AQUATIC ASSESSMENT FOR THE PROPOSED BRONKHORSTSPRUIT DEVELOPMENT



AQUATIC BIO-MONITORING SURVEY AND WETLAND DELINEATION FOR THE PROPOSED BRONKHORSTSPRUIT DEVELOPMENT

PREPARED FOR:

I-CAT INTERNATIONAL CONSULTING & TRADING (PTY) LTD AFRICA

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30200307/09/200
Rev 2
28 October 2016

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REPORT NO 30200307/09

OCTOBER 2016

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I-CAT INTERNATIONAL CONSULTING & TRADING (PTY) LTD

AQUATIC ASSESSMENT FOR THE PROPOSED BRONKHORSTSPRUIT DEVELOPMENT

REPORT NO 30200307/11

OCTOBER 2016

EXECUTIVE SUMMARY

Knight Piésold (Pty) Ltd was appointed by I-CAT International Consulting & Trading (Pty) Ltd to conduct the aquatic assessment for the Environmental Authorisation (EA) process and the Water Use Licence Application of the proposed Bronkhorstspruit Development. The aquatic assessment included the aquatic bio-monitoring of the Bronkhorstspruit as well as the lineation of any wetland areas within 500m of the proposed development. This report concerns the impacts of the proposed development on the aquatic ecosystem.

The aim of this report was:

- To describe the Present Ecological State of the aquatic ecosystem in the area of the Bronkhorstspruit development
- Assess the possible impacts of the proposed developments on the aquatic ecosystems during the various phases, in terms of the relevant temporal and spatial scales determined of the Extent, Magnitude and Duration criteria associated with a particular impact
- Provide measures to mitigate the potential detrimental impacts of the proposed development
- Assess the overall significance of the possible impacts after mitigation measures are applied.

Present Ecological State (PES)

Macro Invertebrates

The Present Ecological State of aquatic macroinvertebrate in the Bronkhorstspruit during the surveys in October 2016 ranged between Category C (Moderately Modified) downstream and Category D (Largely Modified) upstream of the proposed development. Not all sites presented suitable habitat availability for macro invertebrates. A large number of taxa sensitive to water quality were recorded in the Bronkhorstspruit.

Fish

The Present Ecological State of fish in the Bronkhorstspruit in 2016 ranged between a Category E (Severely Modified) at the impact site and a Category F (Critically Modified) at the control and downstream points. No alien fish were recorded. No IUCN significant fish species were recorded.

Wetland

The presence of a wetland was verified during field investigations and one hydrogeomorphic wetland type was identified namely a valley bottom without a channel. The wetland covers 5.2 ha and is located approximately 300m to the north east of the proposed development.

The wetland area showed some signs of disturbance as it is situated on a livestock farm and was categorised as a PES of C, indicating a moderately modified state.

Potential Impacts

The impacts described below relates to the potential impacts on the Bronkhorstspruit that flows adjacent to the proposed development. No impact is envisaged on the wetland.

Construction phase:

- Surface water pollution
- Increase in surface water runoff leading to erosion
- Sedimentation of the aquatic environment.

Operational phase:

- Increase in surface water runoff leading to potential erosion of the Bronkhorstspruit embankment
- Surface water pollution from increased runoff and possible hydrocarbon contamination from fuel station and parking areas

Mitigation

Key mitigation measures include:

- Hazardous products should be stored off site
- Vehicles should be parked on impermeable surfaces to prevent hydrocarbon spillages
- General housekeeping and waste management measures should be implemented to avoid littering and dumping
- Design surface water management infrastructure to minimise the surface water runoff impact on the Bronkhorstspruit.
- The extent of exposed soils at one time should be limited
- Construction footprints should be minimised

- Low-level berms and sediment traps should be placed at low gradient points on the construction site.

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1 INTRODUCTION

1.1 Background Information

The Bronkhorstspruit proposed development is located along the R25 on route to the Bronkhorstspruit Dam. The proposed development will include a shopping centre and fuel station. The Environmental Authorisation (EA) process for the proposed development is being undertaken by I-CAT International Consulting & Trading (Pty) Ltd.

Knight Piésold (Pty) Ltd was appointed to undertake the aquatic assessment specialist study to form part of the Environmental Authorisation and Water Use Licence Process. The project area is located along the Bronkhorstspruit downstream of the Bronkhorstspruit Dam.

1.2 Scope of Report

The aquatic assessment report is broken down in two parts:

Part 1: Aquatic Specialist Study

- To provide feedback on the Aquatic Bio-monitoring for the September 2016 survey
- To assess the Present Ecological State (PES) of the Bronkhorstspruit
- To assess potential impacts of the proposed development on the aquatic ecosystem
- To provide mitigation and early detection of any possible impacts on the aquatic ecosystem.

Part 2: Wetland Specialist Study

- Hydrogeomorphic setting of the wetland
- Delineation of the wetland system
- WET-Health and WET Eco Services assessment of the wetland
- Potential impact of infrastructure on the wetland
- Mitigation measures for the proposed infrastructure

2 SITE DESCRIPTION

2.1 General Site Characteristics

The proposed site is located along the R25, downstream of the Bronkhorstspruit Dam in the north-eastern part of Gauteng. The study area is shown in Figure 1:

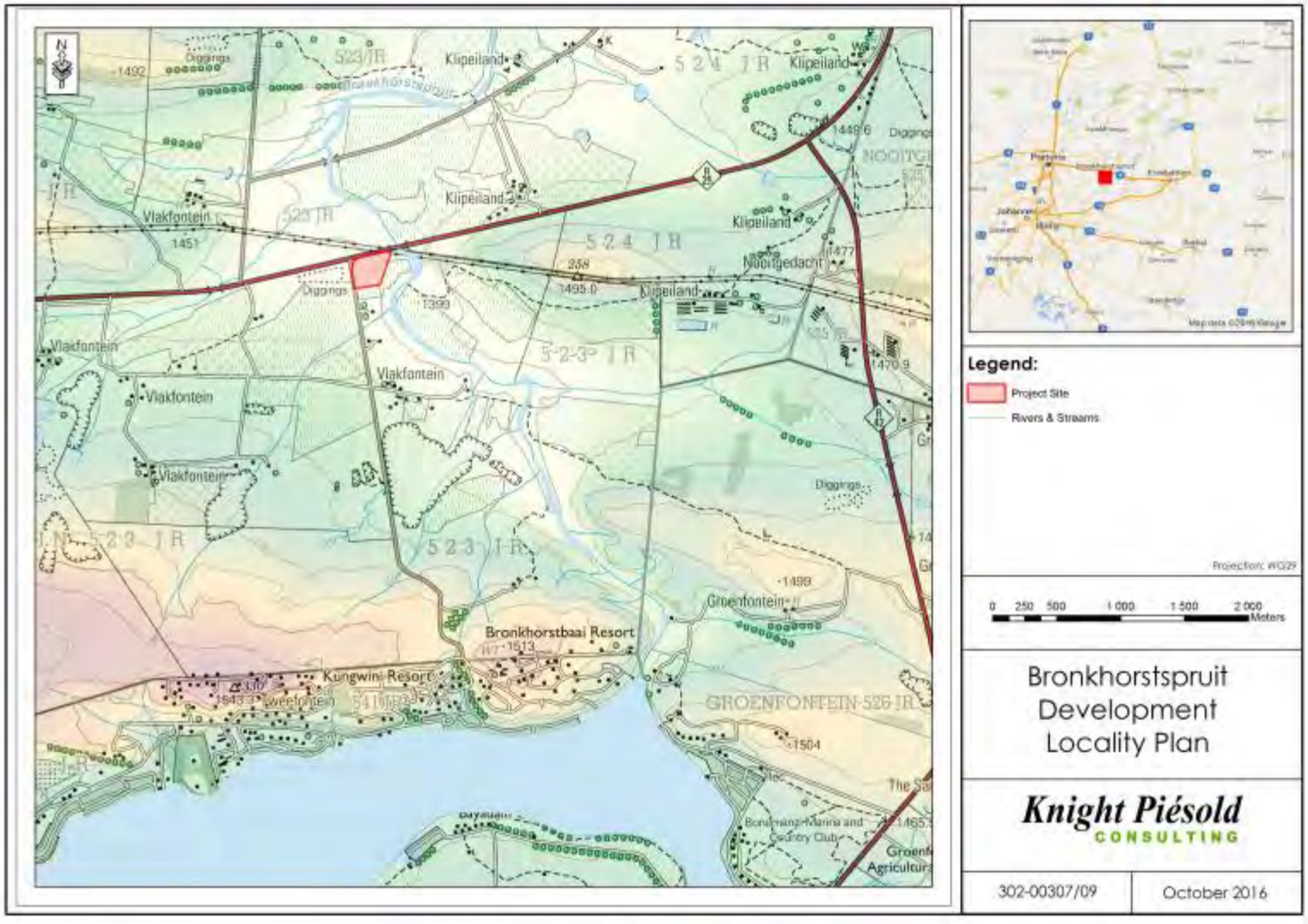

Figure 1: Location of Proposed Development Site

2.2 Catchments

The proposed development is situated within the Olifants River Catchment (Primary Catchment B) and within quaternary catchment B20D. The Bronkhorstspruit Dam is located upstream of the study area. The Bronkhorstspruit drains into the Wilge River which eventually flows into the Olifants River further north-east of the study area.

The catchment size, mean annual runoff and rainfall for the quaternary catchment are provided in the table below (Middleton et al., 1990).

Table 1: Catchment data

Quaternary Catchment	Catchment Surface Area km^2	Mean Annual Precipitation (MAP) in mm	Mean Annual Run-off (MAR) in mm
B20D	480	677	36

2.3 Sites selected for aquatic bio-monitoring

Bio-monitoring has not been conducted previously at the proposed development therefore aquatic bio-monitoring points were pre assessed with the use of GIS imagery and verified during the site assessment. The GPS co-ordinates of the sampling points were taken on site. Three bio-monitoring sites were identified to assess the Present Ecological State (PES) and identify possible impacts on the Bronkhorstspruit.

The bio-monitoring sites are illustrated in Figure 2 and further described in Table 2 below.

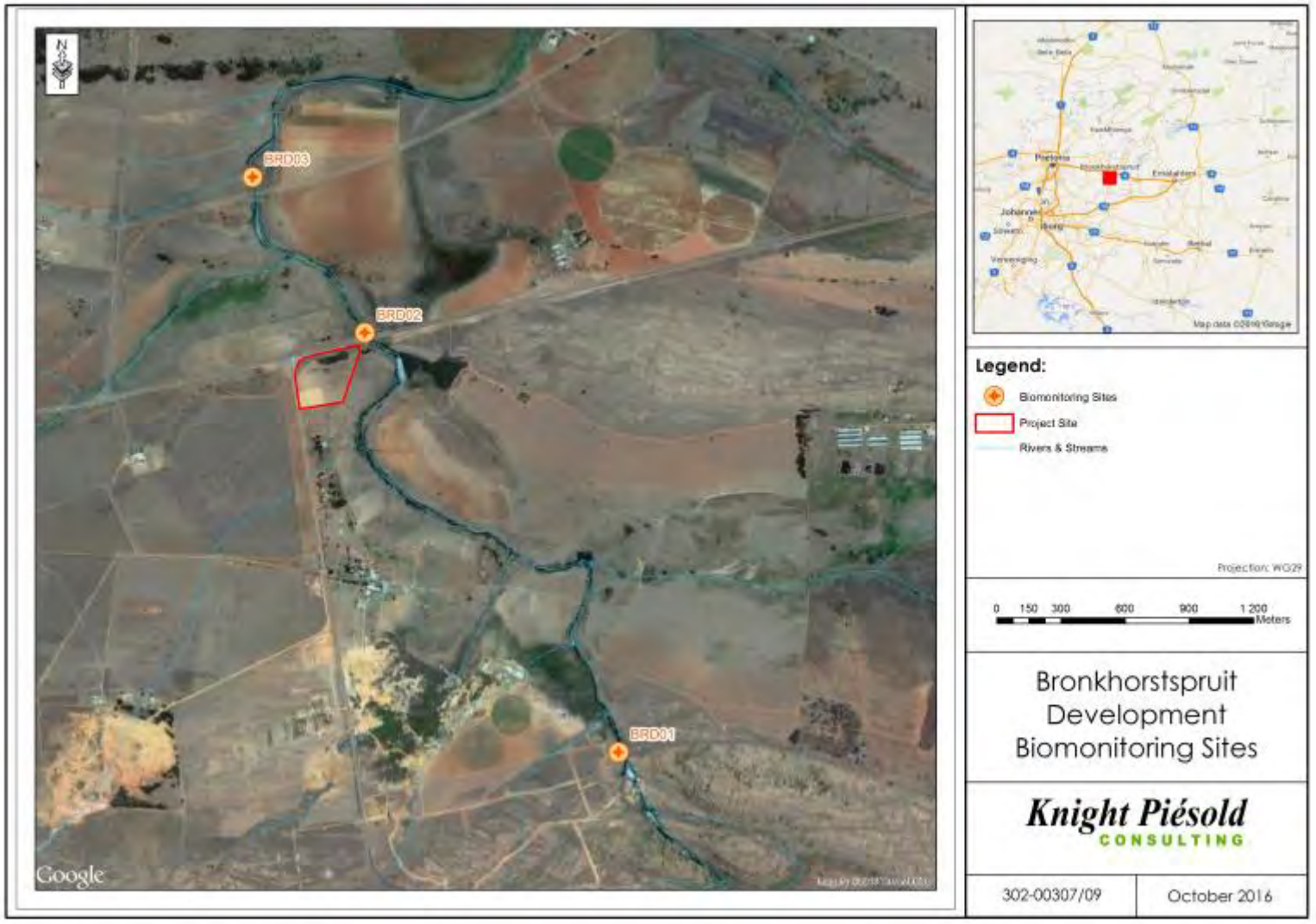

Figure 2: Locality of the Aquatic Bio-monitoring Sites

Table 2: General Description of the Bio-monitoring Sites

Site Code	Description	Distance From Development (km)	Position UTM (WGS 84)
BRD 01	The upstream site, located along a developing eco-estate downstream of the Bronkhorstspruit Dam, will be used as the control site to monitor the possible impact of the proposed development on the Bronkhorstspruit. The riverbed was comprised predominantly of bedrock, with scattered patches of sand and gravel.	-2.78	25 52' 25.802" S 28 42' 51.394" E
BRD 02	Impact site, located at the R25 bridge adjacent to the proposed development. The impact site will be used to determine the PES of the Bronkhorstspruit directly down gradient of the proposed development.	0.12	25 51' 21.998" S 28 42' 08.942" E
BRD 03	Downstream site, located further downstream within the Bronkhorstspruit at the Cathie Road bridge.	1.11	25 50' 58.300" S 28 41' 50.155" E

2.4 Wetland Identification

A preliminary desktop wetland assessment was conducted using 1:10 000 orthophotos and Google Earth imagery. All rivers (if present) and wetness signatures were identified within 500m of the proposed development on the maps for further investigation in the field (Figure 3).

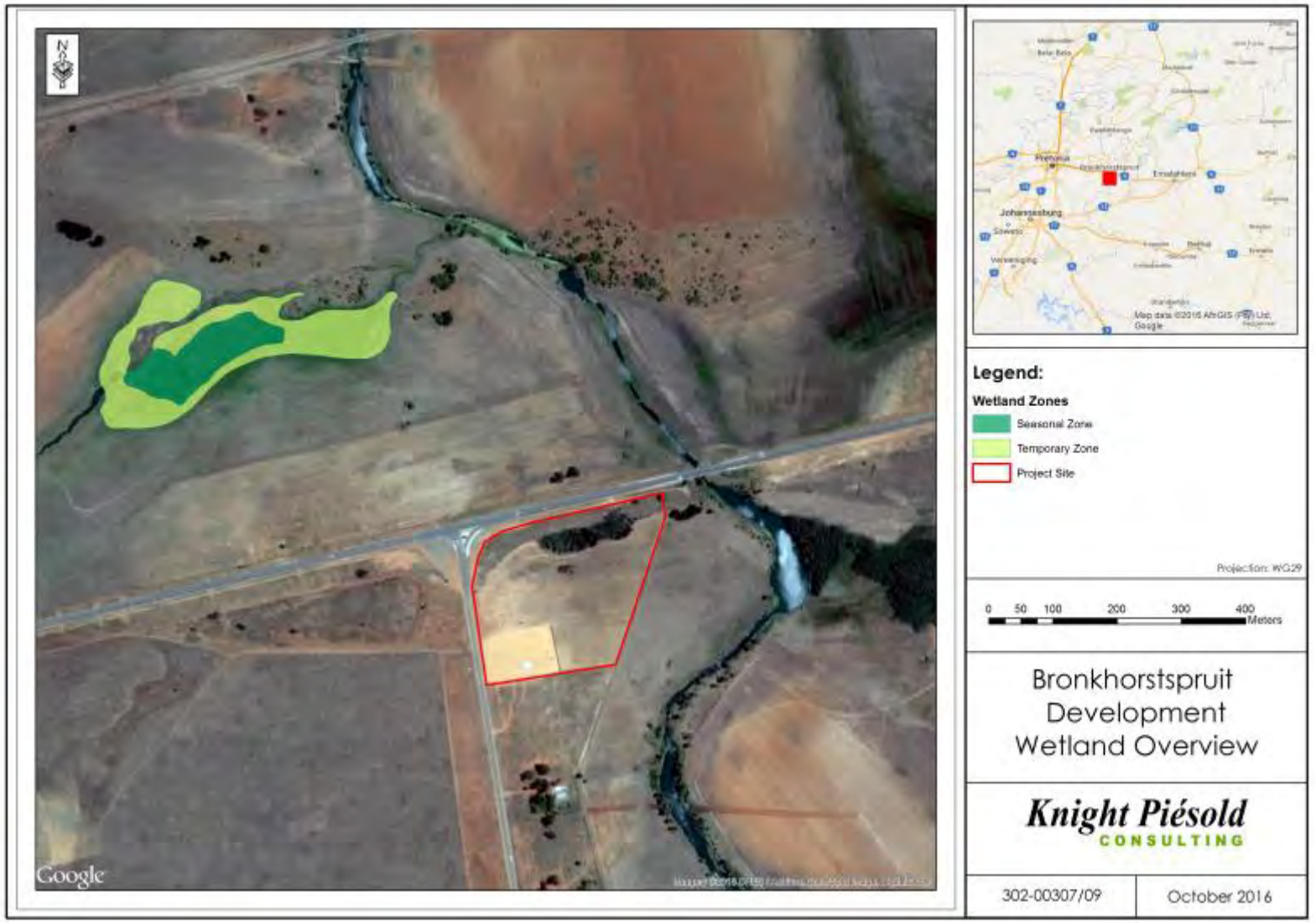

Figure 3: Identified wetland area in relation to project area

3 METHODS

3.1 Aquatic Bio-monitoring

The South African River Eco-status Monitoring Programme (REMP) was designed to measure, assess and report on the general state of rivers and to provide an overview of the ecological health of the rivers. The REMP incorporates the application of biological indicators and relevant non-biological indicators (indices) to assess the condition or "health" of the aquatic ecosystems. This assessment was based on selected abiotic and biotic components.

The results of these indices are presented in the form of one of six Present Ecological State (PES) categories. The categories range from an "A" to an "F" state. The categories and state descriptions are represented in Table 3 below.

Table 3: Present Ecological State

PES	PES Name	Description
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Severely Modified	Seriously modified
F	Critically Modified	Critically or extremely modified

The following ecological indicators were selected to represent the general ecological components involved in the aquatic environment:

- ***In situ* water quality** – pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Temperature (^{o}C) and Dissolved Oxygen concentration (mg/l).
- **Visual assessment** – In-stream habitat conditions include a general description of each site, GPS locations, photographs for future reference and surrounding features that may lead to pollution.
- **Invertebrate Habitat Assessment** – habitat suitability available for macro-invertebrates such as Stone, Vegetation and GSM (Gravel, Sand and Mud).
- **Invertebrates** – Benthic aquatic invertebrates comprise of a wide range of taxa that live in streams and rivers. Abundance and compositions of invertebrate communities reflect water quality and in stream habitat conditions.
- **Ichthyofauna –** Fish typically reflect water quality and instream habitat conditions. The presence of fish species provides a valuable biological indicator of aquatic health in the long term.

3.1.1 Water Quality

Water quality is used to describe the physical, chemical, biological and aesthetic properties of water that determine its fitness for a variety of uses and for the protection of the health and integrity of aquatic ecosystems (DWAF, 1996).

The following water quality parameters were determined during the field survey using the Ex-Tech II EC500 multi-parameter probe and Ex-Tech DO600 dissolved oxygen meter field instruments:

- pH
- Total Dissolved Solids
- Electrical Conductivity (mS/m)
- Temperature (^{o}C)
- Dissolved oxygen (DO).

The above mentioned parameters provide an *in-situ* picture of the current water quality at the time of the survey and can be used as an early detection system for any water quality changes.

3.1.2 Visual Assessment

Each site was assessed by in-stream conditions such as morphology, hydrology and general site description. Photographic evidence was taken at each site as a representation of the conditions during the survey.

3.1.3 Invertebrate Habitat Assessment System (IHAS)

IHAS evaluates the availability of suitable habitat for macro-invertebrates and expresses the availability and suitability as a percentage as described above. IHAS scores were interpreted according to the guidelines of McMillan 2002, adapted from McMillan 1998, as follows:

- <55% inadequate habitat
- 55-65% adequate habitat
- >65% good habitat.

The IHAS has been tested and found to be an unsatisfactory method of quantifying invertebrate habitat suitability (Ollis *et al*., 2006). As this study forms part of WUL conditions, IHAS will still be utilised and compared to a suitable simple five points scale as per the SASS 5 sheet.

Each habitat category was assigned weighted importance value that varied according to the geomorphological stream type. The weighted values were multiplied by the suitability rating (0-5), and the results were expressed as a percentage, where 100% indicates that all habitats highly suitable. The percentage values were converted to a Present Ecological State Category (A to F), to allow easy comparison among sites or sampling events.

3.1.4 Aquatic Invertebrates

The South African Scoring System Version 5 (SASS 5) (Dickens and Graham, 2002) is a rapid bio-assessment method to assess the integrity of macro-invertebrates in flowing aquatic ecosystems. The REMP utilises this index to detect the water quality of ecosystems. The index assigns each taxon with a sensitivity score that is used to indicate an overall average score per taxon (ASPT).

Benthic macro-invertebrates, in particular, are recognised as valuable organisms for bio-assessments, due largely to their visibility to the naked eye, ease of identification, rapid life cycle often based on the seasons and their largely sedentary habits (Dickens and Graham, 2002). Sampling was conducted using a standard size SASS net with mesh <1mm, dislodging macro-invertebrates from their habitat substrates into the water column and catching the invertebrates in the net.

SASS Data Interpretation Guidelines (Dallas, 2007) were used to interpret the SASS 5 information collected during the survey. The guidelines method utilises natural variation in SASS 5 scores and ASPT to determine preliminary biological bands. The study area falls within the Level 1 Ecoregion for the Western Bankenveld and the SASS5 score and ASPT values were evaluated according to these bands. Figure 4 below indicates the Western Bankenveld – Upper and Lower Zones biological band.

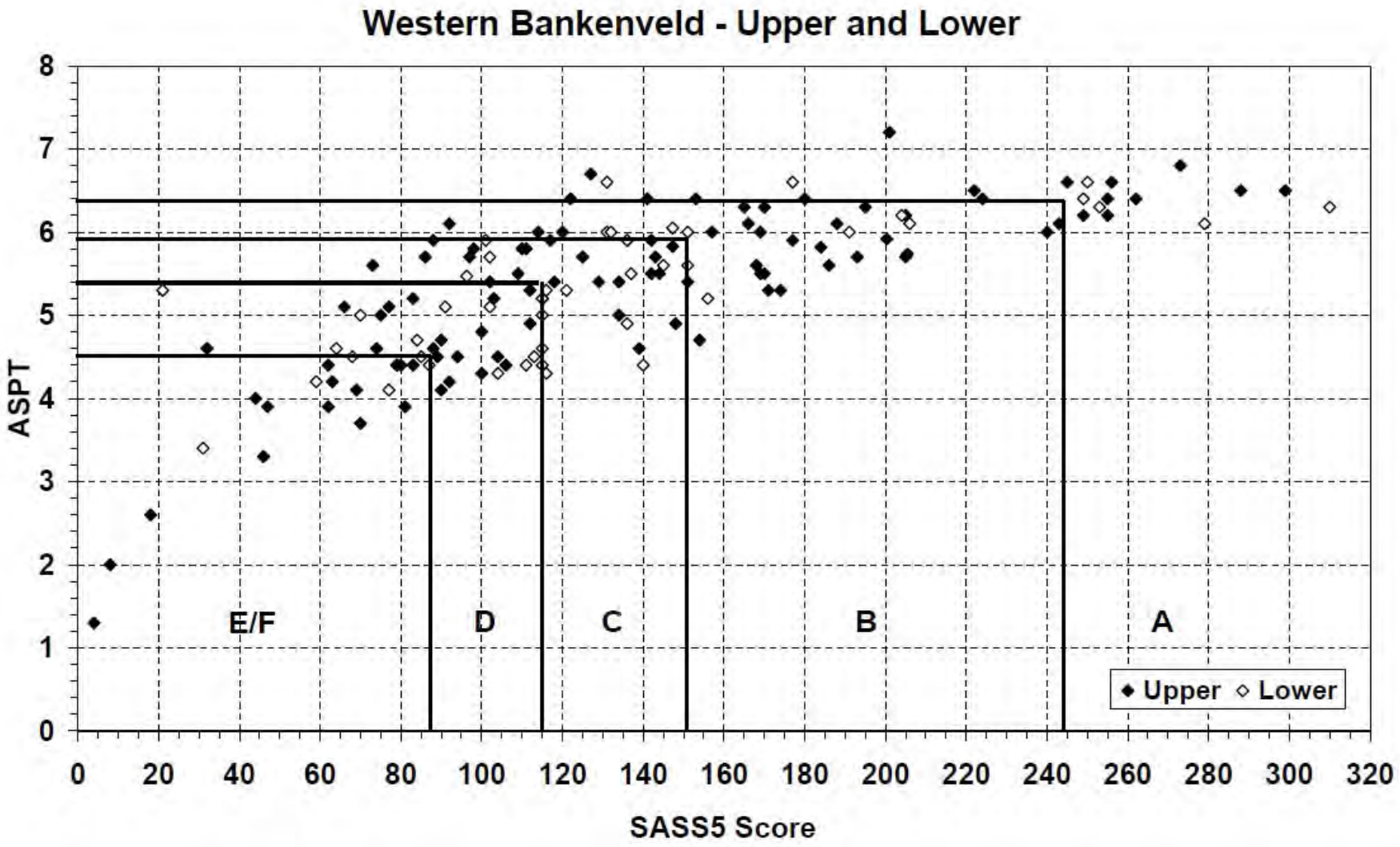

Figure 4: Biological bands for the Western Bankenveld – Upper and Lower zones, calculated using percentiles

3.1.5 Ichthyofauna (Fish)

Fish were sampled using a portable, battery operated electro-fisher (Samus 725M). This is a standard method of sampling fish, and is less prone to biased sampling of certain species than other methods of sampling. Sampling effort at each site varied between about 10 to 30 minutes, depending on the catch.

The Present Ecological State of the fish assemblage was assessed using the species intolerance component of the Fish Assemblage Integrity Index (FAII) (Kleynhans, 1999). The species intolerance values for all species that were recorded at each site were added to obtain a total intolerance score (Kleynhans, 2003). The total scores were expressed as a percentage of the total intolerance scores for species that were expected. The results were classified using a six-point scale, as shown in Table 4.

Table 4: Guidelines used to delineate the Present Ecological State Categories of fish based on comparison and total Observed and Expected intolerance ratings (Kleynhans, 2008).

Category	Description	% of Expected
A	Unmodified, or approximate natural conditions closely	90 to 100
B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification	80 to 89
C	Moderately Modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class.	60 to 79
D	Largely Modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderately intolerant species. Impairment of health may become more evident at the lower limit of this class.	40 to 59
E	Seriously Modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become very evident.	20 to 39
F	Critically Modified. An extremely lowered species richness and absence of intolerant species. Only tolerant species may be present with a complete loss of species at the lower limit of the class. Impairment of health generally very evident	0 to 19

3.2 Wetland Assessment

3.2.1 Wetland Delineation and Classification

During the field investigation, wetlands were identified and delineated according to the delineation procedure set out by "*A Practical Field Procedure for the Identification and Delineation of Wetlands and Riparian Areas*", described by the Department of Water Affairs and Forestry (DWAF), 2003.

The delineation of the actual wetland boundaries used indirect indicators of prolonged saturation such as wetland plants (hydrophytes) and wetland soils (hydromorphic soils) with emphasis on the hydromorphic soils. According to the DWAF 2003 field procedure, soils at 50 cm from the surface should indicate signs of wetness (mottling and gleying).

To determine the boundaries of the wetland, soil samples were taken starting with the wettest part of the wetland and proceeding outwards at regular intervals to check for the soil wetness and vegetation indicators. Each sampling point was sampled at a depth of 0-10 cm and at 40-50 cm.

Wetlands were classified using a Munsell Soil Colour Chart, including the use of soil and vegetation characteristics used in the delineation of wetlands and the determination of wetland zones (Kotze *et al*., 1994).

The information recorded in the field was used as input into the Wetland Assessment Tools:

- WET-Health is an Excel based tool that formulates the appropriate information to determine the health of the wetland system. A score is provided, dependent on the information input, to present the wetland with a Present Ecological State (PES).
- WET-Eco Services is another Excel based tool that provides us with the services that the wetland offers in terms of various aspects such as biodiversity. The services potential of the wetland can be assessed before and after mitigation to determine the efficiency of the recommended mitigation measures.

The Ecological Importance and Sensitivity (EIS) score was formulated according to the guidelines (DWAF, 1999). The EIS provides a guideline for the determination of the Ecological Management Class (EMC), Table 5 below. A series of 10 determinants were assessed for the EIS on a scale of 0 to 4, where 0 indicates no importance and 4, a high importance.

Table 5: Interpretation of Median Scores for the Ecological Importance and Sensitivity Categories

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal Floodplains that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

4 RESULTS AND DISCUSSION

A detailed site visit was undertaken in September 2016 to determine the PES / EIS for the aquatic ecosystems and identify any potential impacts from the proposed development. All the detailed results for the various components are attached in the Appendices.

4.1 Aquatic Bio-monitoring

4.1.1 BRD 01

Plate 1:Upstream of site BRD 01

Plate 2: Downstream BRD 01

BRD 01 located upstream of the proposed construction site within the Bronkhorstspruit was sampled as a control site. The site was accessed through the Jumanji Equestrian and Eco Estate. The sample site had an open, deep channel that limited sampling to areas which were accessible. The surrounding impacts include the clearing of vegetation, developments and some agricultural activities on the eastern side.

4.1.1.1 Water Quality

Table 6: *In-situ* water quality results for site BRD 01

Sample Point	Date	pH	Temp	TDS (mg/l)	Conductivity (mS/m)	DO (mg/l)
DWAF Ecosystem Guidelines		**6.5 – 9.0**	**5 – 30**	**<1100**	**<154**	**>5.0**
BRD 01	28/09/2016	8.6	18.3	274	39.2	5.7

The general water quality parameters at site BRD 01 were within acceptable values, and none had exceeded the DWAF Ecosystem Guidelines as seen in the results above.

4.1.1.2 IHAS

The IHAS score for site BRD 01 indicated that inadequate habitat was available for macro-invertebrates with a score of 47 %. The sample site had limited availability of gravel, sand and mud (GSM) biotope. The alternative method utilised according to the SASS 5 methodology indicate a 29 % suitability score.

4.1.1.3 Aquatic Invertebrates

A SASS 5 score of 102 was obtained with an ASPT of 4.6 across 22 taxa recorded during the survey. Site BRD 01 was categorised as a category D (Largely Modified), which may be attributed to inadequate habitat being available for macro invertebrates. The most sensitive taxa present include Baetidae >2 sp., Aeshnidae (Hawkers & Emperors), Atyidae (Freshwater Shrimps) and Hydracarina (Mites).

4.1.1.4 Ichthyofauna (Fish)

One of the twelve expected fish species within the Bronkhorstspruit, was recorded at BRD 01, namely *Pseudocrenilabrus philander* (Southern Mouth Brooder). As a result of only one of the twelve species being present at this location, a FAII percentage of 6.0 % was obtained, rating this site as a category F (Critically Modified). Sampling was limited to shallow sections of the river with some vegetation cover for fish species.

4.1.2 BRD 02

Plate 3: Upstream of site BRD 02

Plate 4: Downstream of site BRD 02

Site BRD 02 (impact site) was located adjacent to the proposed development site at the R25 Bridge. The impact site provided all biotopes for sampling with the only surrounding impact being small scale livestock farming. The river substrate was dominated by the stone substrate with some isolated stretches of sand. The site had moderate water levels and flow.

4.1.2.1 Water Quality

Table 7: *In-situ* water quality results for site BRD 02

Sample Point	Date	pH	Temp	TDS (mg/l)	Conductivity (mS/m)	DO (mg/l)
DWAF Ecosystem Guidelines		**6.5 – 9.0**	**5 – 30**	**<1100**	**<154**	**>5.0**
BRD 02	28/09/2016	8.3	22.8	263	36.9	4.4

All of the general *in situ* water quality parameters fall within the acceptable DWAF Aquatic Ecosystem guidelines, with the exception of the DO concentration falling below guideline thresholds.

4.1.2.2 IHAS

Site BRD 02 indicated had inadequate macro-invertebrate habitat availability, obtaining an IHAS score of 54 %. Both bedrock and mud biotopes were not present at this site. The alternative SASS method provided a 33 % habitat suitability score.

4.1.2.3 Aquatic Invertebrates

Site BRD 02 obtained a category D (Largely Modified) with a SASS 5 score of 100 with a total of 20 taxa recorded with an ASPT of 5.0. The most sensitive taxa present at this site include the Hydropsychidae >2 sp., Baetidae 2 sp. (Mayflies), Leptophlebiidae (Prongills), Hydracarina (Mites) and Atyidae (Freshwater Shrimp).

4.1.2.4 Ichthyofauna (Fish)

The site provided good aquatic and marginal vegetation cover for fish species with a variation between deeper pools and shallow moderate flowing water. Three of the expected twelve fish species were present at BRD 02, namely *Chiloglanis pretoriae* (Sawfin Suckermouth), *Clarias gariepinus* (Sharptooth Catfish) and *Tilapia sparrmanii* (Banded Tilapia). The FAII score obtained for this site was 29.9 %, therefore BRD 02 obtained a PES rating of category E (Severely modified).

4.1.3 BRD 03

Plate 5: Upstream of site BRD 03

Plate 6: Downstream of site BRD 03

The site BRD 03 was located further downstream of the proposed construction site within the Bronkhorstspruit to provide a PES of the river downstream. The site was located at the Cathie Road Bridge. All biotopes were available for sampling with decent cover for fish species. The surrounding impacts within the area are limited to livestock grazing and agricultural activities. The river provided moderate flow and water levels with the ecological water release from the Bronkhorstspruit Dam providing sufficient water levels downstream of the dam.

4.1.3.1 Water Quality

Table 8: *In-situ* water quality results for site BRD 03

Sample Point	Date	pH	Temp	TDS (mg/l)	Conductivity (mS/m)	DO (mg/l)
DWAF Ecosystem Guidelines		**6.5 – 9.0**	**5 – 30**	**<1100**	**<154**	**>5.0**
BRD 03	28/09/2016	8.1	19.3	221	32.2	3.5

The DO concentration at Site BRD 03 is below the guideline value of 5.0 mg/l and could be due to the algal growth present at the site. All other *in situ* parameters at BRD 03 were within the DWAF Aquatic Ecosystem guidelines for the September 2016 survey.

4.1.3.2 IHAS

The IHAS score obtained for this site was 59 %, indicating that there was adequate invertebrate habitat availability present at this site, whilst the SASS 5 biotope suitability method provided a score of 36 %.

4.1.3.3 Aquatic Invertebrates

The SASS score obtained for BRD 03 was 130, with 26 taxa present, resulting in an ASPT of 5.0 and a PES rating of category C (Moderately Modified). There was an increased abundance of aquatic vegetation at this site, increasing the available habitat for certain taxa. The most sensitive taxa recorded at BRD 03 during the September survey was Crambidae (Pyralidae), Leptophlebiidae (Prongills), Atyidae (Freshwater Shrimp) and Ecnomidae (Caddisflies).

4.1.3.4 Ichthyofauna (Fish)

Only two of the expected twelve species of fish were recorded at Site BRD 03, namely *Pseudocrenilabrus philander* (Southern Mouth Brooder) and *Tilapia sparmanii* (Banded Tilapia). The FAII score obtained was 11.9 % categorising this site as category F (Critically Modified). Site BRD 03 yielded the highest number of fish, which may be attributed to the increased vegetative cover provided by the abundant aquatic vegetation.

4.2 Wetland Delineation

The National Water Act, Act 36 of 1998, defines wetlands as follows:

"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 land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

One wetland area was identified within a 500 m radius of the proposed development area, a valley bottom wetland. The wetland area is located approximately 360 m to the north-west of the project area on an adjacent cattle farm. The wetland area was created due to the impoundment of the drainage line flowing from the west to the Bronkhorstspruit. The impoundment overflows during the rainy season creating a small channel and surrounding soil wetness.

Plate 7: Impoundment of drainage line

Plate 8: Wetland area below the impoundment area

The valley bottom wetland was delineated in two zones namely temporary and seasonal zones as seen in Figure 5. The Gauteng Department of Agriculture and Rural Development (GDARD) requirements for biodiversity assessments require a 50 m buffer zone for wetlands outside urban areas and were applied to the delineated wetland (Figure 6).

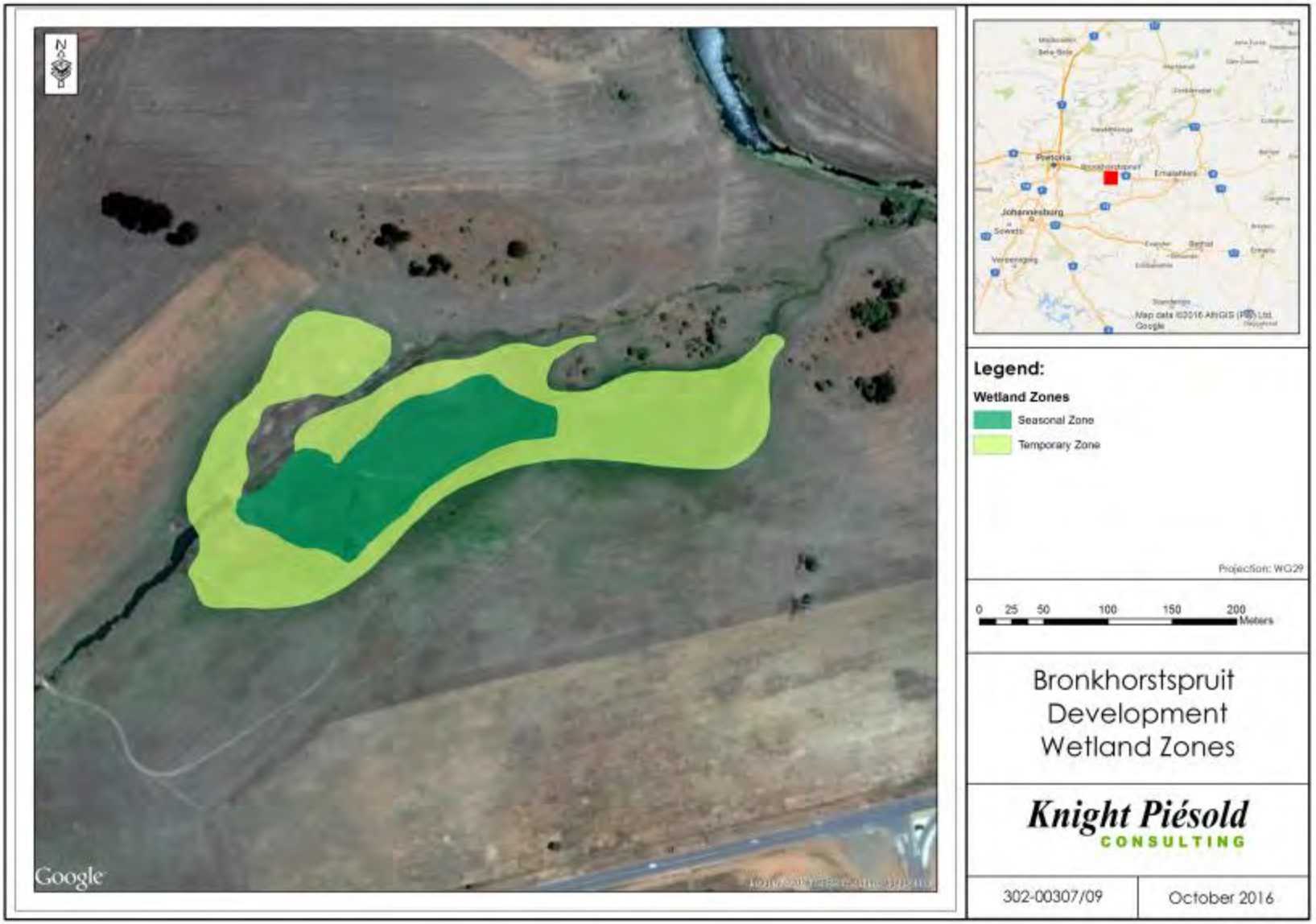

Figure 5: Wetland Delineation

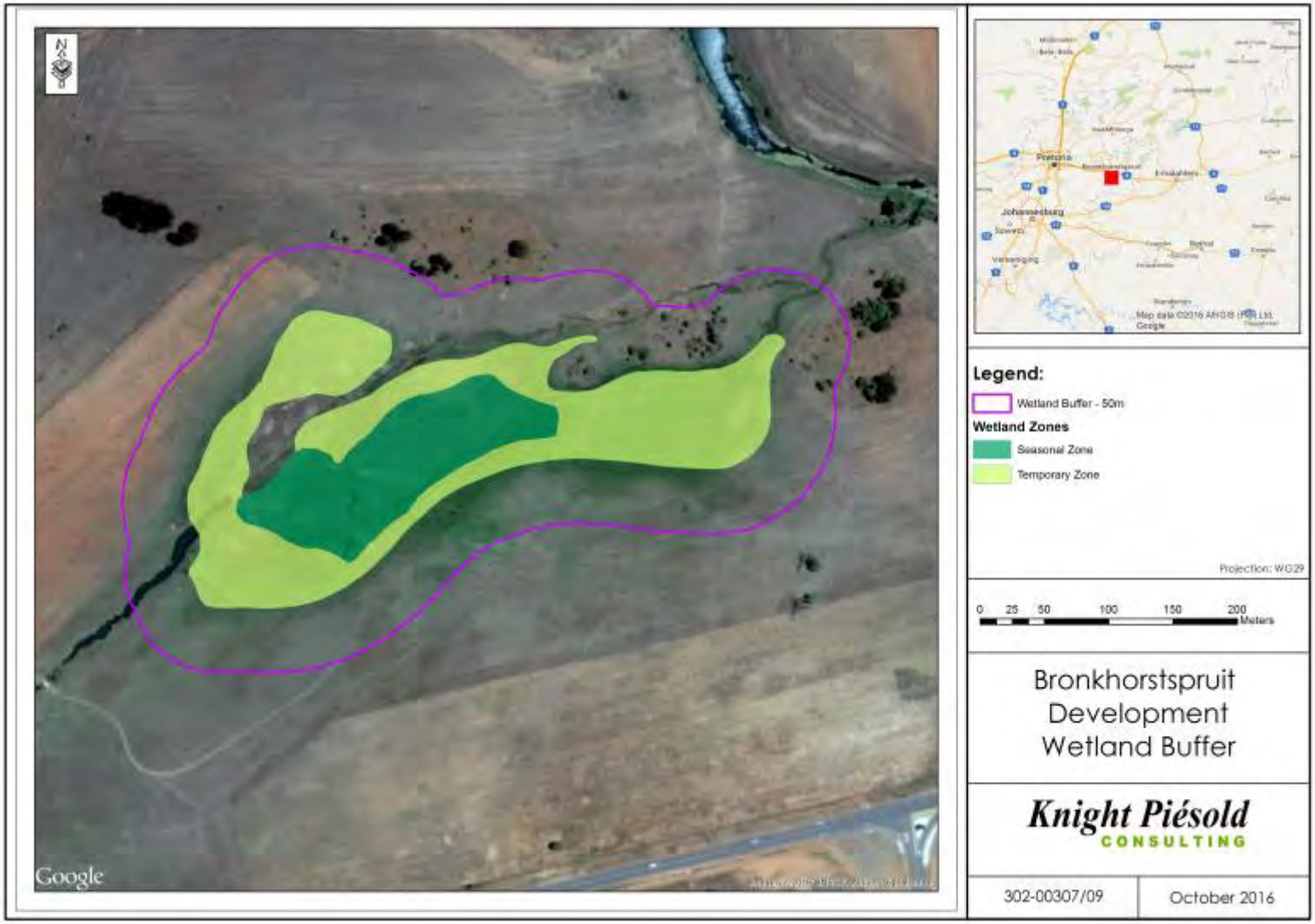

Figure 6: Delineated Wetland with 50m buffer zone

4.2.1 Present Ecological State (Health)

A series of tools were designed to assist and standardise the assessment of wetland systems across South Africa. To determine the PES of the wetland, the WET-Health tool was used.

Wet-Health comprises three modules: a hydrological, geomorphological and vegetation module; each one providing indicators that collectively contribute to determining the PES.

4.2.1.1 Hydrology

The hydrological change associated with the wetland would be the irrigation activities within the area and surface water runoff into the drainage channel that flows into the wetland area.

The change to the hydrology (the deviation at this site compared to a pristine site) is considered to be small with a total impact score of 1.5 suggesting a health category of B as seen in Table 9 below.

Table 9: Hydrology PES

HGM Unit	HGM Type	Impact Score	Health Category
1	valley bottom without a channel	1.5	B

Table 10: Summary of impact scores and health category associated with changes hydrology

Description	Impact Score Range	Health Category
No discernible modifications or the modifications are of such a nature that they have no impact on the hydrological integrity.	0-0.9	A
Although identifiable, the impact of the modifications on the hydrological integrity are small	1-1.9	B
The impact of the modifications on the hydrological interity is clearly identifiable, but limited	2-3.9	C
The impact of the modifications is clearly detrimental to the hydrological integrity. Approximately 50% of the hydrological integrity has been lost	4-5.9	D
Modifications clearly have an adverse effect on the hydrological integrity. 51% to 79% of the hydrological integrity has been lost	6-7.9	E
Modifications are so great that the hydrological functioning has been drastically altered. 80% or more of the hydrological integrity has been lost.	8-10	F

4.2.1.2 Geomorphology

The change in geomorphology is limited to surface run off from the upstream drainage channel and sub-surface drainage that will increase the sediment load within the hydrogeomorphic (HGM) unit. The wetland has a general slope of 1.3% that gives it a protected state of erodibility.

The impact of the modifications on the geomorphological integrity is small, with an impact score of 1.5 and a health category of B as seen in Table 11 below.

Table 11: Geomorphology PES

HGM Unit	HGM Type	Impact Score	Health Category
1	Valley Bottom without drainage channel	1.5	B

Table 12: Summary of impact scores and health category associated with changes in geomorphology

Description	Impact Score Range	Health Category
Unmodified, natural	0-0.9	A
Largely natural with few modifications. A slight change in geomorphic processes is discernible but the system remains largely intact	1 - 1.9	B
Moderately modified. A moderate change in geomorphic processes has taken place but the system remains predominantly intact	2 - 3.9	C
Largely modified. A large change in geomorphic processes has occurred and the system is appreciably altered.	4 - 5.9	D
Greatly modified. The change in geomorphic processes is great but some features are still recognisable.	6 - 7.9	E
Modifications have reached a critical level as geomorphic processes have been modified completely	8 - 10	F

4.2.1.3 Vegetation

The wetland area was created on farm land used for grazing and the vegetation in the wetland indicates that some disturbance has taken place. The vegetation in the seasonal zone has been altered to dominant wetland species with the temporary zone dominated by grassland.

An overall impact score of 3.8 was obtained, categorising the vegetation PES to category C as seen in Table 13 below. Due to grazing by livestock, the vegetation will deteriorate slightly in the next 5 years.

Table 13: Vegetation PES

HGM Unit	HGM Type	Impact Score	Health Category
1	Valley Bottom with a channel	1.3	B

Table 14: Summary of impact scores and health category associated with changes in vegetation

Description	Impact Score Range	Health Category
Vegetation composition appears natural.	0-0.9	A
A very minor change to vegetation composition is evident at the site.	1-1.9	B
Vegetation composition has been moderately altered but introduced alien and/or ruderal species are still clearly less abundant than characteristic indigenous wetland species	2-3.9	C
Vegetation composition has been largely altered and introduced alien and/or ruderal species occur in approximately equal abundance to the characteristic indigenous wetland species.	4-5.9	D
Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species.	6-7.9	E
Vegetation composition has been totally or almost totally altered, and if any characteristic species still remain, their extent is very low.	8-10	F

4.2.1.4 Overall Health for the wetland

The overall WET Health for the HGM unit within the project area, given its relative contributions from each component, indicates a health category of C. The category C health indicates that the wetland system has been moderately modified with limited change to the natural system and may slightly deteriorate over the next 5 years.

4.2.2 Ecosystem Services Assessment

Wetlands are regarded as important components of the landscape in which they occur, as they are associated with a number of functions that are of value to society. These functions include water quality improvement, flood attenuation and biodiversity support.

To determine the function of the wetland, the broader catchment should be taken into consideration as the catchment plays a major role in the functionality of the wetland system. WET-EcoServices was used to assess the ecosystem services for the affected wetland system.

4.2.2.1 Pre-development assessment (current state)

The figure below shows a summary of the functions expected to be performed by the valley bottom wetland.

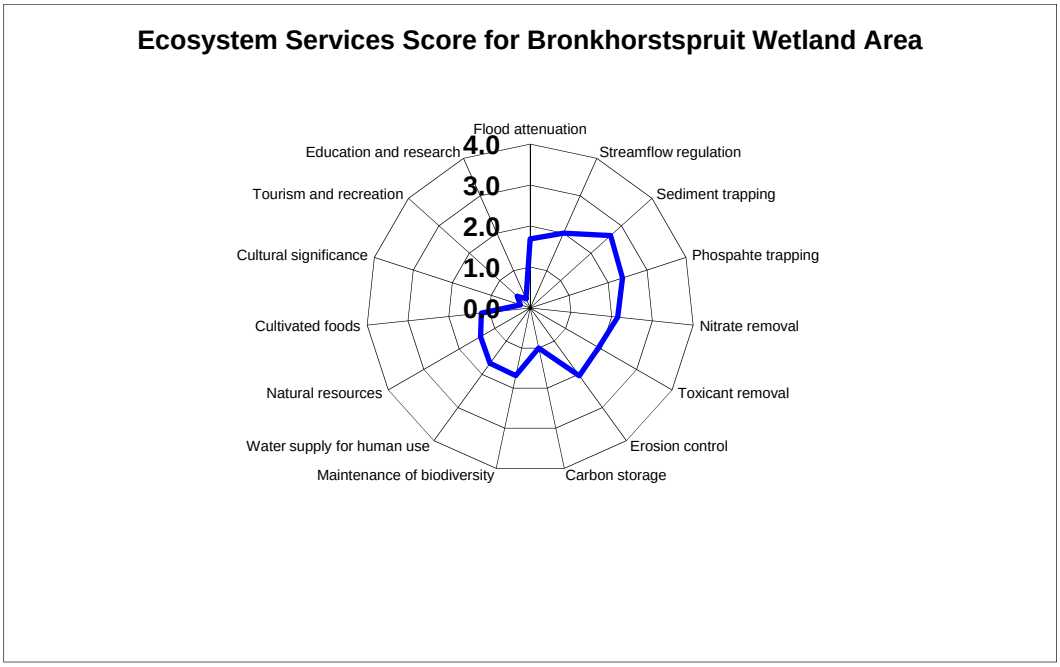

Figure 7: Radial plot indicating ecosystem functions associated with the wetland

The main ecosystem services associated with the wetland area is sediment trapping and erosion control from increased associated surface water runoff into the wetland.

The removal of organics, such as phosphates and nitrates, could be expected as the runoff is collected in the wetland and organics are prevented from washing further down the system.

The wetland has no tourism and recreation services associated as the wetland is located on a farm. The wetland system has created some habitat for biodiversity, especially birds.

4.2.2.2 Post development assessment

It is not envisaged that the proposed development will have any impact on the wetland area and thus a post development assessment was not conducted, as it will not alter the ecosystem services currently provided.

4.2.3 Wetland ecological importance and sensitivity (EIS)

According to the DWAF 1999, “ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system’s ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and Sensitivity provides a guideline for determination of the Ecological Management Class (EMC).

The EIS was conducted according to the DWAF guidelines (1999) for the one HGM unit found in the wetland system. Results for the EIS are presented in Table 15 below:

Table 15: Interpretation of median scores for biotic and habitat determinants to determine the EIS

Determinant	Score
PRIMARY DETERMINANTS	
Rare & Endangered Species	0
Populations of Unique Species	0
Species/taxon Richness	0
Diversity of Habitat Types or Features	1
Migration route/breeding and feeding site for wetland species	1
Sensitivity to Changes in the Natural Hydrological Regime	2
Sensitivity to Water Quality Changes	2
Flood Storage, Energy Dissipation & Particulate/Element Removal	3
MODIFYING DETERMINANTS	
Protected Status	0
Ecological Integrity	3
TOTAL	12
MEDIAN	1
OVERALL ECOLOGICAL SENSITIVITY AND IMPORTANCE	**Low/Marginal**
ECOLOGICAL MANAGEMENT CLASS	**D**

5 IMPACT ASSESSMENT

An impact rating methodology was provided by the client to determine the potential impact of the proposed development on the aquatic system. The assessment of impacts will focus on the construction and operational phase of the proposed development.

5.1 The Proposed Project

A proposed development is being planned in the Bronkhorstspruit area. The development will include a shopping centre and fuel station located within the project area. The Bronkhorstspruit development is located on the bank of the Bronkhorstspruit and within 500 m of a wetland area.

The potential impacts of the proposed development on the aquatic systems will be addressed. Mitigation measures will be identified per impact to guide the design team.

5.1.1 Summary of Potential Impacts

The impacts described below relates to the impact on the Bronkhorstspruit that flows adjacent to the proposed development. No impact is envisaged on the wetland.

Construction phase:

- Surface water pollution by hydrocarbons, cement or concrete
- Increase in surface water runoff leading to erosion
- Sedimentation of the aquatic ecosystem.

Operational phase:

- Surface water runoff.

5.1.2 Detailed Potential Impacts and Mitigations

5.1.2.1 Construction Phase

Surface Water Pollution

The proposed development will be constructed up gradient of the Bronkhorstspruit making the aquatic system susceptible to pollution. Dust generated during construction activities, eroded sediments, leaked hydrocarbons from construction vehicles, runoff containing cement or concrete, litter and hazardous substances may enter into the Bronkhorstspruit.

The impact is considered as a negative *low* impact before mitigation and will remain *low* after mitigation.

Mitigation measures

- Hazardous products should be stored in a bunded area away from the watercourse
- Vehicles should be parked on impermeable surfaces to prevent hydrocarbon spillages
- General housekeeping and waste management measures should be implemented to avoid littering and dumping
- The Bronkhorstspruit watercourse should be declared a no-go area for contractors.

Increase Surface Water Runoff

As the proposed project area will be cleared of all vegetation, surface water runoff into the Bronkhorstspruit will increase. The increase in surface water runoff may lead to erosion and the increase of inorganic material being washed into the aquatic system. The impact is considered to have a *medium* significance pre- and post-mitigation.

Mitigation measures
Design surface water management infrastructure to minimise the surface water runoff impact on the Bronkhorstspruit. Ensure that stormwater control structures with energy dissipaters are incorporated into the design of the shopping complex and filling station.

Sedimentation

During the construction phase the project area will be cleared of all vegetation providing cleared areas open for erosion during rainfall events. The eroded sediment may wash down gradient into the Bronkhorstspruit increasing the silt load within the system and changing the riverbed as well as disturbing the macro invertebrate habitat. The impact is considered to be a negative low significance impact.

Mitigation measures

To reduce the risks of sediment loss:

- The extent of exposed soils at one time should be limited
- Construction footprints should be minimised
- Low-level berms and sediment traps should be placed down gradient of the construction area.

5.1.2.2 Operational Phase

The impacts identified during the construction phase are likely to continue during the operational phase because of their extent and are therefore not repeated.

Surface water pollution

During the operational phase, the fuel station and associated parking area to the shopping centre will increase the possibility of hydrocarbon runoff into the Bronkhorstspruit. The surface water management infrastructure needs to contain oil traps and drains to intercept the water from the area before entering into the aquatic ecosystem.

Table 16: Summary of potential impact during construction and operational phase

Aspect	Extent	Magnitude	Duration	Probability	Reversibility	Irreplacable loss of resources	Mitigation	Confidence	Cumulative	Significance pre-mitigation	Significance post-mitigation
Surface water pollution within the Bronkhorstspruit due to surface water runoff (hydrocarbons etc)	Site	Medium	Long Term	Unlikely	Reversible	Low	High	Sure	Medium	Low	Low
Increase in surface water runoff	Regional	Medium	Long Term	Probable	Reversible	Low	Medium	Sure	Medium	Medium	Medium
Sedimentation	Site	Medium	Short Term	Probable	Reversible	Low	Medium	Sure	Medium	Low	Low

5.1.3 Wetland Impact

No impact is envisaged from the proposed Bronkhorstspruit development, as the wetland area is located approximately 300m to the north-east and up-gradient of the project area (Please refer to Figure 3). The wetland is recharged from the upstream drainage channel that was impounded and artificially created. The wetland is unlikely to have geohydrological recharge and thus it is not envisaged that the development will have any impact on the wetland.

6 CONCLUSION

The following conclusions could be made from the survey:

6.1 Aquatic Bio-monitoring

6.1.1 BRD 01

- Site BRD 01 located upstream of proposed construction site served as control site
- The *in-situ* water quality parameters for the upstream point indicated no exceedances to the DWAF Ecosystem guidelines
- BRD 01 had inadequate habitat suitability for macro-invertebrates. The sample site had limited availability of gravel, sand and mud (GSM) biotope
- The invertebrate PES for the site was rated as a category D (Largely Modified)
- BRD 01 was rated as a category F (Critically modified) for the Fish Assembly index.

6.1.2 BRD 02

- BRD 02 located at the bridge near the proposed construction site serving as the impact site for the bio-monitoring
- With the exception of the low DO concentration, *in-situ* water quality parameters indicated no exceedances to the DWAF Ecosystem guidelines

- BRD 02 had inadequate habitat suitability for macro-invertebrates with representatives of all three biotopes not being available
- The invertebrate PES was categorised as category D (Largely Modified)
- The Fish Assembly Index categorised BRD 02 as category E (Severely Modified)

6.1.3 BRD 03

- Site BRD 03 was located further downstream of the proposed construction site
- The DO concentration at Site BRD 03 is below the guideline value of 5.0 mg/l and could be due to the algal growth present at the site. All other parameters were within guideline values
- The IHAS score for BRD 03 found the habitat suitability to be adequate with all three biotopes available
- The invertebrate PES was categorised as C category (Moderately Modified)
- The Fish Assembly Index categorised BRD 03 as category F (Critically Modified).

6.2 Wetland Delineation

The presence of a wetland was verified during field investigations and one hydrogeomorphic wetland type was identified namely, a valley bottom without a channel. The wetland covers 5.2 ha and is located approximately 300 m to the north-east of the proposed development.

The wetland area showed some signs of disturbance, as it is situated on a livestock farm and was categorised as a PES of C, indicating a moderately modified state.

The nature of the proposed development is such that no impact is envisaged on the wetland area.

7 RECOMMENDATIONS

Aquatic bio-monitoring should continue during the construction phase to ensure that the Bronkhorstspruit is not impacted by the construction of the development.

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APPENDIX 1:
INTEGRATED HABITAT ASSESSMENT SYSTEM

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Bronkhorstspruit	**Date: 28/09/2016**					
Site Code: BRD 01						
SAMPLING HABITAT	**0**	**1**	**2**	**3**	**4**	**5**
Stones-in-current (SIC)						
Total length (m) of broken water (riffles or rapids)	none	0-1	>1-2	>2-3	<3-5	>5
Total length (m) of submerged stones in current (run	none	0-2	>2-5	>5-10	>10	
Number of separate SIC areas kicked (not individual stones)	0	1	2-3	4-5	6+	
Average size (cm) of stones kicked (gravel<2, bedrock >20)	none	<2,<20	2-10	11-20	2-20	
Amount fo stone surface clear (of algae, sediment, silt etc)*	n/a	0-25	26-50	51-75	>75	
Protocal: time (mins) spent actually kicking SIC (grvl/bedr=0)	0	<1	<1-2	2	>2-3	>3
**Note: up to 25% of stones is usually embedded in stream bottom.*	**SIC Score (max. 20)**				**11**	
Vegetation						
Length (m) of fringing vegetation sampled (banks)	none	0-½	>½ - 1	>1-2	2	>2
Amount (m^2) of aquatic vegetation / algae sampled	none	0-½	>½ - 2	>1		
Fringing vegetation sampled in: (none; pool or still only; run only; mixture of both)	none		run	pool		mix
Type of veg (% leafy vegetation vs stems/shoots) (aqv only = 49)	none	0	1-25	26-50	51-75	>75
	Veg Score (max. 15)				**12**	
Other Habitat / General						
Stones-out-of-current (SOOC) sampled: (protocol = $1m^2$)	none	0-½	>½-1	1	>1	
Sand sampled: (protocol = 1min) (present, but only below stones)	none	below	0-½	>½-1	1	>1
Mud sampled: (protocol = 1/2min) (present, but only below stones)	none	below	0-½	½	>½	
Gravel sampled: (protocol=1/2min) if all, SIC stone size =<2)**	none	0-½	½	>½ **		
Bedrock sampled (all=no SIC, sand, gravel) (if all, SIC stone size > 20)**	none	some			All **	
Algae present (1-2m2=algal bed, rocks=on rocks, isol=isolated clumps)	>$2m^2$	rocks	1-$2m^2$	<$1m^2$	Isol.	none
Tray identification (using time as per protocol)		under		Correct		over
** *Note still fill in SIC section*	**Other Habitat Score (max. 20)**				**5**	
	HABITAIT TOTAL (max.55)				**28**	
STREAM CHARACTERISTICS	**0**	**1**	**2**	**3**	**4**	**5**
Physical						
River make up (pool = pool/dam only; run only; rapid/riffle only; 2mix = 2 types etc)	pool		run	Rapid / riffle	2mix	3mix
Average stream width (m)		>10	5-10	<1	1-2	>2-5
Average stream depth (m)	>2	>1-2	1	>½ - 1	½ - ¼	<¼
Approximate stream velocity (slow ≤ 1m/s; fast ≥1m/s)	still	slow	fast	med.		mix
Water colour (disc = discoloured with visible colour but still clearish)	silty	opaque		disc.		clear
Recent disturbances due to: (constr = construction; fl/dr = flood/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 bare banks; farm = farmland/settlements)***	erosn.	farm	trees	other		open
Left bank cover (%) (rocks and vegetation; shear = 0%)	0-50	51-80	81-95	>95		
Right bank cover (%) (rocks and vegetation; shear = 0%)	0-50	51-80	81-95	>95		
	Stream Conditions Total (max.45)				**19**	
***Note: if more than one option, choose lowest*						
	TOTAL IHAS SCORE %:				**47**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Bronkhorstspruit	**Date: 28/09/2016**					
Site Code: BRD 02						
SAMPLING HABITAT	**0**	**1**	**2**	**3**	**4**	**5**
Stones-in-current (SIC)						
Total length (m) of broken water (riffles or rapids)	none	0-1	>1-2	>2-3	<3-5	>5
Total length (m) of submerged stones in current (run	none	0-2	>2-5	>5-10	>10	
Number of separate SIC areas kicked (not individual stones)	0	1	2-3	4-5	6+	
Average size (cm) of stones kicked (gravel<2, bedrock >20)	none	<2,<20	2-10	11-20	2-20	
Amount fo stone surface clear (of algae, sediment, silt etc)*	n/a	0-25	26-50	51-75	>75	
Protocal: time (mins) spent actually kicking SIC (grvl/bedr=0)	0	<1	<1-2	2	>2-3	>3
**Note: up to 25% of stones is usually embedded in stream bottom.*	**SIC Score (max. 20)**				**15**	
Vegetation						
Length (m) of fringing vegetation sampled (banks)	none	0-½	>½ - 1	>1-2	2	>2
Amount (m^2) of aquatic vegetation / algae sampled	none	0-½	>½ - 2	>1		
Fringing vegetation sampled in: (none; pool or still only; run only; mixture of both)	none		run	pool		mix
Type of veg (% leafy vegetation vs stems/shoots) (aqv only = 49)	none	0	1-25	26-50	51-75	>75
	Veg Score (max. 15)				**10**	
Other Habitat / General						
Stones-out-of-current (SOOC) sampled: (protocol = $1m^2$)	none	0-½	>½-1	1	>1	
Sand sampled: (protocol = 1min) (present, but only below stones)	none	below	0-½	>½-1	1	>1
Mud sampled: (protocol = 1/2min) (present, but only below stones)	none	below	0-½	½	>½	
Gravel sampled: (protocol=1/2min) if all, SIC stone size =<2)**	none	0-½	½	>½ **		
Bedrock sampled (all=no SIC, sand, gravel) (if all, SIC stone size > 20)**	none	some			All **	
Algae present (1-2m2=algal bed, rocks=on rocks, isol=isolated clumps)	>$2m^2$	rocks	1-$2m^2$	<$1m^2$	Isol.	none
Tray identification (using time as per protocol)		under		Correct		over
*** Note still fill in SIC section*	**Other Habitat Score (max. 20)**				**11**	
	HABITAIT TOTAL (max.55)				**36**	
STREAM CHARACTERISTICS	**0**	**1**	**2**	**3**	**4**	**5**
Physical						
River make up (pool = pool/dam only; run only; rapid/riffle only; 2mix = 2 types etc)	pool		run	Rapid / riffle	2mix	3mix
Average stream width (m)		>10	5-10	<1	1-2	>2-5
Average stream depth (m)	>2	>1-2	1	>½ - 1	½ - ¼	<¼
Approximate stream velocity (slow ≤ 1m/s; fast ≥1m/s)	still	slow	fast	med.		mix
Water colour (disc = discoloured with visible colour but still clearish)	silty	opaque		disc.		clear
Recent disturbances due to: (constr = construction; fl/dr = flood/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 bare banks; farm = farmland/settlements)***	erosn.	farm	trees	other		open
Left bank cover (%) (rocks and vegetation; shear = 0%)	0-50	51-80	81-95	>95		
Right bank cover (%) (rocks and vegetation; shear = 0%)	0-50	51-80	81-95	>95		
	Stream Conditions Total (max.45)				**18**	
****Note: if more than one option, choose lowest*						
	TOTAL IHAS SCORE %:				**54**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name: Bronkhorstspruit	**Date: 28/09/2016**					
Site Code: BRD 03						
SAMPLING HABITAT	**0**	**1**	**2**	**3**	**4**	**5**
Stones-in-current (SIC)						
Total length (m) of broken water (riffles or rapids)	none	0-1	>1-2	>2-3	<3-5	>5
Total length (m) of submerged stones in current (run	none	0-2	>2-5	>5-10	>10	
Number of separate SIC areas kicked (not individual stones)	0	1	2-3	4-5	6+	
Average size (cm) of stones kicked (gravel<2, bedrock >20)	none	<2,<20	2-10	11-20	2-20	
Amount fo stone surface clear (of algae, sediment, silt etc)*	n/a	0-25	26-50	51-75	>75	
Protocal: time (mins) spent actually kicking SIC (grvl/bedr=0)	0	<1	<1-2	2	>2-3	>3
**Note: up to 25% of stones is usually embedded in stream bottom.*	**SIC Score (max. 20)**				**13**	
Vegetation						
Length (m) of fringing vegetation sampled (banks)	none	0-½	>½ - 1	>1-2	2	>2
Amount (m^2) of aquatic vegetation / algae sampled	none	0-½	>½ - 2	>1		
Fringing vegetation sampled in: (none; pool or still only; run only; mixture of both)	none		run	pool		mix
Type of veg (% leafy vegetation vs stems/shoots) (aqv only = 49)	none	0	1-25	26-50	51-75	>75
	Veg Score (max. 15)				**13**	
Other Habitat / General						
Stones-out-of-current (SOOC) sampled: (protocol = $1m^2$)	none	0-½	>½-1	1	>1	
Sand sampled: (protocol = 1min) (present, but only below stones)	none	below	0-½	>½-1	1	>1
Mud sampled: (protocol = 1/2min) (present, but only below stones)	none	below	0-½	½	>½	
Gravel sampled: (protocol=1/2min) if all, SIC stone size =<2)**	none	0-½	½	>½ **		
Bedrock sampled (all=no SIC, sand, gravel) (if all, SIC stone size > 20)**	none	some			All **	
Algae present (1-2m2=algal bed, rocks=on rocks, isol=isolated clumps)	>$2m^2$	rocks	1-$2m^2$	<$1m^2$	Isol.	none
Tray identification (using time as per protocol)		under		Correct		over
*** Note still fill in SIC section*	**Other Habitat Score (max. 20)**				**13**	
	HABITAIT TOTAL (max.55)				**39**	
STREAM CHARACTERISTICS	**0**	**1**	**2**	**3**	**4**	**5**
Physical						
River make up (pool = pool/dam only; run only; rapid/riffle only; 2mix = 2 types etc)	pool		run	Rapid / riffle	2mix	3mix
Average stream width (m)		>10	5-10	<1	1-2	>2-5
Average stream depth (m)	>2	>1-2	1	>½ - 1	½ - ¼	<¼
Approximate stream velocity (slow ≤ 1m/s; fast ≥1m/s)	still	slow	fast	med.		mix
Water colour (disc = discoloured with visible colour but still clearish)	silty	opaque		disc.		clear
Recent disturbances due to: (constr = construction; fl/dr = flood/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 bare banks; farm = farmland/settlements)***	erosn.	farm	trees	other		open
Left bank cover (%) (rocks and vegetation; shear = 0%)	0-50	51-80	81-95	>95		
Right bank cover (%) (rocks and vegetation; shear = 0%)	0-50	51-80	81-95	>95		
	Stream Conditions Total (max.45)				**20**	
****Note: if more than one option, choose lowest*						
	TOTAL IHAS SCORE %:				**59**	

APPENDIX 2:
SUMMARISED RESULTS FOR INVERTEBRATES

Knight Piésold CONSULTING

Taxon	QV	BRD 01			BRD 02			BRD 03		
		S	Veg	GSM	S	Veg	GSM	S	Veg	GSM
Baetidae > 2 sp	12	A								
Crambidae (Pyralidae)	12								1	
Hydropsychidae > 2 sp	12				A					
Leptophlebiidae (Prongills)	9				A			A		
Atyidae (Freshwater Shrimps)	8		A			A		1	A	
Hydracarina (Mites)	8	A	A	A		A	A	A	A	
Aeshnidae (Hawkers & Emperors)	8		1							
Ecnomidae	8							A	1	
Elmidae/Dryopidae* (Riffle beetles)	8									
Baetidae 2 sp	6		A	A	A	B	A	A		
Caenidae (Squaregills/Cainfles)	6	A		A	A	A	A	A	A	A
Hydropsychidae 2 sp	6						B	A		
Leptoceridae	6					1	1	1		
Ancylidae (Limpets)	6	1		A	A	1		A		
Gerridae* (Pond skaters/Water striders)	5								A	
Dytiscidae/Noteridae* (Diving beetles)	5		A	A					A	
Gyrinidae* (Whirligig beetles)	5	1	A			A		1	A	
Hydrophilidae* (Water scavenger beetles)	5		1							
Ceratopogonidae (Biting midges)	5	A	A	A	A	A			A	
Simuliidae (Blackflies)	5					A	B	A		
Baetidae 1sp	4								A	
Coenagrionidae (Sprites and blues)	4		A	1		B	A	1	A	A
Libellulidae (Darters/Skimmers)	4		A			A			1	
Pleidae* (Pygmy backswimmers)	4								A	
Hydropsychidae 1 sp	4	A		A						
Turbellaria (Flatworms)	3	A		A	A			A	B	A
Hirudinea (Leeches)	3			A	A			A		
Potamonautidae* (Crabs)	3								A	
Belostomatidae* (Giant water bugs)	3		1							
Corixidae* (Water boatmen)	3								A	
Notonectidae* (Backswimmers)	3		1							
Lymnaeidae* (Pond snails)	3								A	A
Physidae* (Pouch snails)	3		A		1	1		A	A	
Planorbinae* (Orb snails)	3	1								
Sphaeriidae (Pill clams)	3				A		A			
Chironomidae (Midges)	2	A	A	A	A	A	B	A	A	A
Oligochaeta (Earthworms)	1			A	A		B			1
Culicidae* (Mosquitoes)	1	A							A	
Muscidae (House flies, Stable flies)	1				1			1		1
SASS Score		**102**			**100**			**130**		
No. of Taxa		**22**			**20**			**26**		
ASPT		**4.6**			**5.0**			**5.0**		

APPENDIX 3:
DETAILED RESULTS FOR FISH

Species Name	Common Name	Abbreviation	Conservation Status	BRD 01	BRD 02	BRD 03
Barbus paludinosis	Straightfin Barb	bpau	Least Concern			
Barbus trimaculatus	Threespot Barb	btri	Least Concern			
Chiloglanis pretoriae	Sawfin Suckermouth	cpre	Least Concern		3	
Clarias gariepinus	Sharptooth Catfish	cgar	Least Concern		1	
Labeobarbus marequensis	Largescale Yellowfish	bmar	Least Concern			
Gambusia affinis	Mosquitofish	gaff	Least Concern			
Micropterus salmoides	Largemouth Bass	msal	Least Concern			
Labeo umbratus	Moggel	lumb	Least Concern			
Pseudocrenilabrus philander	Southern Mouthbrooder	pphi	Least Concern	4		29
Cyprinus carpio	Carp	ccar	Vulnerable			
Oreochromis mossambicus	Mozambique Tilapia	omos	Near Threatened			
Tilapia sparrmanii	Banded Tilapia	tspa	Least Concern		7	3
	Sample Size (n)			4	11	32
	Effort (Min)			20	30	28
	Catch per unit effort (number/hr)			12	22	69
	Number of Fish Species			1	3	2
	Percentage of expected fish species caught			8.3	25.0	16.7
	FAII (%)			5.4	29.3	10.7
	PES Category			F	E	F

APPENDIX 4:
PHOTO REPORT

Plate 9: *Tilapia sparrmanii* recorded at BRD 03

Plate 10: *Clarias gariepinus* recorded at site BRD 02

Plate 11: *Chiloglanis pretoriae* recorded at site BRD 02

Plate 12: *Pseudocrenilabrus philander* recorded at site BRD 01

Plate 13: Temporary zone of wetland

Plate 14: Seasonal zone of wetland