8	A		1	A
*Gyrinidae**	Whirligig beetles	5				
*Haliplidae**	Crawling water beetles	5				
Helodidae	Marsh beetles	12				
*Hydraenidae**	Minute moss beetles	8				
*Hydrophilidae**	Water scavenger beetles	5				
Limnichidae	Marsh-Loving Beetles	10				
Psephenidae	Water Pennies	10				

TAXON		QV	S	VEG	GSM	TOTAL
DIPTERA	Flies					
Athericidae	Snipe flies	10			1	1
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5			1	1
Chironomidae	Midges	2	B	A	1	B
*Culicidae**	Mosquitoes	1				
*Dixidae**	Dixid midge	10				
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5	1	B		B
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5				
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6	1			1
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3				
*Planorbinae**	Orb snails	3		A	1	A
Thiaridae =Melanidae*		3	A	B	C	C
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					128
	No. of Taxa					23
	ASPT					5.565

1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000

Other biota:

Comments/Observations:

SASS5 sampling sheet for Sampling Point: NK7

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3				
ANNELIDA						
Oligochaeta	Earthworms	1	1		A	A
Hirudinea	Leeches	3			1	1
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3	1	A		A
Atyidae	Freshwater Shrimps	8				
Palaemonidae	Freshwater Prawns	10				
HYDRACARINA	Mites	8				
PLECOPTERA	Stoneflies					
Notonemouridae		14				
Perlidae		12				
EPHEMEROPTERA	Mayflies					
Baetidae 1sp		4				
Baetidae 2 sp		6			A	
Baetidae > 2 sp		12	1	A		B
Caenidae	Squaregills/Cainfles	6		A	A	B
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9				
Oligoneuridae	Brushlegged mayflies	15				
Polymitarcyidae	Pale Burrowers	10				
Prosopistomatidae	Water specs	15				
Teloganodidae SWC	Spiny Crawlers	12				
Tricorythidae	Stout Crawlers	9				
ODONATA	Dragonflies & Damselflies					
Calopterygidae ST,T	Demoiselles	10				
Chlorocyphidae	Jewels	10				
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4	1	B	A	B
Lestidae	Emerald Damselflies/Spreadwings	8				
Platycnemidae	Stream Damselflies	10	1	1		A
Protoneuridae	Threadwings	8				
Aeshnidae	Hawkers & Emperors	8		A		A
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6	1	A	B	B
Libellulidae	Darters/Skimmers	4	1		A	A
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3		B		B
*Corixidae**	Water boatmen	3				
*Gerridae**	Pond skaters/Water striders	5				
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7	1		A	A
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3				
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5		A		A
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8				
Hydropsychidae 1 sp		4	1			1
Hydropsychidae 2 sp		6				
Hydropsychidae > 2 sp		12				
Philopotamidae		10	1			1
Polycentropodidae		12				
Psychomyiidae/Xiphocentronidae		8				
Cased caddis:						
Barbarochthonidae SWC		13				
Calamoceratidae ST		11				
Glossosomatidae SWC		11				
Hydroptilidae		6	1			1
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6	1			1
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5				
*Elmidae/Dryopidae**	Riffle beetles	8	1			1
*Gyrinidae**	Whirligig beetles	5				
*Haliplidae**	Crawling water beetles	5				
Helodidae	Marsh beetles	12				
*Hydraenidae**	Minute moss beetles	8				
*Hydrophilidae**	Water scavenger beetles	5				
Limnichidae	Marsh-Loving Beetles	10				
Psephenidae	Water Pennies	10				

TAXON		QV	S	VEG	GSM	TOTAL
DIPTERA	Flies					
Athericidae	Snipe flies	10				
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5	1			1
Chironomidae	Midges	2	1	A		A
*Culicidae**	Mosquitoes	1				
*Dixidae**	Dixid midge	10				
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5	1			1
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5				
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6				
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3		1		1
*Planorbinae**	Orb snails	3		A		A
Thiaridae =Melanidae*		3	1	A	B	B
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					126
	No. of Taxa					24
	ASPT					5.25

1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000

Other biota:

Comments/Observations:

SASS5 sampling sheet for Sampling Point: NK8

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3				
ANNELIDA						
Oligochaeta	Earthworms	1	A			A
Hirudinea	Leeches	3				
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3		A	A	B
Atyidae	Freshwater Shrimps	8				
Palaemonidae	Freshwater Prawns	10				
HYDRACARINA	Mites	8				
PLECOPTERA	Stoneflies					
Notonemouridae		14				
Perlidae		12				
EPHEMEROPTERA	Mayflies					
Baetidae 1sp		4	A			
Baetidae 2 sp		6			B	B
Baetidae > 2 sp		12				
Caenidae	Squaregills/Cainfles	6		A	A	B
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9	A	A	B	B
Oligoneuridae	Brushlegged mayflies	15				
Polymitarcyidae	Pale Burrowers	10				
Prosopistomatidae	Water specs	15				
Teloganodidae SWC	Spiny Crawlers	12				
Tricorythidae	Stout Crawlers	9				
ODONATA	Dragonflies & Damselflies					
Calopterygidae ST,T	Demoiselles	10				
Chlorocyphidae	Jewels	10				
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4		B	A	B
Lestidae	Emerald Damselflies/Spreadwings	8				
Platycnemidae	Stream Damselflies	10				
Protoneuridae	Threadwings	8				
Aeshnidae	Hawkers & Emperors	8		1		1
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6		A	B	B
Libellulidae	Darters/Skimmers	4				
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3				
*Corixidae**	Water boatmen	3		A		A
*Gerridae**	Pond skaters/Water striders	5				
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7				
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		A	A	A
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5		A	1	A
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8				
Hydropsychidae 1 sp		4	1			1
Hydropsychidae 2 sp		6				
Hydropsychidae > 2 sp		12				
Philopotamidae		10	A	A	A	A
Polycentropodidae		12				
Psychomyiidae/Xiphocentronidae		8				
Cased caddis:						
Barbarochthonidae SWC		13				
Calamoceratidae ST		11				
Glossosomatidae SWC		11				
Hydroptilidae		6				
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6				
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5	A	A		B
*Elmidae/Dryopidae**	Riffle beetles	8				
*Gyrinidae**	Whirligig beetles	5		A		A
*Haliplidae**	Crawling water beetles	5				
Helodidae	Marsh beetles	12				
*Hydraenidae**	Minute moss beetles	8				
*Hydrophilidae**	Water scavenger beetles	5				
Limnichidae	Marsh-Loving Beetles	10				
Psephenidae	Water Pennies	10				

TAXON		QV	S	VEG	GSM	TOTAL
DIPTERA	Flies					
Athericidae	Snipe flies	10				
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5				
Chironomidae	Midges	2	A	1		A
*Culicidae**	Mosquitoes	1				
*Dixidae**	Dixid midge	10				
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5	A		A	A
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5			1	1
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6	1			1
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3				
*Planorbinae**	Orb snails	3				
Thiaridae =Melanidae*		3	A	B	B	
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					98
	No. of Taxa					20
	ASPT					4.9

1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000

Other biota:

Comments/Observations:

SASS5 sampling sheet for Sampling Point: NK9

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3				
ANNELIDA						
Oligochaeta	Earthworms	1	A		1	A
Hirudinea	Leeches	3				
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3	A	A	1	B
Atyidae	Freshwater Shrimps	8				
Palaemonidae	Freshwater Prawns	10				
HYDRACARINA	Mites	8				
PLECOPTERA	Stoneflies					
Notonemouridae		14				
Perlidae		12				
EPHEMEROPTERA	Mayflies					
Baetidae 1sp		4				
Baetidae 2 sp		6				
Baetidae > 2 sp		12	B	B	B	B
Caenidae	Squaregills/Cainfles	6	A	A	B	B
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9				
Oligoneuridae	Brushlegged mayflies	15				
Polymitarcyidae	Pale Burrowers	10				
Prosopistomatidae	Water specs	15				
Teloganodidae SWC	Spiny Crawlers	12				
Tricorythidae	Stout Crawlers	9				
ODONATA	Dragonflies & Damselflies					
Calopterygidae ST,T	Demoiselles	10				
Chlorocyphidae	Jewels	10				
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4		B		B
Lestidae	Emerald Damselflies/Spreadwings	8				
Platycnemidae	Stream Damselflies	10				
Protoneuridae	Threadwings	8				
Aeshnidae	Hawkers & Emperors	8				
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6	A		A	B
Libellulidae	Darters/Skimmers	4		A		A
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3		A		A
*Corixidae**	Water boatmen	3				
*Gerridae**	Pond skaters/Water striders	5				
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7			1	1
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		A		A
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5				
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8				
Hydropsychidae 1 sp		4	1			1
Hydropsychidae 2 sp		6				
Hydropsychidae > 2 sp		12				
Philopotamidae		10	A			A
Polycentropodidae		12				
Psychomyiidae/Xiphocentronidae		8				
Cased caddis:						
Barbarochthonidae SWC		13				
Calamoceratidae ST		11				
Glossosomatidae SWC		11				
Hydroptilidae		6	A			A
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6				
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5			A	A
*Elmidae/Dryopidae**	Riffle beetles	8				
*Gyrinidae**	Whirligig beetles	5				
*Haliplidae**	Crawling water beetles	5				
Helodidae	Marsh beetles	12				
*Hydraenidae**	Minute moss beetles	8				
*Hydrophilidae**	Water scavenger beetles	5				
Limnichidae	Marsh-Loving Beetles	10				
Psephenidae	Water Pennies	10				

TAXON		QV	S	VEG	GSM	TOTAL
DIPTERA	Flies					
Athericidae	Snipe flies	10				
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5				
Chironomidae	Midges	2	A	A	A	B
*Culicidae**	Mosquitoes	1				
*Dixidae**	Dixid midge	10				
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5	B	B		C
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5				
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6				
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3				
*Planorbinae**	Orb snails	3		A		A
Thiaridae =Melanidae*		3	A	A	B	B
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					86
	No. of Taxa					18
	ASPT					4.77

1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000

Other biota:

Comments/Observations:

SASS5 sampling sheet for Sampling Point: NK10

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3				
ANNELIDA						
Oligochaeta	Earthworms	1	A		A	A
Hirudinea	Leeches	3				
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3	A			A
Atyidae	Freshwater Shrimps	8				
Palaemonidae	Freshwater Prawns	10				
HYDRACARINA	Mites	8				
PLECOPTERA	Stoneflies					
Notonemouridae		14				
Perlidae		12				
EPHEMEROPTERA	Mayflies					
Baetidae 1sp		4			1	
Baetidae 2 sp		6		B		
Baetidae > 2 sp		12				B
Caenidae	Squaregills/Cainfles	6	1	A		A
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9				
Oligoneuridae	Brushlegged mayflies	15				
Polymitarcyidae	Pale Burrowers	10				
Prosopistomatidae	Water specs	15				
Teloganodidae SWC	Spiny Crawlers	12				
Tricorythidae	Stout Crawlers	9				
ODONATA	Dragonflies & Damselflies					
Calopterygidae ST,T	Demoiselles	10		A		A
Chlorocyphidae	Jewels	10				
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4	A	B		B
Lestidae	Emerald Damselflies/Spreadwings	8				
Platycnemidae	Stream Damselflies	10				
Protoneuridae	Threadwings	8				
Aeshnidae	Hawkers & Emperors	8				
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6	A			A
Libellulidae	Darters/Skimmers	4	A			A
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3		B		B
*Corixidae**	Water boatmen	3	A			A
*Gerridae**	Pond skaters/Water striders	5		A		A
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7	A	A	1	B
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3				
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5		B		B
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8	1			1
Hydropsychidae 1 sp		4	A	A		
Hydropsychidae 2 sp		6				A
Hydropsychidae > 2 sp		12				
Philopotamidae		10				
Polycentropodidae		12				
Psychomyiidae/Xiphocentronidae		8				
Cased caddis:						
Barbarochthonidae SWC		13				
Calamoceratidae ST		11				
Glossosomatidae SWC		11				
Hydroptilidae		6			1	1
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6		1	1	A
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5				
*Elmidae/Dryopidae**	Riffle beetles	8				
*Gyrinidae**	Whirligig beetles	5		A		A
*Haliplidae**	Crawling water beetles	5				
Helodidae	Marsh beetles	12				
*Hydraenidae**	Minute moss beetles	8				
*Hydrophilidae**	Water scavenger beetles	5			1	1
Limnichidae	Marsh-Loving Beetles	10				
Psephenidae	Water Pennies	10				

TAXON		QV	S	VEG	GSM	TOTAL
DIPTERA	Flies					
Athericidae	Snipe flies	10				
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5	A	A		A
Chironomidae	Midges	2	A	A	1	B
*Culicidae**	Mosquitoes	1				
*Dixidae**	Dixid midge	10				
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5		A		A
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5	A			A
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6				
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3				
*Planorbinae**	Orb snails	3				
Thiaridae =Melanidae*		3		1		1
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					123
	No. of Taxa					24
	ASPT					5.125

1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000

Other biota:

Comments/Observations:

Annexure E: Results – VEGRAI Data Interpretation

VEGRAI Results for NK5

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	26.3	14.6	1.7	1.0	100.0
NON MARGINAL	46.3	20.6	1.7	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				35.2	
VEGRAI EC				**E**	
AVERAGE CONFIDENCE				1.7	

VEGRAI results for NK6

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	58.9	32.7	1.0	1.0	100.0
NON MARGINAL	68.5	30.5	1.7	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				63.2	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				1.3	

VEGRAI results for NK7

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	62.6	34.8	1.0	1.0	100.0
NON MARGINAL	68.5	30.5	1.7	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				65.2	
VEGRAI EC				**C**	
AVERAGE CONFIDENCE				1.3	

VEGRAI results for NK8

LEVEL 3 ASSESSMENT					
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**
MARGINAL	53.3	29.6	1.0	1.0	100.0
NON MARGINAL	56.3	25.0	1.7	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				54.7	
VEGRAI EC				**D**	
AVERAGE CONFIDENCE				1.3	

VEGRAI results for NK9

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	44.8	24.9	1.0	1.0	100.0
NON MARGINAL	46.3	20.6	1.7	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				45.5	
VEGRAI EC				**D**	
AVERAGE CONFIDENCE				1.3	

VEGRAI results for site NK10

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	26.3	14.6	1.7	1.0	100.0
NON MARGINAL	46.3	20.6	1.7	2.0	80.0
	2.0				180.0
LEVEL 3 VEGRAI (%)				35.2	
VEGRAI EC				**E**	
AVERAGE CONFIDENCE				1.7	

Annexure F: Results – Fish

F.1: Observed fish assemblage

Sampling was conducted by electrofishing in shallow flowing and non-flowing habitats with cover provided primarily by marginal vegetation, stones out of current and stones in current. Due to lack of surface water sampling could only be conducted at 4 of the proposed sites namely NK6, NK7, NK9 and NK10.

A total of 5 of the 14 expected indigenous fish species were recorded during the field survey (Table 23). Four (4) fish species were recorded at site NK10, and 3 at each of the remaining sites (NK6, NK7 and NK9) (Table 23).

No alien invasive or introduced fish species were recorded during the survey.

Table 23: Abundance and diversity of fish species recorded during the March 2018 field survey

SPECIES	SITE			
	NK6	NK7	NK9	NK10
Clarias gariepinus	2	6	1	5
Enteromius trimaculatus	42	21	10	7
Oreochromis mossambicus	4	1	1	
Enteromius viviparus				6
Enteromius paludinosus				5
ABUNDANCE	48	28	12	23
DIVERSITY	3	3	3	4

**** Alien invasive***

F.2: Species Intolerance Ratings

Fish have different sensitivities or levels of tolerance to various aspects that they are subjected to within the aquatic environment. These tolerance levels for the expected and observed fish species are presented in Table 24. These tolerance levels are scored to show each fish species' sensitivity to flow and physico-chemical modifications (Table 24).

All of the observed fish species are rated as either moderately tolerant or tolerant to water quality impairment (Table 24). The absence of any fish species with moderate intolerance or intolerance to modified water quality indicates that water quality is a limiting factor of fish species diversity in these catchments. This can be attributed to the urbanized nature of the catchments that these streams are situated in. Although *in situ* water quality parameters were adequate at all these sites, it is most likely sporadic runoff events that result in the absence of species such as *Micralestes acutidens* (Silver robber) and *Enteromius eutaenia* (Orangefin barb) that are moderately tolerant and intolerant to impaired water quality

Similarly all of the observed fish species are either moderately tolerant or tolerant to disruptions in flow (Table 24). This was expected as all the aquatic ecosystems in the project area can be described as non-perennial. The non-perennial nature of the aquatic ecosystems in the project area would have contributed to the absence of species such as *Labeo cylindricus* (Redeyed labeo) from the observed species assemblage.

Table 24: Tolerance Ratings of expected and observed fish species to physico-chemical and flow rated stressors

SPECIES	COMMON NAME	PHYSICO-CHEMICAL TOLERANCE	FLOW TOLERANCE
Clarias gariepinus	Sharptooth catfish	1.0	1.7
Enteromius trimaculatus	Threespot barb	1.8	2.7
Oreochromis mossambicus	Mozambique tilapia	1.3	0.9
Enteromius viviparus	Bowstripe barb	3.0	2.3
Enteromius paludinosus	Straightfin barb	1.8	2.3

F.3: Fish Response Assessment Index (FRAI)

Fish data collected during the high flow survey was applied to the Fish Response Assessment Index (FRAI). FRAI results for this present March 2018 survey are presented in Table 25.

Table 25: FRAI results for the March 2018 survey

SITE	NK6	NK7	NK9	NK10
FRAI (%)	35.2	29.5	27.5	37.9
EC: FRAI	E	E	E	D/E

Based on the FRAI scores the fish communities at sites NK6, NK7 and NK9 were seriously modified (Class E) (Table 25). The fish community at site NK10 was on the margin between being largely and seriously modified (Class D/E) (Table 25). As mentioned above, the observed fish species are all regarded as tolerant or moderately tolerant of water quality and flow modifications. Therefore, water quality and flow related impacts are likely to have been significant limiting factors on the fish assemblages.

Annexure G: Specialist CV

Lorainmari den Boogert

Resume Summary

Contact: +27 722 006244
Email: lorain@iggdrasilscientific.com
Languages: English, Afrikaans, Dutch

Education and Training

Degrees

- **Master of Science Plant Science** **2010**
  University of Pretoria, SA and Wageningen University, The Netherlands
- **Bachelor of Science (Honours) Plant Science (Cum Laude)** **2008**
  University of Pretoria, SA
- **Bachelor of Science Ecology** **2007**
  University of Pretoria, SA

Certificates and Accreditations

- **SASS5 Accreditation (freshwater Aquatic Zoology)** **2011,2014,2017**
  Department of Water Affairs, SA
- **Dutch as a professional language** **2011**
  CNaTV, Belgium

Additional Courses

- Asteraceae ID course, by Paul Herman from SANBI's National Herbarium at the University of Pretoria, Department of Plant and Soil Sciences. 2018
- MIRAI (Macro invertebrate Response Assessment Index), Department of Water and Sanitation 2016
- Invasive Species and Herbicide Training, South African Green Industries Council (SAGIC) 2016
- A rapid method for water quality assessment, Nepid Consultants, Sabie 2011
- EIA water use authorisation and waste management activity licences, CBSS, Pretoria 2011
- Tools for wetland assessment, Rhodes University, Grahamstown 2011
- Inventory and survey methods for invasive plants, Online Course, Department of land resource of environmental Sciences, Montana State University, Bozeman, Montana. 2009

Career Highlights

DIRECTOR/ECOLOGIST
Iggdrasil Scientific Services **Feb 2012 – Present**
A medium sized enterprise specialising in ecological assessments, covering fauna, flora, wetland and aquatic ecosystems.

PLANT ECOLOGIST
GEM – Science, South Africa **Oct 2010 – Feb 2012**
A medium sized enterprise providing comprehensive geological and environmental consulting service for the mining industry.

JUNIOR ENVIRONMENTAL CONSULTANT
Bokamoso Environmental Consultants, SA **Jan 2010 – Oct 2010**

PROJECT RESEARCH ASSISTANT
Abiotic Research Group, Alterra, Wageningen, The Netherlands **Jan 2009 – Jun 2009**

BOTANY DEMONSTRATOR **Jul 2008 – Nov 2008**
University of Pretoria, Plant Sciences, SA

FIELD ASSISTANT SA **Nov 2007 – Feb 2007**
University of Pretoria, Zoology, SA

PROJECT RESEARCH ASSISTANT SA **Jan 2006 – Aug 2006**
University of Pretoria, Zoology, SA

Conference Presentations

- **Course Presenter: Riparian Vegetation Assessment Methods for DWS** **2017**
  Department of Water and Sanitation, DWS, Roodeplaat
- **Conservation Planning in Urban Open Spaces** **2016**
  Botanical Society, Pretoria
- **Presentation on: The Vegetation ecology of Seringveld Conservancy, Cullinan South Africa** **2010**
  South African Association of Botanist's Annual Conference, Potchefstroom
- **Presentation on: A comparison between Ellenberg and Wamelink Biological indicator values** **2009**
  Wageninen Abiotic Research Group, Alterra Annual Conference, Wageningen, The Netherlands
- **Presentation on: The effect of the higher energy flow in the Ash River System, Bethlehem, SA** **2003**
  Stockholm International Youth Science Seminar, Sweden
- **Presentation on: The youth of South Africa would like to see underground water pollution addresses in light of the international summit for sustainable development**
  2003
  Water institute of South Africa, Annual Conference, Durban

Achievements

- Overall Winner and gold medalist of the Eskom Expo for Young Scientist, representing south Africa in the Stockholm Sweden at the Stockholm international youth seminar
- Winner of the South Africa youth water prize of the department of water affairs and represented South Africa at the international youth water prize during world water week in Stockholm Sweden.

Membership & Associations

- **South African Council of Natural Scientific Professions**
  Registered Professional Scientist (Pri.Sci.Nat: 400003/13),
- **South African Association for Botanists,**
- **South African Botanical Society,**
  Committee member.
- **South African Society for Aquatic Scientist,**
- **Department of Water Affairs SASS5 practitioners.**