Baseline Aquatic Assessment: 2017 Nkosi City,

Mpumalanga Province, South Africa

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Report Status

Report Title:	**Baseline Aquatic Assessment Report: 2017 Nkosi City, Mpumalanga Province, South Africa.**
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Client:	**Bokamoso Environmental Consultants**
Client Representative:	**Lizette Delport**
Report Status:	**Final Report**
Date of Report:	**31 May 2017**

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.

Boogert

Signature of specialist

Iggdrasil Scientific Services (Pty) Ltd.

Name of company

31 May 2017

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 the within the X24B and X24C quaternary catchment areas and within the Inkomati Water Management Area (WMA 5).

There are a number of non-perennial, un-named 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 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. The upstream section of 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 (Department of Water and Sanitation, 2014).

According to the RIVCON data used by 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 Baseline Aquatic Assessment at the proposed Nkosi City development was conducted on the 9th to the 11th of May 2017. 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 **NK1, NK2, NK3, NK4 and NK5**. Site **NK1** was inaccessible, sites **NK2, NK3, and NK4** were dry, and site **NK5** consisted of small, isolated pools of water.

This implied that **NK6, NK7, NK8, NK9, and NK10** could be further assessed by means of the sampling methods. *In situ* water quality parameters were measured at all of the sampling points that were sampled.

With regard to **habitat integrity**, the *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems, with the exception of Dissolved Oxygen at sampling locations NK6, NK7, and NK10. At sampling sites NK6 and NK7 the DO was above TWQRs for aquatic ecosystems and could possibly indicate a eutrophic system. At sampling location NK10 the DO was below TWQRs for aquatic ecosystems but still above sub-lethal limits.

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 baseline aquatic survey, the results obtained from each of these sampling points can be summarised as follows:

- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK6** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat highly suitable to support a diverse macro-invertebrate community. One species of *Enteromius trimaculatus* was found in the SASS5 net at NK6;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK7** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat highly suitable to support a diverse macro-invertebrate community;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK8** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat suitable to support a diverse macro-invertebrate community;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK9** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat highly suitable to support a diverse macro-invertebrate community;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK10** was modified. The SASS5 EC was D although the IHAS score indicated a habitat suitable to support a diverse macro-invertebrate community;
- Potential impacts were assessed in terms of consequence and probability and a significance ranking was assigned to every impact.
- Potential impacts that will affect the flow regime of the watercourse were ranked as high prior to mitigation and were ranked as high-medium post mitigation; and
- Potential impacts that will alter the water quality of the area – increasing the amounts of nutrients such as phosphates, nitrites and nitrates, were ranked as high prior to mitigation and were ranked as medium post mitigation.

If alteration of flow regimes and water quality 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 significant decrease in species richness of aquatic fauna and benthic macroinvertebrates.

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
ESAs	Ecological Support Areas
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
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.

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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 within the X24B and X24C quaternary catchment areas and within the Inkomati Water Management Area (WMA 5).

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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 baseline aquatic assessment for the proposed development of the Nkosi City, Mpumalanga Province, South Africa.

The project has one main deliverable namely a baseline aquatic assessment report after completion of the site visit. Kimberley Perry (M.Sc. Water Resource Management (UP), and SASS5 accredited by the Department of Water and Sanitation (“DWS”)) of ISS conducted the 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):

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 000m^2 Shopping centre;
- Fresh produce market;
- Entertainment and restuarants;
- 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.

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):

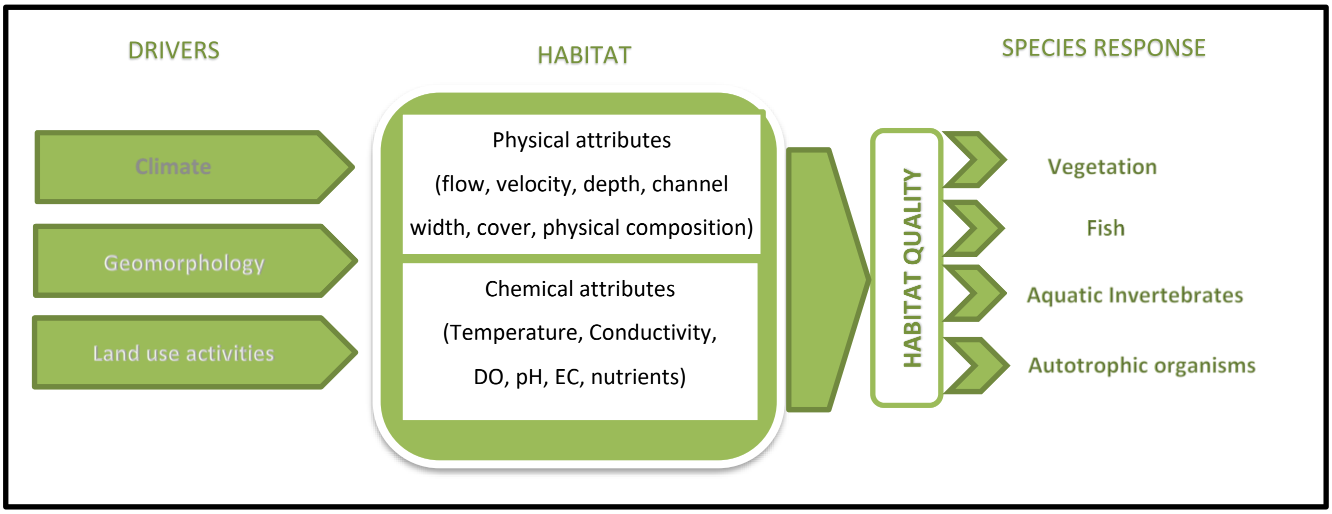

Figure 1: Relationships between Ecosystem responses to Drivers of Change

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 the **Integrated Habitat Assessment System ("IHAS")**. IHAS was developed in 1998 by McMilan, and version 2 is the currently used assessment index.

- **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 baseline aquatic assessment the **Integrated Habitat Assessment System ("IHAS")** and the **South African Scoring System, version 5 ("SASS5")** methodologies will be used to assess the biotic integrity of the study area.

1.4. Objective of this Report

The objective of this baseline aquatic report is to summarise the findings of the survey conducted from the 9th to the 11th of May 2017 at the proposed development study area for Nkosi City.

1.5. Report Structure

This Report is structured as follows:
Considering the above discussion on the purpose of aquatic assessments, the objective of this Report is met by addressing the following aspects:

- 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 baseline assessment at the study area is described, followed by a discussion of the **results** obtained during this **baseline aquatic survey**, both with regard to the evaluation of **habitat conditions** and disturbances, as well as the **species response** of aquatic biota (namely invertebrates in this study) by determining their occurrence and composition; and
- Section 4 contains conclusions and makes recommendations for the study area in terms of future surveys.

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.

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[1] Mucina and Rutherford 2006

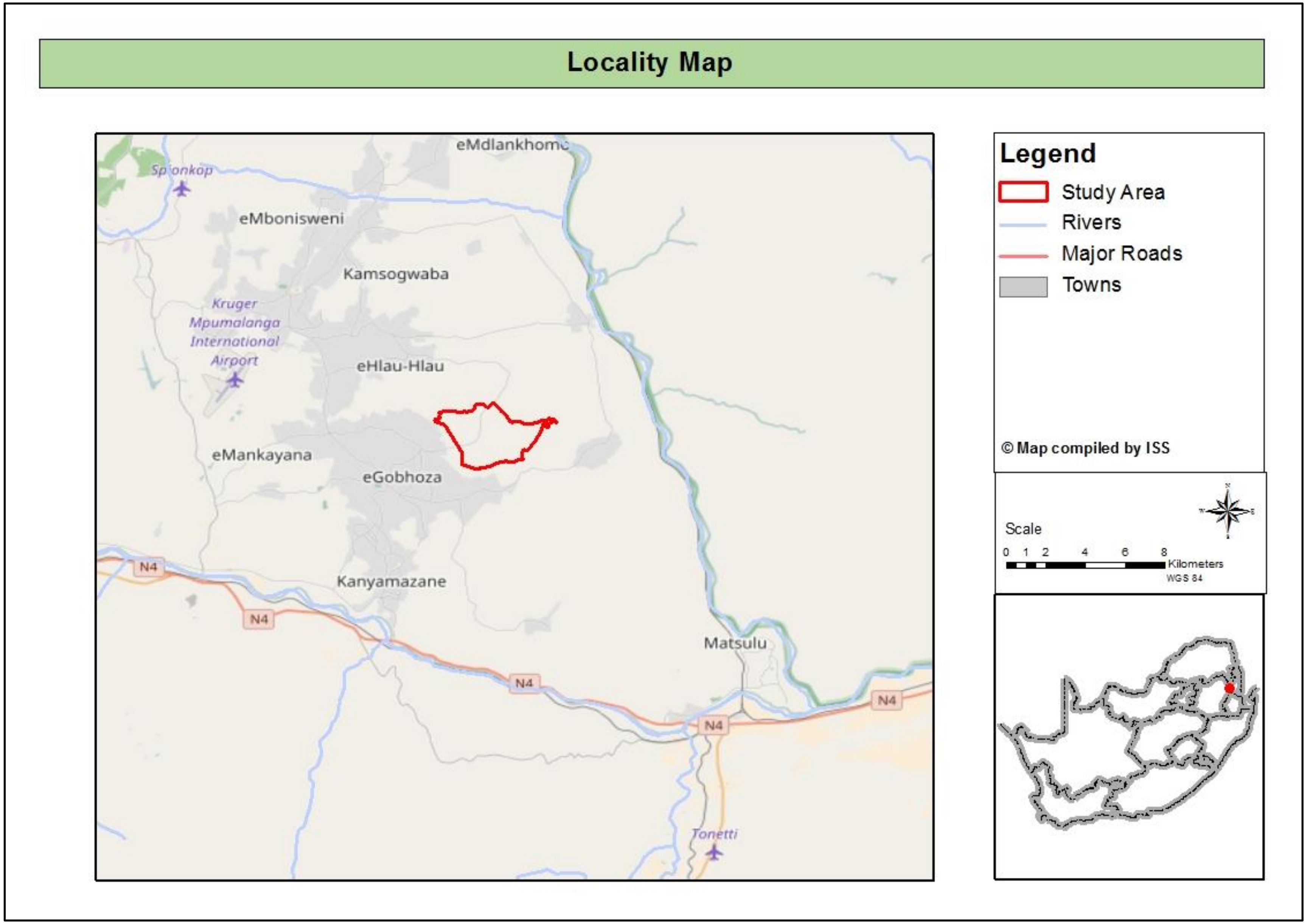


Figure 2: Nkosi City (study area) located in the Mpumalanga Province of South Africa

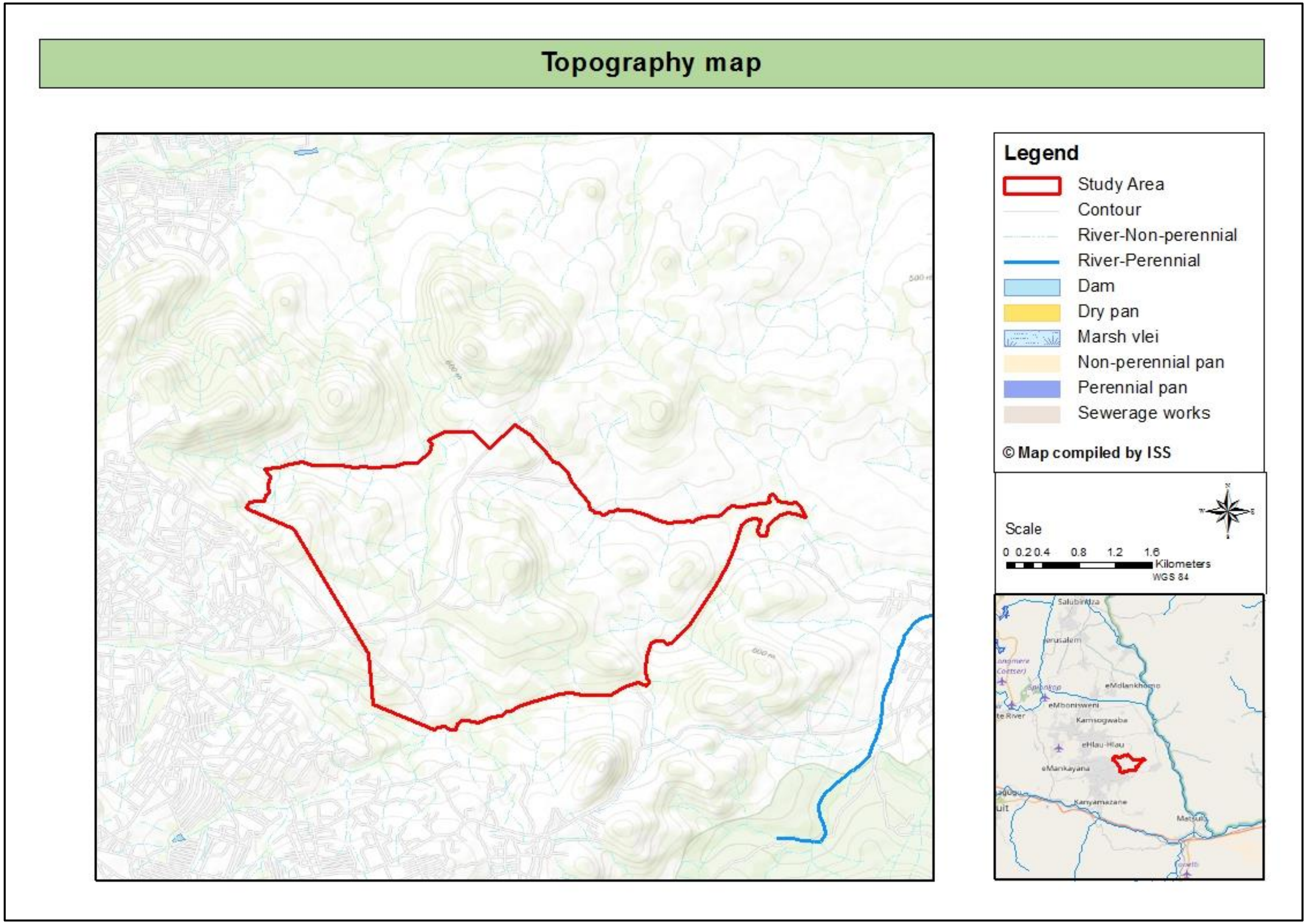


Figure 3: Topography of the study area

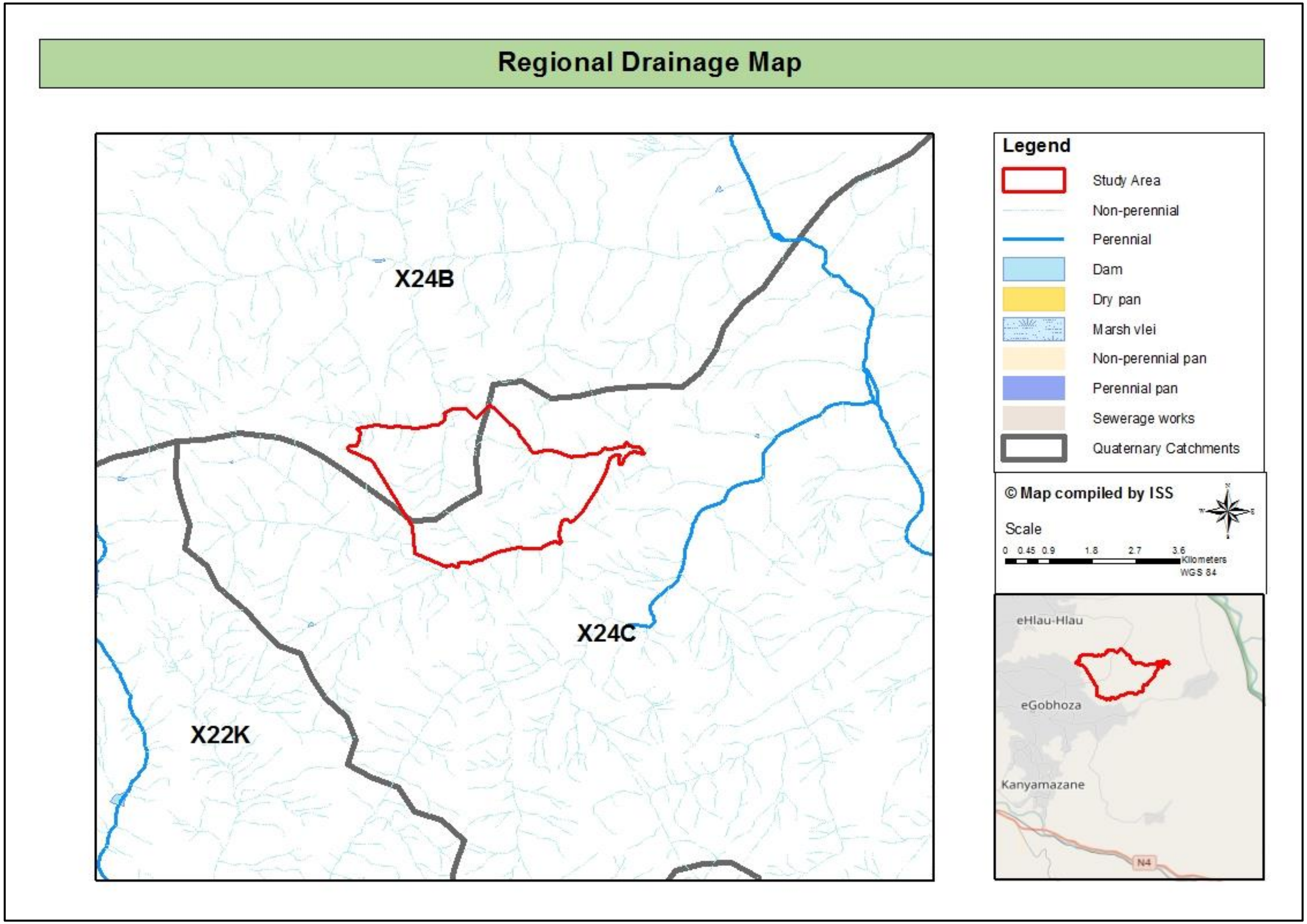


Figure 4: Regional drainage for the study area.

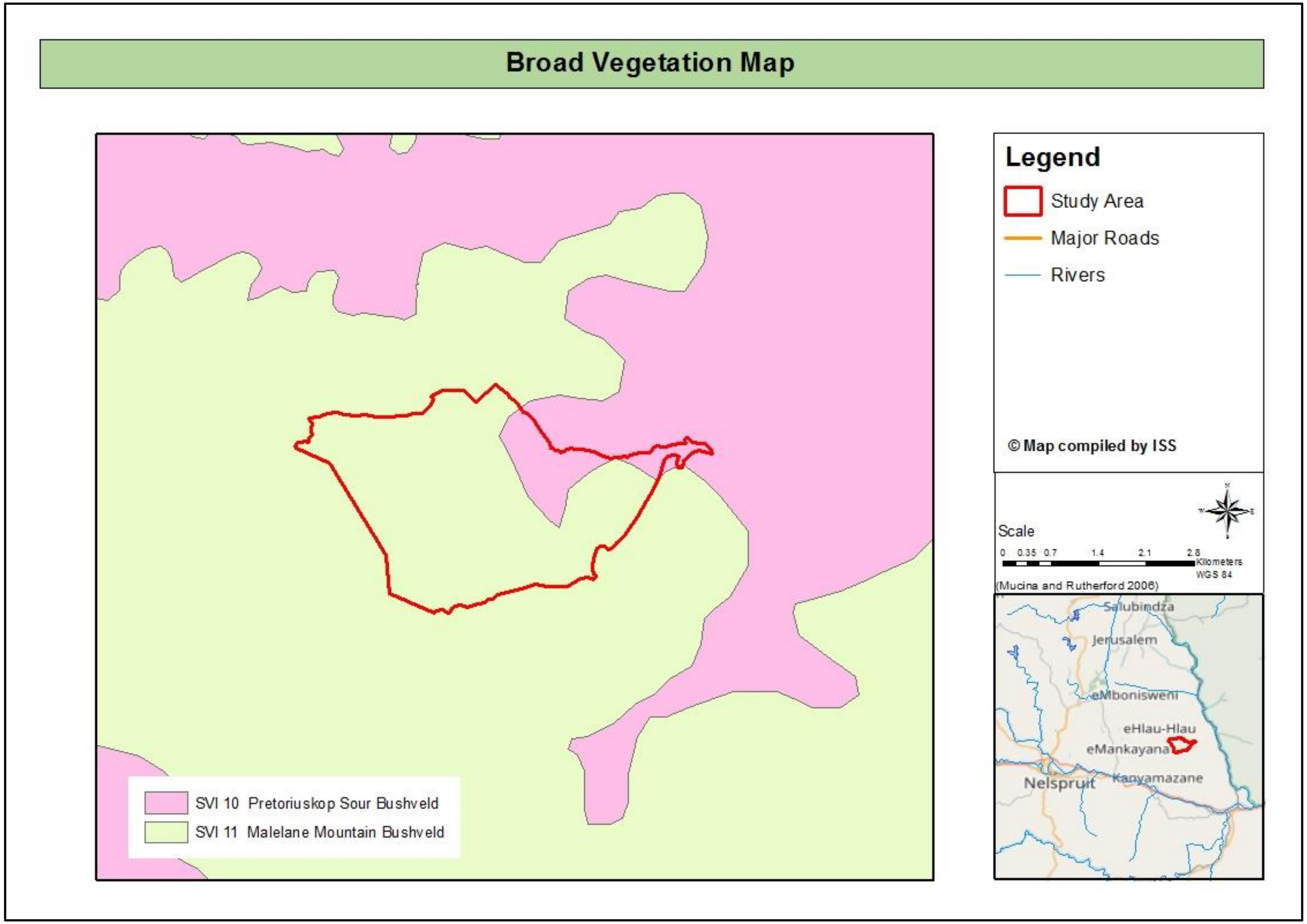


Figure 5: Broad Vegetation Map for the Study Area

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. Also 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).

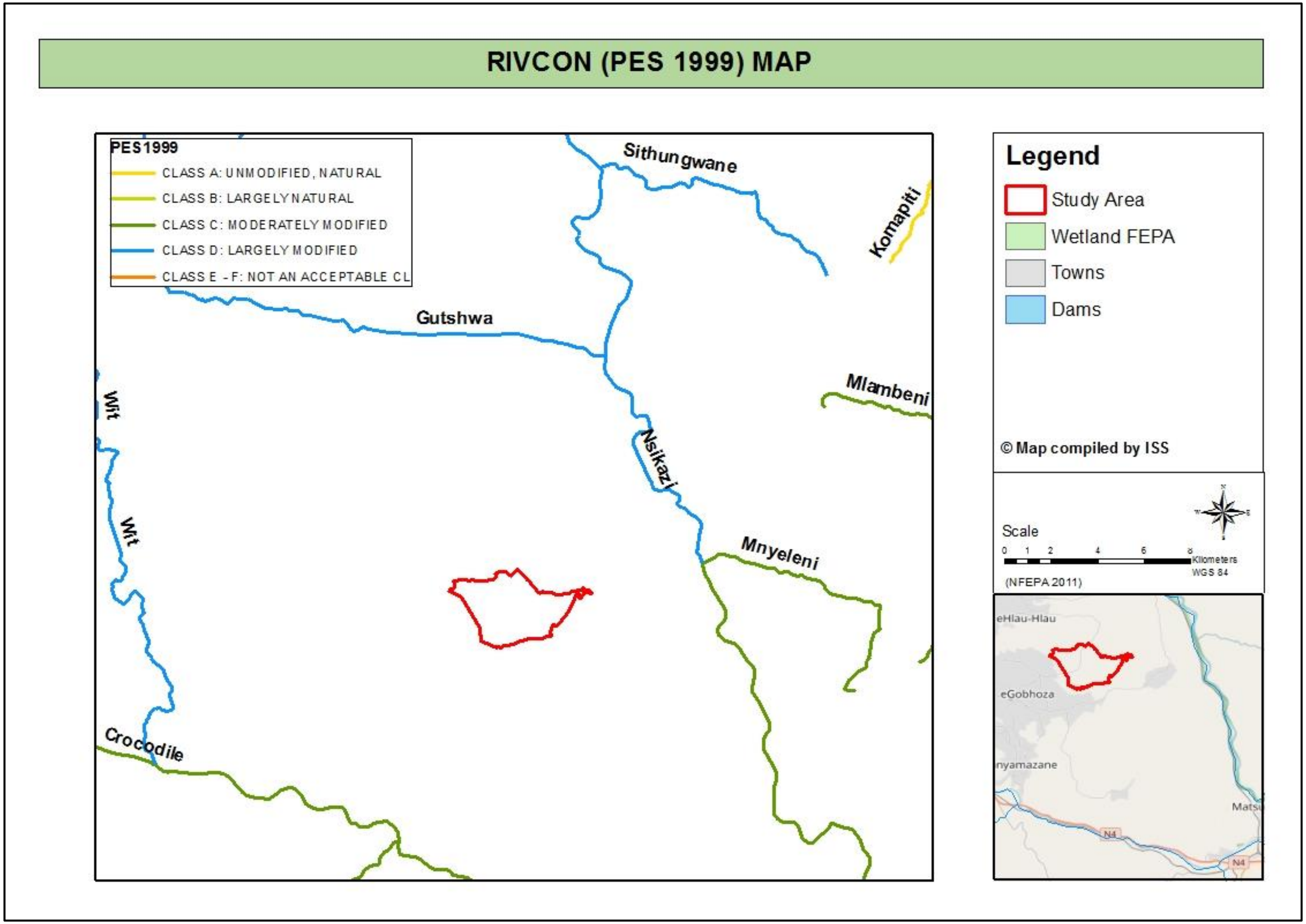


Figure 6: RIVCON (PES 1999) Map for the study area

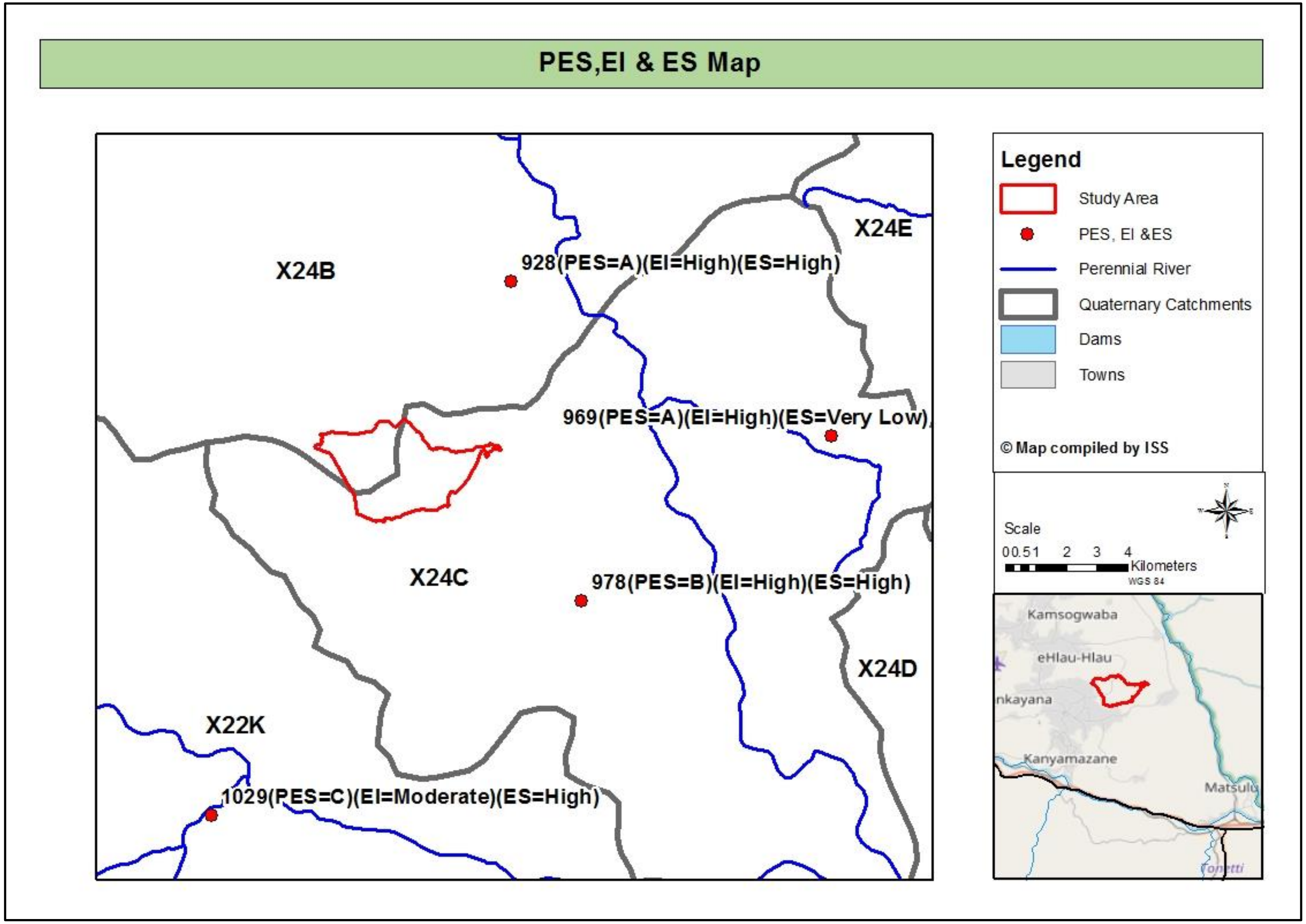


Figure 7: 2014 PES, EI and ES Map for the study area

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.

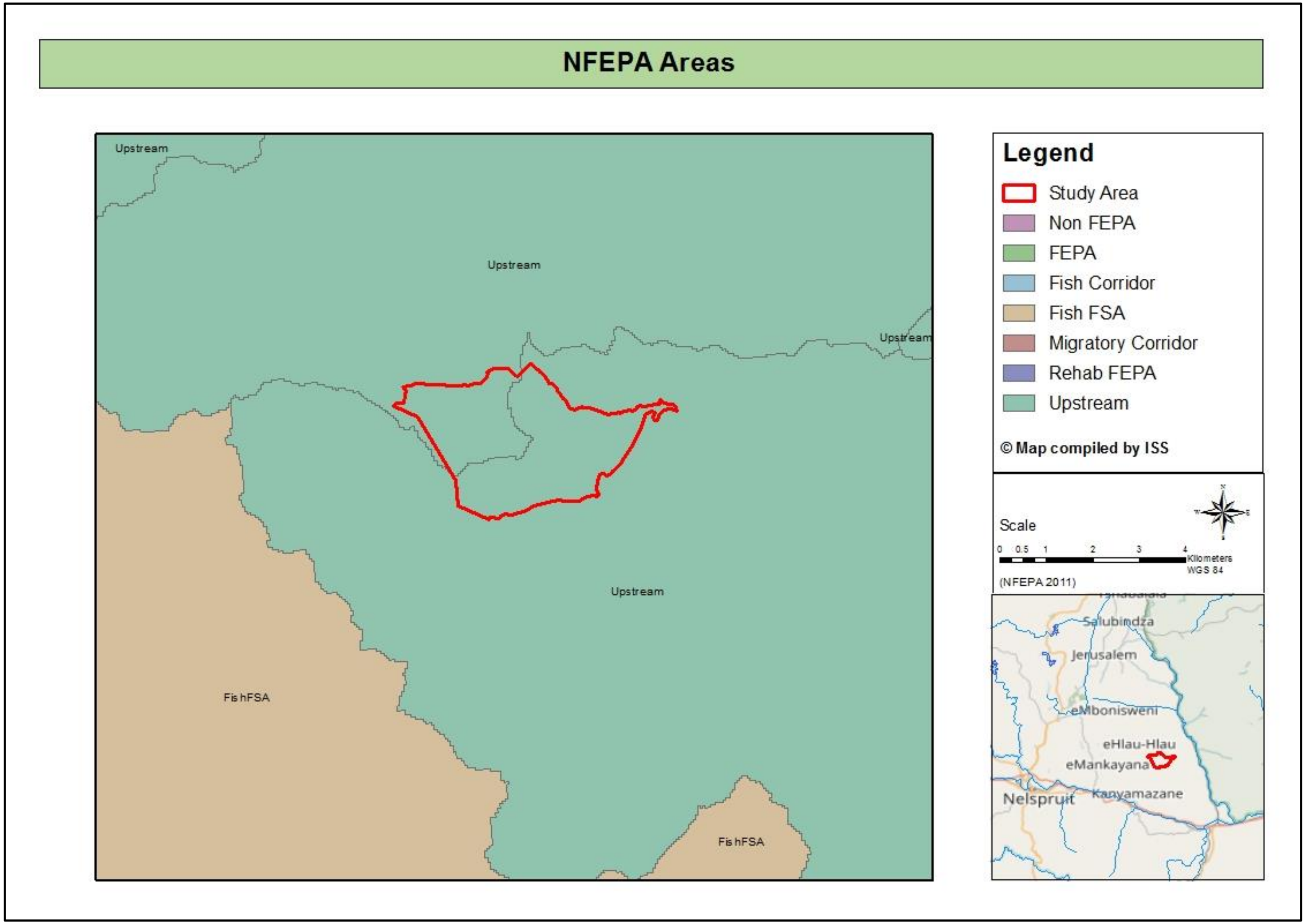


Figure 8: NFEPA Map for the study area

The study area traverses an Upstream FEPA.

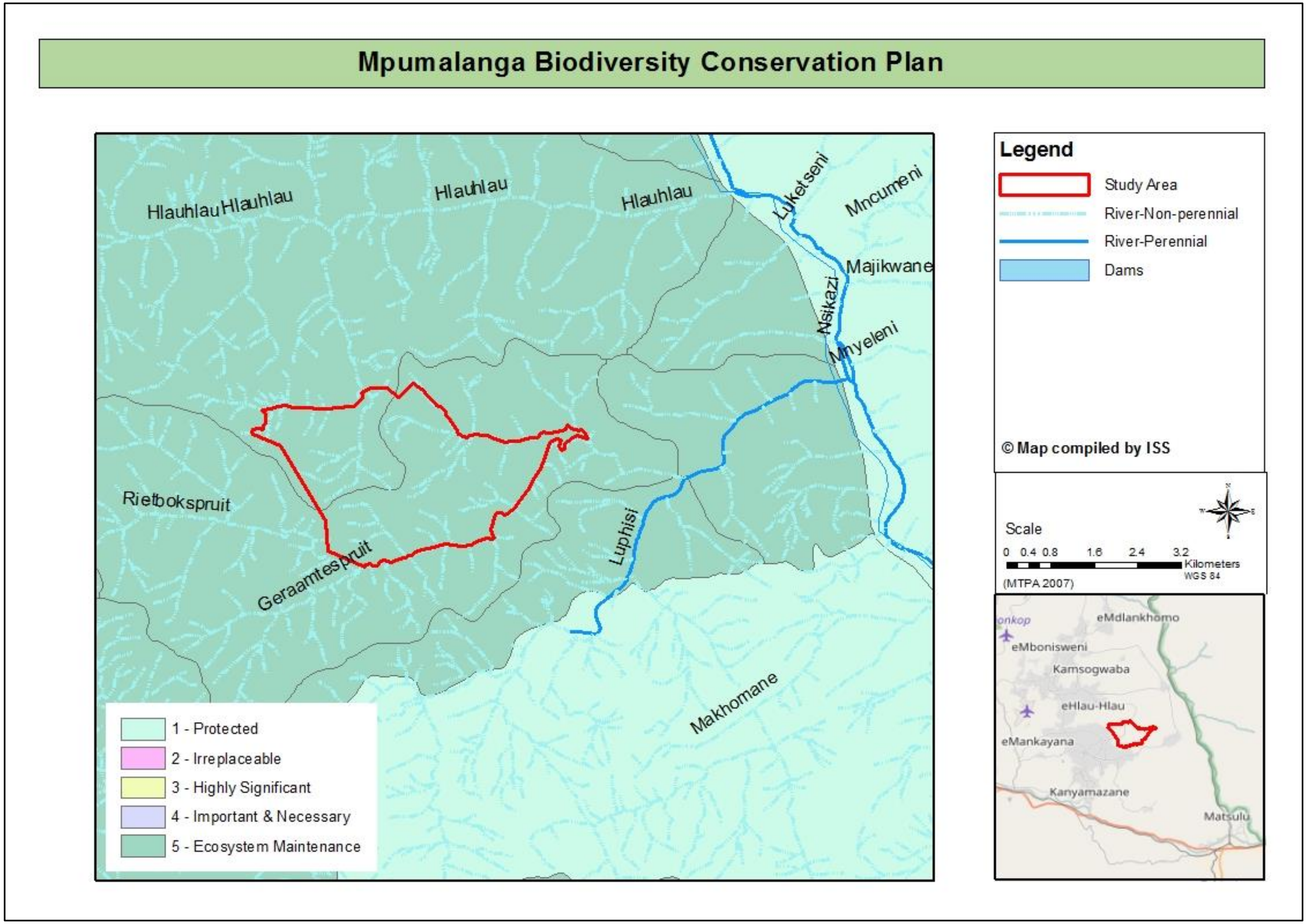


Figure 9: The Aquatic Biodiversity Sub-catchment Map for the study area (from the MBCP)

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

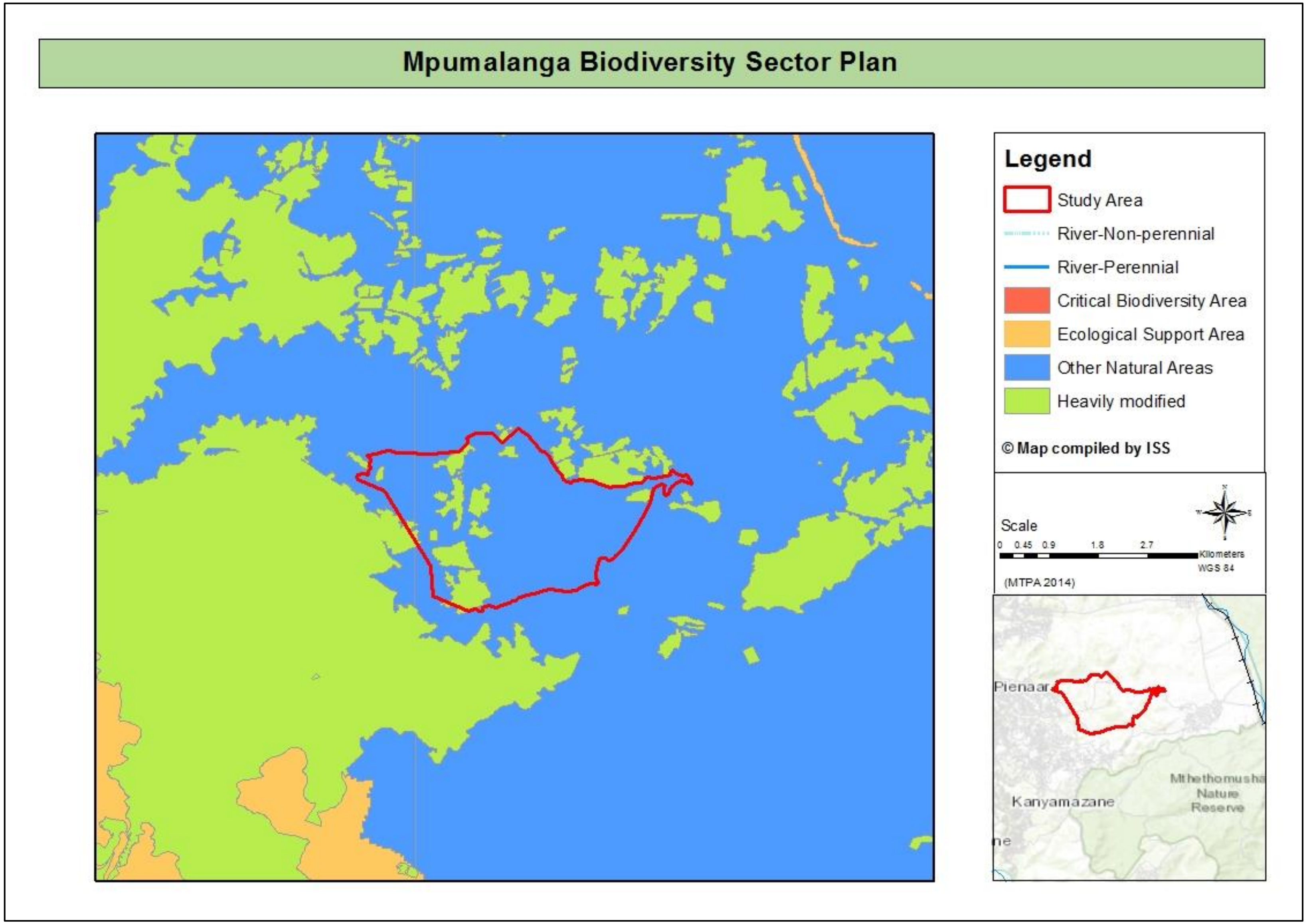


Figure 10: Mpumalanga Biodiversity Sector Plan Map for the study area (from the MBSP)

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 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 macro invertebrates by determining their occurrence and composition at the sampling points described below.

3.1. Selection of Sampling Points for the 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 have been selected for the baseline aquatic assessment. Table 2 over the page indicates the number, GPS coordinates, and a description of each of the sampling points.

The locations of these sampling points are illustrated in Figure 11 on page 26.

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.
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.

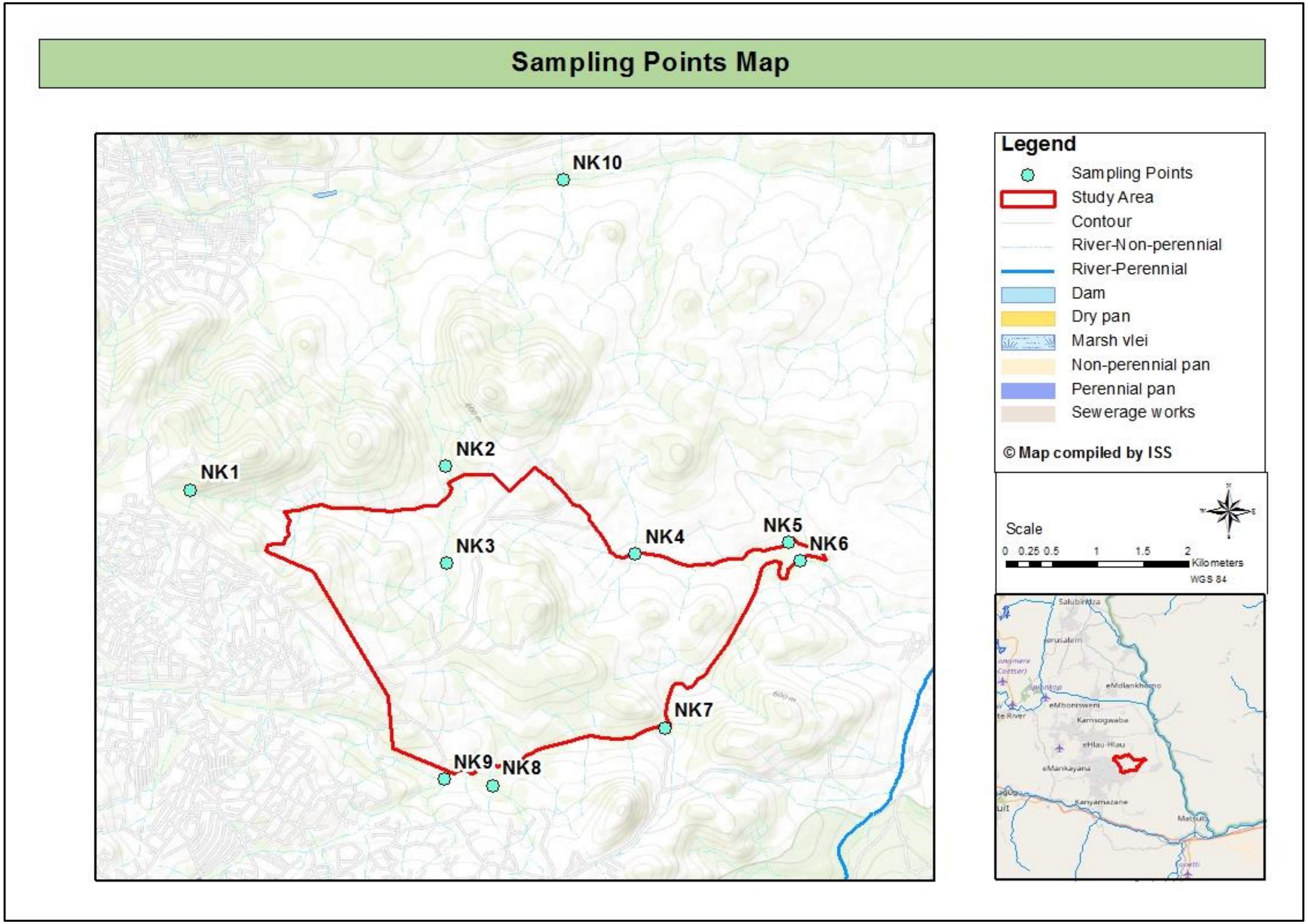
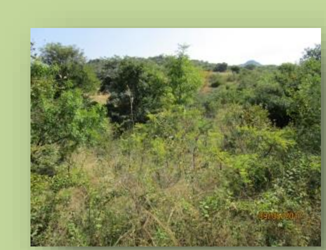
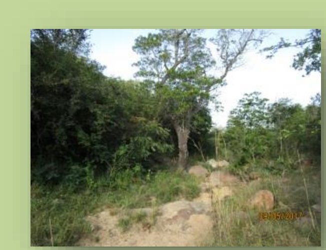
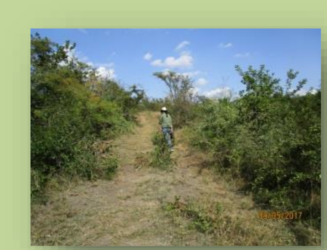


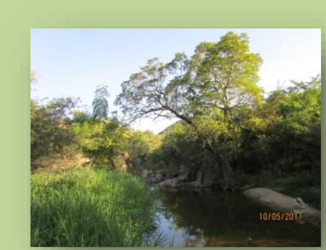
Figure 11: Sampling points for the Baseline Aquatic Assessment for the proposed Nkosi City development

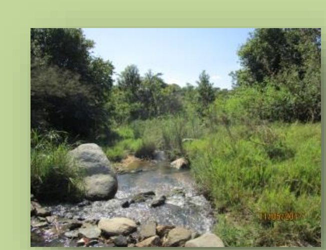
Table 3: Evaluation of Suitability and Impacts at each sampling point

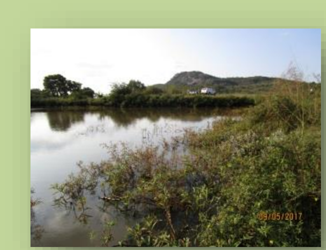
SURVEY SITE	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK1**	SITE VISITED	Yes	UPSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Located in the headwaters of an unnamed tributary. ▪ According to local residents the sampling point is dry. ▪ No accessible way down to the exact sampling location.	▪ Residential areas. ▪ Trampling and grazing from livestock. ▪ Small amount of rubbish dumping.
	SITE SAMPLED	No No Access			
	SUITABLE FOR FUTURE SAMPLING	No			
 **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 completely dry.	▪ 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 Dry System			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SURVEY SITE	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **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 completely dry.	- Road and bridge crossing downstream. - Dam located downstream. - Riparian vegetation located close to river bed. - Limited alien vegetation present. - Natural habitat.
	SITE SAMPLED	No Dry System			
	SUITABLE FOR FUTURE SAMPLING	Yes			
 **NK4**	SITE VISITED	Yes	UPSTREAM SITE FOR NKOSI CITY - On an unnamed tributary of the Nsikazi River.	- River bed completely dry. - 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 Area was dry			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SURVEY SITE	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **NK5**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Dense vegetation present at sampling point. ▪ Small isolated pools of clear water. ▪ Habitat consisted of GSM and bedrock, and a small amount of Stones.	▪ Natural habitat typical of Savanna vegetation. ▪ Small amount of subsistence agriculture in surrounding area. ▪ Limited impacts from surrounding area.
	SITE SAMPLED	No Isolated pools of water			
	SUITABLE FOR FUTURE SAMPLING	Yes			
 **NK6**	SITE VISITED	Yes	DOWNSTREAM SITE FOR NKOSI CITY ▪ On an unnamed tributary of the Nsikazi River.	▪ Dense vegetation surrounding sampling point. ▪ Habitat consists of large boulders, small cobbles and GSM, whilst a small amount of bedrock is present.	▪ Natural habitat typical of Savanna vegetation. ▪ Small amount of subsistence agriculture and livestock (cattle) present in surrounding area. ▪ Small amount of sediment present on Stones. ▪ 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			

SURVEY SITE	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **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. ▪ Small amount of rubbish present at the sampling point. ▪ 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			
 **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. ▪ Dirt road present. ▪ Some residential areas. ▪ Sampling point may be affected by upstream residential area Daantjie.
	SITE SAMPLED	Yes but water levels were low			
	SUITABLE FOR FUTURE SAMPLING	Yes			

SURVEY SITE	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **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.	▪ Dirt road crossing. ▪ 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			
 **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.	▪ Road crossing. ▪ 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			

SURVEY SITE	SUITABILITY EVALUATION		SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
 **DAM**	SITE VISITED	Yes	LOCATED AT THE DAM ▪ The dam is located in the study area between sampling points NK3 and NK2. ▪ Water quality parameters were taken.		
	SITE SAMPLED	No Not suitable			
	SUITABLE FOR FUTURE SAMPLING	No			

3.2. Conducting the 2017 Baseline Aquatic Assessment

The 2017 baseline aquatic assessment was conducted by Kimberley Perry, and all the sampling points listed in Table 2 were visited between the 9th to the 11th of May 2017.

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 27**.

The outcome of this evaluation indicated that biomonitoring sampling methods could not be applied at sampling points **NK1, NK2, NK3, NK4 and NK5**. Site **NK1** was inaccessible, sites **NK2, NK3, and NK4** were dry, and site **NK5** consisted of small, isolated pools of water.

This implied that **NK6, NK7, NK8, NK9, and NK10** could be further assessed by means of the biomonitoring sampling methods described in paragraph 1.3.1 on page 6 (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"**).

Considering the above, as well as the statutory requirements for biomonitoring surveys, the following methods were used in this biomonitoring survey at these sampling points:

- **Habitat evaluations:**
  - Observations regarding possible impacts and effects at each survey site (see Table 3 on page 27);
  - IHAS evaluation (see **Annexure B.1**); and
  - Measuring relevant *in-situ* water quality parameters and comparing the results obtained with the TWQRs for aquatic ecosystems (see **Annexure B.2**).

- **Species Response evaluations:**
  - Aquatic Invertebrate response evaluation, making use of SASS5 (see **Annexure A.3**).

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 **species response** at **NK6, NK7, NK8, NK9, and NK10** were measured by means of the SASS5 methods. The SASS5 Score-sheets are attached as **Annexure "D"**.

The results obtained during this baseline aquatic assessment at these sites are discussed below.

3.3. Results of 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 4 contains an overview of the conditions observed at NK6. The drivers and biotic responses observed at NK6 is summarised in Table 5.

Table 4: Overview of conditions observed at downstream site NK6

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

10/05/2017

Table 5: 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><i>IN SITU</i> WATER QUALITY</td><td>The visual appearance of the water prior to sampling was clear. The <i>in situ</i> chemical parameters measured (Annexure B) were within the TWQRs for aquatic ecosystems with the exception of DO. Do levels at NK6 were in excess of 100%. This is super saturated and can be indicative of eutrophication. The pH at the site was also slightly elevated (8.50 and 8.59) indicating a more alkaline environment.</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. Dense vegetation surrounds the site. Annexure C contains the IHAS Score Sheets. The IHAS score was 85, which indicates 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 during this survey can be summarised as follows:
<table>
<tr><th></th><th>May 2017</th></tr>
<tr><td><i>SASS5 EC</i></td><td>C</td></tr>
<tr><td>SASS5 score</td><td>131</td></tr>
<tr><td>Number of Taxa</td><td>25</td></tr>
<tr><td>ASPT</td><td>5.24</td></tr>
</table>
Taxa present at this biomonitoring point in high abundances (10-100 individuals) include Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, Vellidae, Gyrinidae, Chironomidae, and Simuliidae.</td></tr>
<tr><td>FISH</td><td>One species of <i>Enteromius trimaculatus</i> was found in the SASS5 net at NK6.</td></tr>
</table>

3.4. Results of 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 6 contains an overview of the conditions observed at NK7. The drivers and biotic response observed at NK7 is summarised in Table 7.

Table 6: Overview of conditions observed at downstream site NK7

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

10/05/2017

Table 7: 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><i>IN SITU</i> WATER QUALITY</td><td>The visual appearance of the water prior to sampling was clear and flow was high but probability of artificial flow is high due to WWTW upstream. The <i>in situ</i> chemical parameters measured (Annexure B) were all within the TWQR's for aquatic ecosystems. DO levels at NK7 were in excess of 100%. This is super saturated and can be indicative of eutrophication.</td></tr>
<tr><td>HABITAT</td><td>The flow is moderate. 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 85, which indicates 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 during this survey can be summarised as follows:
<table>
<tr><th></th><th>May 2017</th></tr>
<tr><td><i>SASS5 EC</i></td><td>C</td></tr>
<tr><td>SASS5 score</td><td>124</td></tr>
<tr><td>Number of Taxa</td><td>23</td></tr>
<tr><td>ASPT</td><td>5.39</td></tr>
</table>
Taxa present at this biomonitoring point in high abundances (10-100 individuals) include Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, Chironomidae, and Simuliidae.</td></tr>
</table>

3.5. Results of 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 6 contains an overview of the conditions observed at NK8. The drivers and biotic response observed at NK8 is summarised in Table 7.

Table 8: Overview of conditions observed at upstream site NK8

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


11/05/2017

Table 9: Drivers and biotic responses at upstream site NK8

INDICATOR	DESCRIPTION
PHYSICO-CHEMICAL DRIVERS	
***IN SITU* WATER QUALITY**	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.
HABITAT	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 73, which indicates a habitat that is acceptable for supporting a diverse macroinvertebrate community.
SPECIES RESPONSE	
INVERTEBRATES	The SASS5 evaluation sheets are contained in **Annexure D**. The SASS5 results obtained during this survey can be summarised as follows: May 2017: *SASS5 EC* C; SASS5 score 140; Number of Taxa 24; ASPT 5.83 Taxa present at this biomonitoring point in high abundances (10-100 individuals) include Baetidae, Caenidae, Leptophlebiidae, Coenagrionidae, Gomphidae, Libellulidae, Corixidae, Gerridae, Notonectidae, Vellidae, Gyrinidae, and Chironomidae.

	May 2017
SASS5 EC	C
SASS5 score	140
Number of Taxa	24
ASPT	5.83

3.6. Results of 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 6 contains an overview of the conditions observed at NK9. The drivers and biotic response observed at NK9 is summarised in Table 7.

Table 10: Overview of conditions observed at upstream site NK9

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

Table 11: 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><i>IN SITU</i> WATER QUALITY</td><td>The visual appearance of the water prior to sampling was opaque. The <i>in situ</i> chemical parameters measured (Annexure B) were all within the TWQR’s for aquatic ecosystems.</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 76, which indicates 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 during this survey can be summarised as follows:
<table>
<tr><th></th><th>May 2017</th></tr>
<tr><td><i>SASS5 EC</i></td><td>C</td></tr>
<tr><td>SASS5 score</td><td>107</td></tr>
<tr><td>Number of Taxa</td><td>23</td></tr>
<tr><td>ASPT</td><td>4.65</td></tr>
</table>
Taxa present at this biomonitoring point in high abundances (10-100 individuals) include Baetidae, Caenidae, Coenagrionidae, Gomphidae, Libellulidae, Simuliidae, Chironomidae, and Thiaridae.</td></tr>
</table>

3.7. Results of Baseline Aquatic Assessment at downstream 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 6 contains an overview of the conditions observed at NK10. The drivers and biotic response observed at NK10 is summarised in Table 7.

Table 12: Overview of conditions observed at upstream site NK10

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

Table 13: Drivers and biotic responses at upstream site NK10

<table>
<tr><th>INDICATOR</th><th>DESCRIPTION</th></tr>
<tr><td colspan="2">PHYSICO-CHEMICAL DRIVERS</td></tr>
<tr><td><i>IN SITU</i> WATER QUALITY</td><td>The visual appearance of the water prior to sampling was opaque. The <i>in situ</i> chemical parameters measured (Annexure B) 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 but still above sub lethal limits.</td></tr>
<tr><td>HABITAT</td><td>The flow was high. 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 72, which indicates 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 during this survey can be summarised as follows:
<table>
<tr><th></th><th>May 2017</th></tr>
<tr><td><i>SASS5 EC</i></td><td>D</td></tr>
<tr><td>SASS5 score</td><td>115</td></tr>
<tr><td>Number of Taxa</td><td>23</td></tr>
<tr><td>ASPT</td><td>5.00</td></tr>
</table>
Taxa present at this biomonitoring point in high abundances (10-100 individuals) include Baetidae, Coenagrionidae, Gomphidae, Libellulidae, Gerridae, Hydroptilidae, Chironomidae, Planorbinae, and Thiaridae.</td></tr>
</table>

3.8. Determination of SASS5 Ecological Category

For the purposes of the baseline aquatic survey 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, and *in situ* water quality. **Species response** was determined by making use of SASS5 methods.

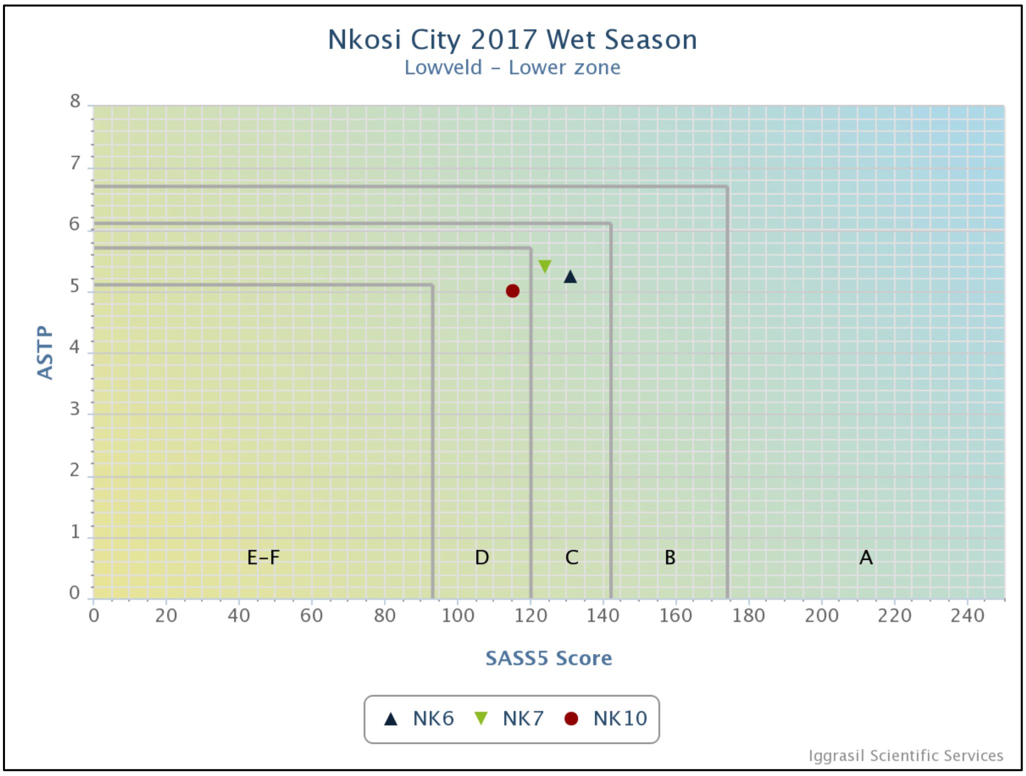


Figure 12: SASS5 Score and ASPT Plot for sampling points at Nkosi City

The SASS5 Score and ASPT for the 2017 baseline aquatic survey at the proposed Nkosi City site in comparison to the biological bands for the Lowveld Ecoregion (Lower zone) (Dallas 2007)

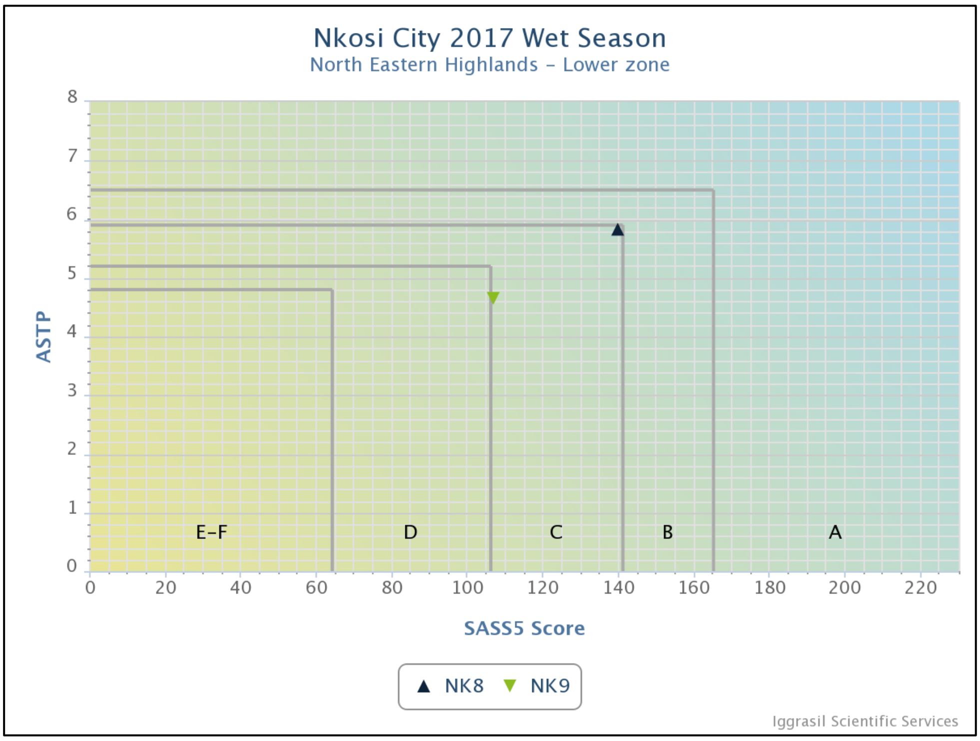


Figure 13: SASS5 Score and ASPT Plot for sampling points at Nkosi City

The SASS5 Score and ASPT for the 2017 baseline 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 C. At downstream sites NK6, NK7 the SASS5 EC was determined to be C, whilst the downstream site NK10 had a SASS5 EC of D.

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 number 2.

The largest impacts which currently face the proposed study area are water quality and water 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 and availability 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, 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 this 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 although already impacted by Daantjie residential areas.

According to proposed plans there will be farming land along this particular unnamed tributary of the Nsikazi River which runs along the South of the study area. 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 an aquatic ecosystem. However, if mitigation measures to address the possible threats to the aquatic ecosystem are followed, the impacts could be lower. These mitigation measures have been listed in Table 16. It is important that any mitigation be implemented in the context of an Environmental Management Plan 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 14.

Table 14: 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.

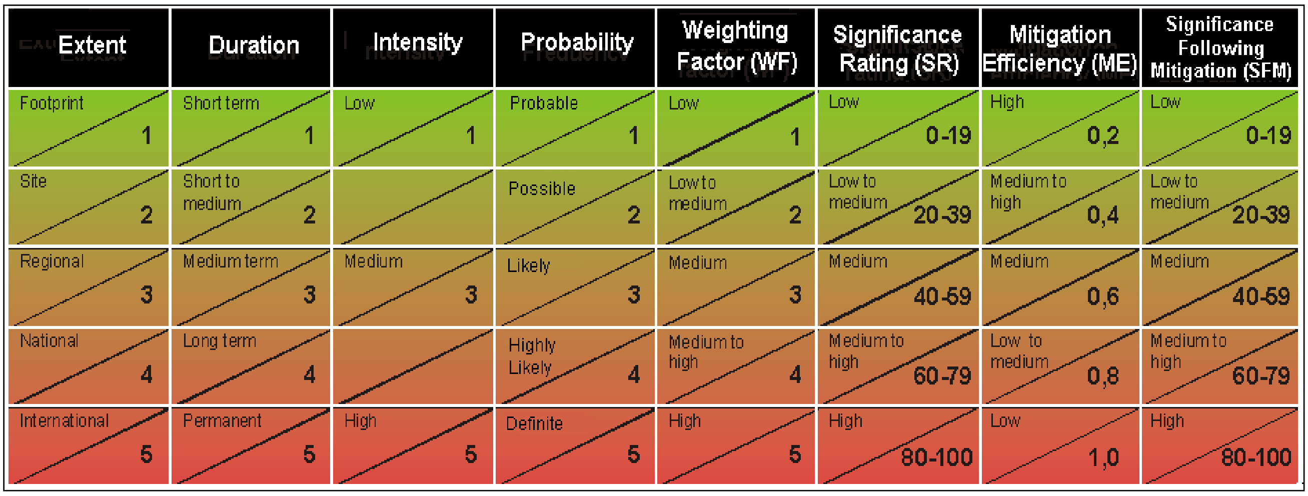
Determination of Significance – With Mitigation – Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation will be rated on the following scale:

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 13 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 13: 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 15: 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
	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 16: 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 soil. 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. 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 Baseline Aquatic Assessment at the proposed Nkosi City development was conducted on the 9th to the 11th of May 2017. 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 **NK1, NK2, NK3, NK4 and NK5**. Site **NK1** was inaccessible, sites **NK2, NK3, and NK4** were dry, and site **NK5** consisted of small, isolated pools of water.

This implied that **NK6, NK7, NK8, NK9, and NK10** could be further assessed by means of the sampling methods. *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.

With regard to **habitat integrity**, the *in situ* chemical parameters measured were all within the TWQRs for aquatic ecosystems, with the exception of Dissolved Oxygen at sampling locations NK6, NK7, and NK10. At sampling sites NK6 and NK7 the DO was above TWQRs for aquatic ecosystems and could possibly indicate a eutrophic system. At sampling location NK10 the DO was below TWQRs for aquatic ecosystems but still above sub-lethal limits.

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 baseline aquatic survey, the results obtained from each of these sampling points can be summarised as follows:

- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK6** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat highly suitable to support a diverse macro-invertebrate community. One species of *Enteromius trimaculatus* was found in the SASS5 net at NK6;

- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK7** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat highly suitable to support a diverse macro-invertebrate community;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK8** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat suitable to support a diverse macro-invertebrate community;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK9** was moderately modified. The SASS5 EC was C although the IHAS score indicated a habitat highly suitable to support a diverse macro-invertebrate community;
- The biotic integrity of the unnamed, non-perennial tributary of the Nsikazi River at site **NK10** was modified. The SASS5 EC was D although the IHAS score indicated a habitat suitable to support a diverse macro-invertebrate community;
- Potential impacts were assessed in terms of consequence and probability and a significance ranking was assigned to every impact.
- Potential impacts that will affect the flow regime of the watercourse were ranked as high prior to mitigation and were ranked as high-medium post mitigation; and
- Potential impacts that will alter the water quality of the area – increasing the amounts of nutrients such as phosphates, nitrites and nitrates, were ranked as high prior to mitigation and were ranked as medium post mitigation.

If alteration of flow regimes and water quality 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 significant decrease in species richness of aquatic fauna and benthic macroinvertebrates.

5.2. Recommendations

A follow up biomonitoring survey which includes a fish assessment should be conducted for the proposed development of the Nkosi City during the wet season. Because DO levels indicated possible eutrophication it is recommended that diatoms are added as a biomonitoring tool during the wet season survey.

The proposed Nkosi City is located approximately five (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 or an updated habitat evaluation method, MERAI, 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.

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 to largely modified. 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.

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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.

Detailed layout plans were not provided to the specialist during the time to report compilation,

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.

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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: 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, 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)

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

A.3: 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

Annexure B: Results – In situ Water Quality

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

Comparison of *in situ* water quality results for the baseline aquatic assessment

SAMPLING POINT	NK5	NK6		NK7		NK8		NK9		NK10		DAM
IHAS Score	NA	85%		85%		73%		76%		72%		NA
IHAS Class description	NA	Highly suitable		Highly suitable		Suitable		Highly suitable		Suitable		NA
Visual appearance of water prior to sampling	Clear	Clear		Clear		Clear		Opaque		Opaque		Opaque
Date	2017/05/10	2017/05/10		2017/05/11		2017/05/11		2017/05/10		2017/05/10		2017/05/09
Time (hh:mm)	11:53	12:23	13:51	15:38	16:47	10:06	11:24	11:53	12:59	8:49	10:06	15:40
Temperature (°C)	20.9	21.5	21.3	21.0	20.0	19.0	19.80	21.0	22.70	19.30	19.10	26.7
pH	7.13	8.50	8.59	8.57	8.56	7.50	7.97	8.31	8.20	7.20	7.49	7.10
EC (mS/m)	38.3	54.7	55.2	56.3	55.6	53.10	53.30	53.30	51.60	40.6	40.30	41.10
DO (%)	**98.90**	**129**	**124**	**106.10**	**106.0**	90.30	90.90	98.40	92.30	**73.40**	**77.20**	**124.8**

Annexure C: IHAS Score Sheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK6**					
Date: 2017/05/10	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)					**15**	
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)					**48**	
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)					**37**	
TOTAL IHAS SCORE					**85 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK7**					
Date: 2017/05/11	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)					**20**	
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)					**14**	
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: ('1-2m^2'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m^2	**rocks**	1-2m^2	<1m^2	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)					**15**	
HABITAT TOTAL (Max. 55)					**49**	
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)					**36**	
TOTAL IHAS SCORE					**85 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: Unnamed Tributary of the Nsikazi River | **Site name: NK8**

Date: 2017/05/11 | 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)					**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: ('1-2m^2'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m^2	rocks	1-2m^2	<1m^2	**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)					**39**	
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					**73 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK9**					
Date: 2017/05/11	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)					**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: ('1-2m^2'=algal bed; 'rocks'=on rocks; 'isol.'=isolated clumps) ***	>2m^2	rocks	1-2m^2	<1m^2	**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)					**15**	
HABITAT TOTAL (Max. 55)					**44**	
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					**76 %**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name: Unnamed Tributary of the Nsikazi River	**Site name: NK10**					
Date: 2017/05/10	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)					**14**	
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)					**15**	
HABITAT TOTAL (Max. 55)					**44**	
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)					**28**	
TOTAL IHAS SCORE					**72 %**	

Annexure D: SASS Version 5 Score Sheets

SASS5 sampling sheet for Sampling Point: NK6

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3				
ANNELIDA						
Oligochaeta	Earthworms	1			1	1
Hirudinea	Leeches	3		1		1
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3	1	1		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				
Baetidae > 2 sp		12	A	B		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		1		1
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		A		A
Corduliidae	Cruisers	8				
Gomphidae	Clubtails	6	B		B	B
Libellulidae	Darters/Skimmers	4	A	A	A	B
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	1			1
*Gerridae**	Pond skaters/Water striders	5		A		A
*Hydrometridae**	Water measurers	6		A		A
*Naucoridae**	Creeping water bugs	7	1	1		A
*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				
Hydropsychidae 1 sp		4				
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		1	A
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6				
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		B
*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				
Chironomidae	Midges	2	A	A	A	B
*Culicidae**	Mosquitoes	1		1		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		B
*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				
Thiaridae =Melanidae*		3	B	B	B	C
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					131
	No. of Taxa					25
	ASPT					5.24

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

Other biota:
Daphnia in Stones Biotope
Fish (one individual of Enteromius paludinosus) found in Vegetation Biotope

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				
Hirudinea	Leeches	3	1			1
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				
Baetidae 2 sp		6	A	B	B	
Baetidae > 2 sp		12				B
Caenidae	Squaregills/Cainfles	6	A	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	1	A		A
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4	1	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	A	B	A	B
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3		1		1
*Corixidae**	Water boatmen	3			1	1
*Gerridae**	Pond skaters/Water striders	5		A		A
*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		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				
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		1		1
*Elmidae/Dryopidae**	Riffle beetles	8		1		1
*Gyrinidae**	Whirligig beetles	5				
*Haliplidae**	Crawling water beetles	5		1		1
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	A			A
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5		1		1
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	A	A		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				
Thiaridae =Melanidae*		3			A	A
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					124
	No. of Taxa					23
	ASPT					5.39

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				
Hirudinea	Leeches	3				
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3	1	1		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	A		
Baetidae > 2 sp		12				B
Caenidae	Squaregills/Cainfles	6	A	A	A	B
Ephemeridae		15				
Heptageniidae	Flatheaded mayflies	13				
Leptophlebiidae	Prongills	9	A	A	A	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	A	1		A
Synlestidae (Chlorolestidae)	Sylphs	8				
Coenagrionidae	Sprites and blues	4	1	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	A	B
Libellulidae	Darters/Skimmers	4	1	A	A	B
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	B
*Gerridae**	Pond skaters/Water striders	5		B		
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7				
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		A	A	B
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5	B		A	B
MEGALOPTERA	Fishflies, Dobsonflies & Alderflies					
Corydalidae	Fishflies & Dobsonflies	8				
Sialidae	Alderflies	6				
TRICHOPTERA	Caddisflies					
Dipseudopsidae		10				
Ecnomidae		8				
Hydropsychidae 1 sp		4	A			A
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				
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6				
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5				
*Elmidae/Dryopidae**	Riffle beetles	8				
*Gyrinidae**	Whirligig beetles	5		B		B
*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	1	1		A
Blepharoceridae	Mountain midges	15				
Ceratopogonidae	Biting midges	5	1	1	A	A
Chironomidae	Midges	2	A		A	B
*Culicidae**	Mosquitoes	1				
*Dixidae**	Dixid midge	10	1			1
Empididae	Dance flies	6				
Ephydridae	Shore flies	3				
Muscidae	House flies, Stable flies	1				
Psychodidae	Moth flies	1				
Simuliidae	Blackflies	5		1	1	A
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5				
Tipulidae	Crane flies	5			1	1
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		A
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					140
	No. of Taxa					24
	ASPT					5.83

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

Other biota:
Daphnia in GSM

Comments/Observations:

SASS5 sampling sheet for Sampling Point: NK9

TAXON		QV	S	VEG	GSM	TOTAL
PORIFERA	Sponge	5				
COELENTERATA (Cnidaria)		1				
TURBELLARIA	Flatworms	3	A			A
ANNELIDA						
Oligochaeta	Earthworms	1	1		A	A
Hirudinea	Leeches	3	1			1
CRUSTACEA						
Amphipoda	Scuds	13				
*Potamonautidae**	Crabs	3	1	1		A
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	A		
Baetidae > 2 sp		12		A		B
Caenidae	Squaregills/Cainfles	6	A	1	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	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	B	B
Libellulidae	Darters/Skimmers	4	B	A	1	B
LEPIDOPTERA	Aquatic Caterpillars/Moths					
Crambidae	Pyralidae	12				

TAXON		QV	S	VEG	GSM	TOTAL
HEMIPTERA	Bugs					
*Belostomatidae**	Giant water bugs	3				
*Corixidae**	Water boatmen	3				
*Gerridae**	Pond skaters/Water striders	5				
*Hydrometridae**	Water measurers	6				
*Naucoridae**	Creeping water bugs	7				
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		A		A
*Pleidae**	Pygmy backswimmers	4				
*Veliidae/M...veliidae**	Ripple bugs	5		1		1
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	A			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	A	1		A
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6				
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5				
*Elmidae/Dryopidae**	Riffle beetles	8	1	1		A
*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			1	1
Chironomidae	Midges	2	B		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	A		B
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5	1	1	1	A
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6		A		A
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3		1		1
*Planorbinae**	Orb snails	3		A		A
Thiaridae =Melanidae*		3	A		B	B
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					107
	No. of Taxa					23
	ASPT					4.65

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

Other biota:
Tadpoles in Vegetation.

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
Hirudinea	Leeches	3			1	1
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				
Baetidae > 2 sp		12		B		B
Caenidae	Squaregills/Cainfles	6	1			1
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		A	1	A
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		B
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		B		B
*Hydrometridae**	Water measurers	6		A		A
*Naucoridae**	Creeping water bugs	7				
*Nepidae**	Water scorpions	3				
*Notonectidae**	Backswimmers	3		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	1			1
Hydropsychidae 1 sp		4				
Hydropsychidae 2 sp		6	A			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	B			B
Hydrosalpingidae SWC		15				
Lepidostomatidae		10				
Leptoceridae		6				
Petrothrincidae SWC		11				
Pisuliidae		10				
Sericostomatidae SWC		13				
COLEOPTERA	Beetles					
*Dytiscidae/Noteridae**	Diving beetles	5				
*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		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				
Chironomidae	Midges	2	1	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		A		A
*Syrphidae**	Rat tailed maggots	1				
Tabanidae	Horse flies	5				
Tipulidae	Crane flies	5				
GASTROPODA	Snails					
Ancylidae	Limpets	6		A		A
*Bulininae**		3				
*Hydrobiidae**		3				
*Lymnaeidae**	Pond snails	3				
*Physidae**	Pouch snails	3		A		A
*Planorbinae**	Orb snails	3	A	A		B
Thiaridae =Melanidae*		3	B	B	A	B
Viviparidae ST*		5				
PELECYPODA	Bivalves					
Corbiculidae	Clams	5				
Sphaeriidae	Pill clams	3				
Unionidae	Perly mussels	6				
	SASS Score					115
	No. of Taxa					23
	ASPT					5.00

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

Other biota:

Comments/Observations:

Annexure E: 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

- Inventory and survey methods for invasive plants, Online Course, Department of land resource of environmental Sciences, Montana State University, Bozeman, Montana. (2009)
- A rapid method for water quality assessment, Nepid Consultants, Sabie (2011)
- EIA water use authorisation and waste management activity licences, Carin Bossman Sustainable Solutions, Pretoria (2011)
- Tools for wetland assessment, Rhodes University, Grahamstown (2011)

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

- **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,**

Completed project list

Please note that this is not a complete project list

Vegetation Reports:

Construction:

2010: Vegetation Survey for Portion 1 of the Farm Doornkloof 391.
2010: Vegetation Survey for the Proposed Resedential Development at Erasmia, Gauteng, South Africa.
2010: Vegetation Survey for the Proposed Longmore Bridge, Pretoria, Gauteng.
2010: Vegetation Survey for the Proposed Township: Clayville X 10, Johannesburg, Gauteng.
2010: Vegetation Survey for the Proposed Filling Station, Newcastle, KwaZulu – Natal
2010: Vegetation Survey for the Bails Bridge, Centurion, Gauteng
2010: Vegetation Survey for the Proposed Hatfield Heights, Pretoria, Gauteng
2011: Vegetation Survey for Portion 37 of the farm Elandsfontein 334 IQ, Gauteng, South Africa

Mining:

2010: Vegetation Survey for the Proposed Vlakvarkfontein Colliery, Mpumalanga, South Africa
2010: Vegetation Survey for the Proposed Buffelskloof Iron Ore Mine, Mpumalanga, South Africa
2011: Background Biodiversity Report for the Wakkerstroom Area, KwaZulu – Natal, South Africa

2011: Flora Desktop Study for the Proposed Boschpoort Colliery, Mpumalanga, South Africa
2011: Flora Desktop Study for the Proposed Welstand Colliery, Mpumalanga, South Africa
2011: Flora Desktop Study for the Proposed Welgemeend Colliery, Mpumalanga, South Africa
2011: Flora Desktop Study for the Proposed Vaalwater Colliery, Mpumalanga, South Africa.
2011: Vegetation Survey for the Proposed Onbekend Colliery, Mpumalanga, South Africa
2011: Vegetation Survey for the Proposed Roodepoort Colliery, Mpumalanga, South Africa
2011: Vegetation Survey for the Proposed Boschpoort Colliery, Mpumalanga, South Africa
2011: Vegetation Survey for the Proposed Welstand Colliery, Mpumalanga, South Africa
2011: Vegetation Survey for the Proposed Welgemeend Colliery, Mpumalanga, South Africa
2011: Vegetation Survey for the Proposed Vaalwater Colliery, Mpumalanga, South Africa

Game farm management:

Tuli Roan and Sable Farm, 2010: Game Farm Management Plan for Tuli Roan and Sable Farm, Tuli Block ,Botswana
J&L Fourie Trust, 2010: Game Farm Management for the Farm Mazunga 184 KT, Gravelotte, Limpopo, South Africa.

Rehabilitation plans:

2011: Provisional Land Rehabilitation Plan for the farm Buffelskloof 141 JS. Limpopo, South Africa
2011: Provisional Land Rehabilitation Plan for the farm Onbekend, Mpumalanga, South Africa
2011: Provisional Land Rehabilitation Plan for the Farm Vlakvarkfontein 213 IR Portion 2, Mpumalanga South Africa
2011: Provisional Land Rehabilitation Plan for the Proposed Roodepoort Colliery, Mpumalanga, South Africa
2011: Provisional Land Rehabilitation Plan for the Proposed Welgemeend Colliery, Mpumalanga, South Africa
2011: Provisional Land Rehabilitation Plan for the Proposed Welstand Colliery, Mpumalanga, South Africa

Aquatic Zoological Reports:

Construction:

2011: Aquatic Ecology Report for the Upgrade of the Sewerage Works at the Modikwa Platinum Mine, Anglo Platinum, Mpumalanga, South Africa
2013: Biomonitoring Report: Burgersfort waste water treatment works upgrade, Mooifontein 313 KT.
2013: Biomonitoring Report: Marble Hall waste water treatment works upgrade, portion of the farm Uyskraal 10 JS.
2013: Biomonitoring Report: Steelpoort waste water treatment works upgrade, Goudmyn 337 KT.
2014: Baseline Aquatic Report: Proposed Township Establishment Blesboklaagte and Leeufontein KOR-EMA-13-12-02

Mining:

2012: Preliminary Biomonitoring Plan: Bankfontein Colliery.
2012: Preliminary Biomonitoring Plan: Brakfontein Colliery.
2012: Preliminary Biomonitoring Plan: Doornrug Colliery.
2012: Preliminary Biomonitoring Plan: Graspan Colliery.
2012: Preliminary Biomonitoring Plan: Grootpan Colliery.
2012: Preliminary Biomonitoring Plan: Kangra Siding Colliery. 2012: Preliminary Biomonitoring Plan: Kleinfontein Colliery.
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2012: Preliminary Biomonitoring Plan: Proposed Springboklaagte Colliery.
2012: Preliminary Biomonitoring Plan: Steelecoal Colliery.
2012: Preliminary Biomonitoring Plan: Uitkyk Siding Colliery.
2012: Preliminary Biomonitoring Plan: Proposed Wonderfontein Colliery.
2012: Dry Season Biomonitoring Report: Bankfontein Colliery.
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2012: Wet Season Biomonitoring Report: Bankfontein Colliery.
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2013: Dry Season Biomonitoring Report: Steelecoal Colliery.
2013: Dry Season Biomonitoring Report: Uitkyk Siding Colliery.
2013: Dry Season Biomonitoring Report: Proposed Wonderfontein Colliery.
2013: Baseline aquatic ecology assessment for the proposed Pegasus Mine.

2014: Wet Season Biomonitoring Report: Bankfontein Colliery.
2014: Wet Season Biomonitoring Report: Brakfontein Colliery.
2014: Wet Season Biomonitoring Report: Doornrug Colliery.
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2014: Dry Season Biomonitoring Report: Uitkyk Siding Colliery.
2014: Dry Season Biomonitoring Report: Proposed Wonderfontein Colliery.
2014: Dry season aquatic ecology assessment for the proposed Pegasus Mine.
2014: Dry season Biomonitoring Report: Chlemsford Colliery
2014: Dry season Biomonitoring Report: Dama Colliery
2014: Dry season Biomonitoring Report for the Proposed Pegasus Colliery

2015: Wet Season Biomonitoring Report: Chlemsford Colliery
2015: Wet Season Biomonitoring Report: Dama Colliery
2015: Wet Season aquatic Zoological Basline Report for the Krugersdrop Game Reserve, Mogale City, Gauteng.
2015: Wet Season Biomonitoring Report: Bankfontein Colliery.
2015: Wet Season Biomonitoring Report: Brakfontein Colliery.
2015: Wet Season Biomonitoring Report: Doornrug Colliery.
2015: Wet Season Biomonitoring Report: Graspan Colliery.
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2015: Wet Season Biomonitoring Report: Uitkyk Siding Colliery.
2015: Wet Season Biomonitoring Report: Wonderfontein Colliery

Nature conservation:

2014: Dry season baseline aquatic zoological report: Mogale City – Krugersdrop Game Reserve.

Wetland Reports:

2011: Vierfontein Colliery: Wetland Assessment Report. Mentored and reviewed by Stephan Veldsman.
2012: Wetland Health and function for the proposed Tzaneen X100. Mentored and reviewed by Piet-Louis Grundling.
2013: Wetland Health and function for the proposed Tzaneen Waterfront Development. Mentored and reviewed by Piet-Louis Grundling.