Langaville Sewer and Water Pipeline, Ekurhuleni Metropolitan Municipality, Gauteng Province

Aquatic Biodiversity Assessment

May 2021

Drafted by
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Declaration of Independence

I, **Antoinette Bootsma**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

Antoinette Bootsma (PrSciNat)
Ecologist/Botanist
SACNASP Reg. No. 400222-09

2021.05.19
Date

I, **Bertus Fourie**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

Mr Bertus Fourie (PrSciNat)
Aquatic Ecologist
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2021.04.19
Date

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Project name: Langaville Sewer and Water Pipeline, Ekurhuleni Metropolitan Municipality, Gauteng Province			
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Technical Review	Antoinette Bootsma		2021.05.19
Client review			
Final Report	Antoinette Bootsma		

EXECUTIVE SUMMARY

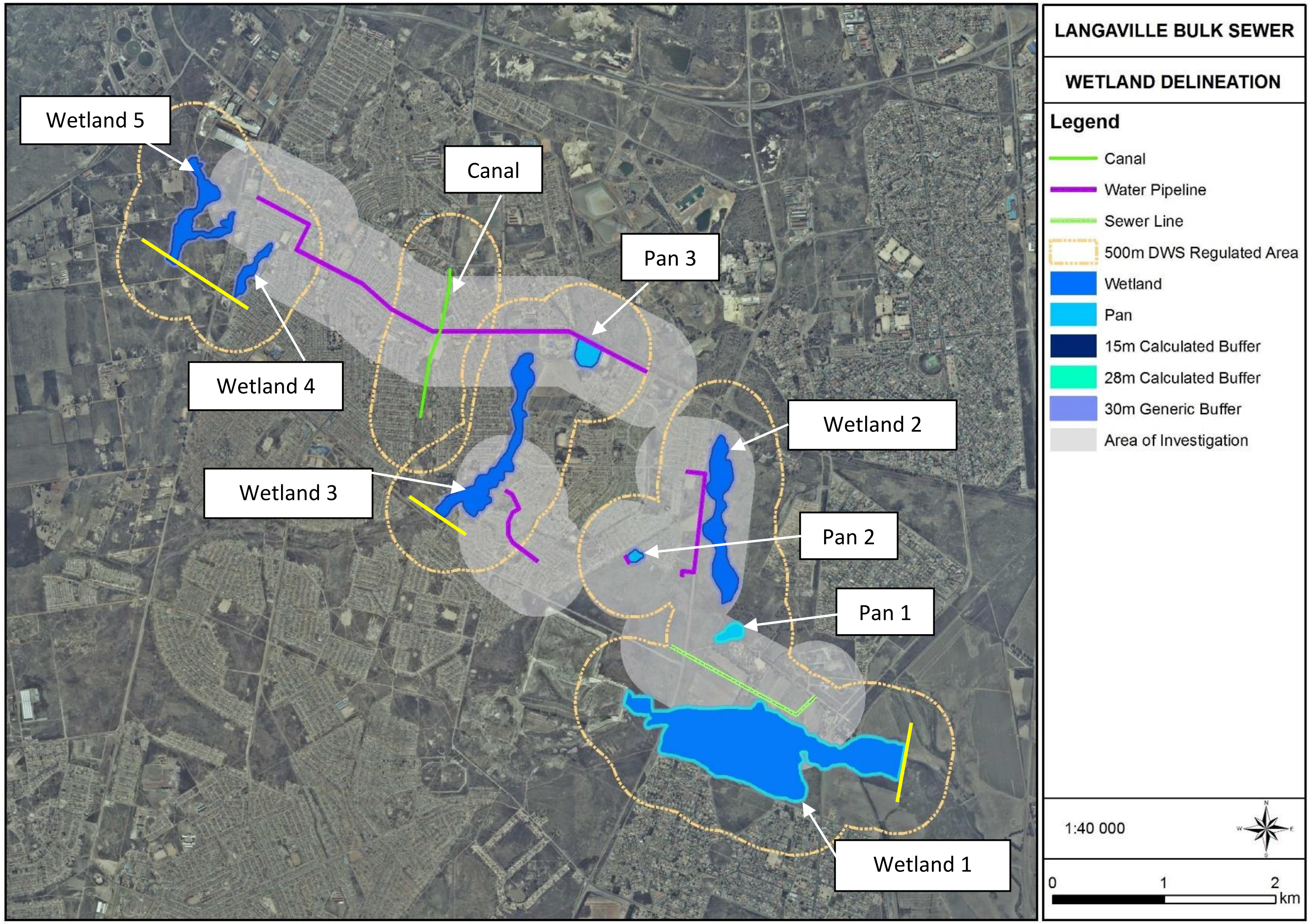
Limosella Consulting was appointed by Thembeka Environmental Consulting to undertake an aquatic biodiversity assessment, including reference to wetlands and riparian areas, to inform the Environmental Authorization process for proposed sewer and water pipelines installation and repair located in Langaville, Ekurhuleni, Gauteng. The proposed activities include replacement of sections of old water pipelines within existing road servitudes and the implementation of a sewer pipeline. Pipes will be laid primarily through trenching.

Fieldwork was conducted in April 2021.

The terms of reference for the study were as follows:

- Delineate the wetland and riparian areas to inform the placement of infrastructure;
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant,
- Compile a baseline description of the aquatic environment potentially impacted by the development as specified in GN320, March 2020,
- Undertake functional and integrity assessment of wetlands and riparian areas as specified in General Notice 267 of 24 March 2017;
- Undertake an impact assessment as specified in Appendix 6 of the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Recommend suitable buffer zones as specified in General Notice 267 of 24 March 2017, following Macfarlane *et al* 2015; and
- Discuss appropriate mitigation and management procedures relevant to the conserving wetland areas on the site as specified in Appendix 6 of the NEMA 2014 regulations, as amended and GN320, March 2020.

Watercourses in the 500m area of investigation around each section of pipeline discussed in this report lie in two quarternary catchments. In quarternary catchment C21E 2 valley bottom and 3 pan wetlands drain into the Blesbokspruit. In Quarternary catchment C22C 3 valley bottom wetlands drain into a tributary of the Rietspruit. A canalised watercourse extends across both catchments. The Figure below presents the delineated wetlands as well as the associated buffer zones and DWS regulated area.


Wetland 5
Canal
Pan 3
Wetland 4
Wetland 2
Wetland 3
Pan 2
Pan 1
Wetland 1
LANGAVILLE BULK SEWER
WETLAND DELINEATION
Legend
Canal
Water Pipeline
Sewer Line
500m DWS Regulated Area
Wetland
Pan
15m Calculated Buffer
28m Calculated Buffer
30m Generic Buffer
Area of Investigation
1:40 000
0
1
2
km

Since the proposed sewer pipeline is located outside the Wetland 1 and its buffer zone, it is unlikely that the construction related activities will affect the wetland. However, spills of sewage into the downslope wetland will have a significant effect on aquatic biota and water quality. The reference site condition (as presented in this report) must be used as baseline for the construction and operational phases of the proposed sewage pipeline. The Average Score Per Taxon of aquatic biota of 2.8 must be maintained or improved. Biomonitoring should be undertaken on a quarterly basis during construction and bi-annually during the operational phase to demonstrate that water quality is maintained.

The water pipelines earmarked for repair and upgrade are all located in existing servitudes. The wetlands closest to the water pipelines, and consequently the most likely to be impacted are Pans 2 and 3. Particularly Pan 3 lies immediately adjacent to a section of pipeline. Earthworks associated with removal of old pipes and replacement with new pipes may negatively affect the wetland unless care is taken to implement effective mitigation.

The important factors relevant to the project are summarised in Table 1 below:

Table 1: important factors relevant to the project

<table>
<tr><th colspan="2" rowspan="2"></th><th>Quaternary Catchment and WMA areas</th><th>Important Rivers possibly affected</th></tr>
<tr><td>C21E and C22C – #5 WMA, Vaal Major</td><td>The wetlands in catchment C21E on the study site drains into the Nigel dam which in turn drains into the Blesbokspruit River. Wetlands in catchment C22C drain into a tributary of the Rietspruit</td></tr>
<tr><td colspan="2">Watercourse classification</td><td colspan="2">Catchment C21E:
– Channelled valley bottom wetland 1
– Unchannelled valley bottom wetland 2
– Pan 1
– Pan 2
– Pan 3
– A section of a canal
Catchment C22C:
– Unchannelled valley bottom wetland 3
– Unchannelled valley bottom wetland 4
– Unchannelled valley bottom wetland 5</td></tr>
<tr><td colspan="2">Buffer Zones</td><td colspan="2">Wetland 1 is potentially affected by a sewer pipeline. The calculated buffer zone for this wetland is 18m. The generic buffer is 30m.
All other wetlands are potentially affected by water pipeline replacement. Their calculated buffer zones are 15m, generic buffer zones are 30m.</td></tr>
<tr><td>Watercourse function and integrity</td><td>Channelled valley bottom wetland 1</td><td colspan="2">PES: 48% - EC = D: Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.
EIS: Low/Marginal. Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers
ES: Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping
Recommended Ecological Management Category: D
Instream habitat (IHAS): The IHAS score was calculated to 44.7% for the sample site. This indicates the habitat that not suitable for supporting a diverse macroinvertebrate community.
Aquatic macroinvertebrate assemblages: The number of taxa observed on site were 8 with a combined SASS score of 18. The Average score per taxon (ASPT) was 2.3- this is low but is mainly driven by the lack of stones habitat and decreased water quality. The taxa observed are all hardy and able to survive in difficult conditions.</td></tr>
</table>

	Unchannelled valley bottom wetland 2	**PES: 48% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D** **Instream habitat (IHAS):** The IHAS score was calculated to 44.7% for the sample site. This indicates the habitat that not suitable for supporting a diverse macroinvertebrate community. **Aquatic macroinvertebrate assemblages:** The number of taxa observed on site were 8 with a combined SASS score of 18. The Average score per taxon (ASPT) was 2.3- this is low but is mainly driven by the lack of stones habitat and decreased water quality. The taxa observed are all hardy and able to survive in difficult conditions.
	Unchannelled valley bottom wetland 3	**PES: 53% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**
	Unchannelled valley bottom wetland 4	**PES: 35% - EC = E: Seriously Modified**. The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**
	wetland 5	**PES: 57% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very High scores are obtained for Toxicant Assimilation and Sediment Trapping. Provisioning and Cultural services score Very Low **Recommended Ecological Management Category: D**
	Pan 2 and 3	**PES: 52% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**

Canal	**PES: 11% - EC = F: Critically Modified**. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.			
NEMA 2014 Impact Assessment	The impact scores for the following aspects are relevant to the operational phase:		Without Mitigation	With Mitigation
	Impacts to hydrological function at a landscape level	Construction	M	L
		Operation	M	L
	Changes to sediment regimes	Construction	M	L
		Operation	L	L
	Establishment of alien plants	Construction	M	L
		Operation	M	L
	Loss of wetland habitat	Construction	M	L
		Operation	L	L
	Pollution of regional watercourses	Construction	M	L
		Operation	M	M
	Loss of aquatic biota	Construction	M	M
		Operation	M	L
Does the specialist support the development?	Yes. Given that the mitigation measures are adhered to and release of pollutants into the watercourses is prevented and the baseline aquatic integrity is maintained			
Recommendations	Biomonitoring should be conducted on a quarterly basis during construction and bi-annually during the operational phase.			

Table of Contents

Figures

Tables

1 INTRODUCTION

Limosella Consulting was appointed by Thembeka Environmental Consulting to undertake an aquatic biodiversity assessment, including reference to wetlands and riparian areas, to inform the Environmental Authorization process for proposed sewer and water pipeline infrastructure located in Langaville, Ekurhuleni, Gauteng. Fieldwork was conducted in April 2021. The proposed activities include replacement of sections of old water pipelines within existing road servitudes and the implementation of a sewer pipeline. Pipes will be laid primarily through trenching.

1.1 Terms of Reference

The terms of reference for the study were as follows:

- Delineate the wetland and riparian areas to inform the placement of infrastructure;
- Classify the watercourse according to the system proposed in the national wetlands inventory if relevant,
- Compile a baseline description of the aquatic environment potentially impacted by the development as specified in GN320, March 2020,
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- Undertake an impact assessment as specified in Appendix 6 of the NEMA 2014 regulations, as amended and GN320, March 2020;
- Undertake a Risk Assessment as specified in General Notice 267 of 24 March 2017;
- Recommend suitable buffer zones, both generic (as required in GDARD, 2014) and scientific as specified in General Notice 267 of 24 March 2017, following Macfarlane *et al* 2015; and
- Discuss appropriate mitigation and management procedures relevant to the conserving wetland areas on the site as specified in Appendix 6 of the NEMA 2014 regulations, as amended and GN320, March 2020.

1.2 Assumptions and Limitations

- The information provided by the client forms the basis of the planning and layouts discussed.
- All wetlands within 500 m and riparian areas within 100m of any developmental activities should be identified as per the DWS Water Use Licence Application regulations. Wetlands and riparian areas associated with the study sites were delineated on a fine scale based on detailed soil and vegetation sampling. Wetlands that fall outside of the site, but that fall within 500 m of the proposed activities were delineated based on desktop analysis of vegetation gradients visible from aerial imagery.
- The detailed field study was conducted from a once off field trip and thus would not depict any seasonal variation in the macroinvertebrates or wetland plant species composition and richness.
- The presence of heavy clay soils throughout the region together with uncharacteristically heavy rains made access to all sections of the site difficult. Observations were limited to accessible areas.
- Description of the depth of the regional water table and geohydrological and hydropedological processes falls outside the scope of the current assessment
- Floodline calculations fall outside the scope of the current assessment

- A Red Data scan, fauna and flora assessments were not included in the current study
- The recreation grade GPS used for wetland and riparian delineations is accurate to within five meters.
- Wetland delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries. The scale at which maps and drawings are presented in the current report may become distorted should they be reproduced by for example photocopying and printing.
- In situ water quality was measured. No laboratory analysis was completed.
- No aquatic assessments were conducted for wetlands 2 to 5, or for the pans,
- The delineation of boundaries for wetlands 2 to 5 (including the pans_ was based on desktop evaluation of moisture gradients. No fieldwork was conducted for these wetlands and the delineation is therefore considered low-confidence.

1.3 Definitions and Legal Framework

The National Water Act, 1998 (Act No. 36 of 1998) [NWA] provides for Constitutional water demands including pollution prevention, ecological and resource conservation and sustainable utilisation. In terms of this Act, all water resources are the property of the State and are regulated by the Department of Water and Sanitation (DWS). The NWA sets out a range of water use related principles that are to be applied by DWS when taking decisions that significantly affect a water resource. The NWA defines a water resource as including a watercourse, surface water, estuary or aquifer. A watercourse includes a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake, pan or dam, into which or from which water flows; any collection of water that the Minister may declare to be a watercourse; and were relevant its beds and banks.

The NWA defines a wetland 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 land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.” In addition to water at or near the surface, other distinguishing indicators of wetlands include hydromorphic soils and vegetation adapted to or tolerant of saturated soils (DWA, 2005).

Riparian habitat often times performs important ecological and hydrological functions, some similar to those performed by wetlands (DWA, 2005). Riparian habitat is also the accepted indicator used to delineate the extent of a river’s footprint (DWAF, 2005). It is defined by the NWA as follows: “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”.

Water uses for which authorisation must be obtained from DWS are indicated in Section 21 of the NWA. Section 21 (c) and (i) is applicable to any activity related to a watercourse:
Section 21(c): Impeding or diverting the flow of water in a watercourse; and
Section 21(i): Altering the bed, banks, course or characteristics of a watercourse.

Authorisations related to wetlands are regulated by Government Notice 509 of 2016 regarding Section 21(c) and (i). This notice grants General Authorisation (GA) from the DWS for the above water uses should the Risk Assessment matrix (DWS, 2016) reflect a Low score. Activities that obtain a Medium or High risk score requires authorisation through a Water Use Licence (WUL) from the Department.
Conditions for impeding or diverting the flow of water or altering the bed, banks, course or characteristics of a watercourse (Section 21(c) and (i) activities) include:
9. (3) (b). The water user must ensure that the selection of a site for establishing any impeding or diverting the flow or altering the bed, banks, course or characteristics of a watercourse works:
(i) is not located on a bend in the watercourse;
(ii) avoid high gradient areas, unstable slopes, actively eroding banks, interflow zones, springs, and seeps.

In March 2020, the Department of Environmental Affairs issued General Notice 320 set out requirements of the EIA Screening Tool Protocols for the Assessment and Reporting of Environmental Themes including Aquatic Biodiversity. These specifications overlap somewhat with the 2014 EIA regulations as amended (GN 982 of 2017). Compliance to these requirements are presented in Appendix A.
In addition to the above, the proponent must also comply with the provisions of the following relevant national legislation, conventions and regulations applicable to wetlands and riparian zones:

- Convention on Wetlands of International Importance - the Ramsar Convention and the South African Wetlands Conservation Programme (SAWCP).
- National Environmental Management Act, 1998 (Act No. 107 of 1998) [NEMA].
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003).
- Regulations GN R.982, R.983, R. 984 and R.985 of 2014, promulgated under NEMA.
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983).
- Regulations and Guidelines on Water Use under the NWA.
- South African Water Quality Guidelines under the NWA.
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 287 of 2002).
- GN 267 (Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals)
- GN 982 of 2017 NEMA EIA regulations

1.4 Locality of the study site

The proposed site earmarked for the establishment of the sewer pipeline is located on the outskirts of Langaville, Brakpan. The R51 lies to the east and the M45 lies to the south. The new residential area od

Sharon Park lies directly north of the proposed sewer line. The water pipelines included in this assessment comprise five sections that lie north of Vlakfontein Road and west of Tonk MeterDrive. South Rand Road (N17) lies 2km north of the northernmost section of the water pipeline discussed in this report (Figure 1).

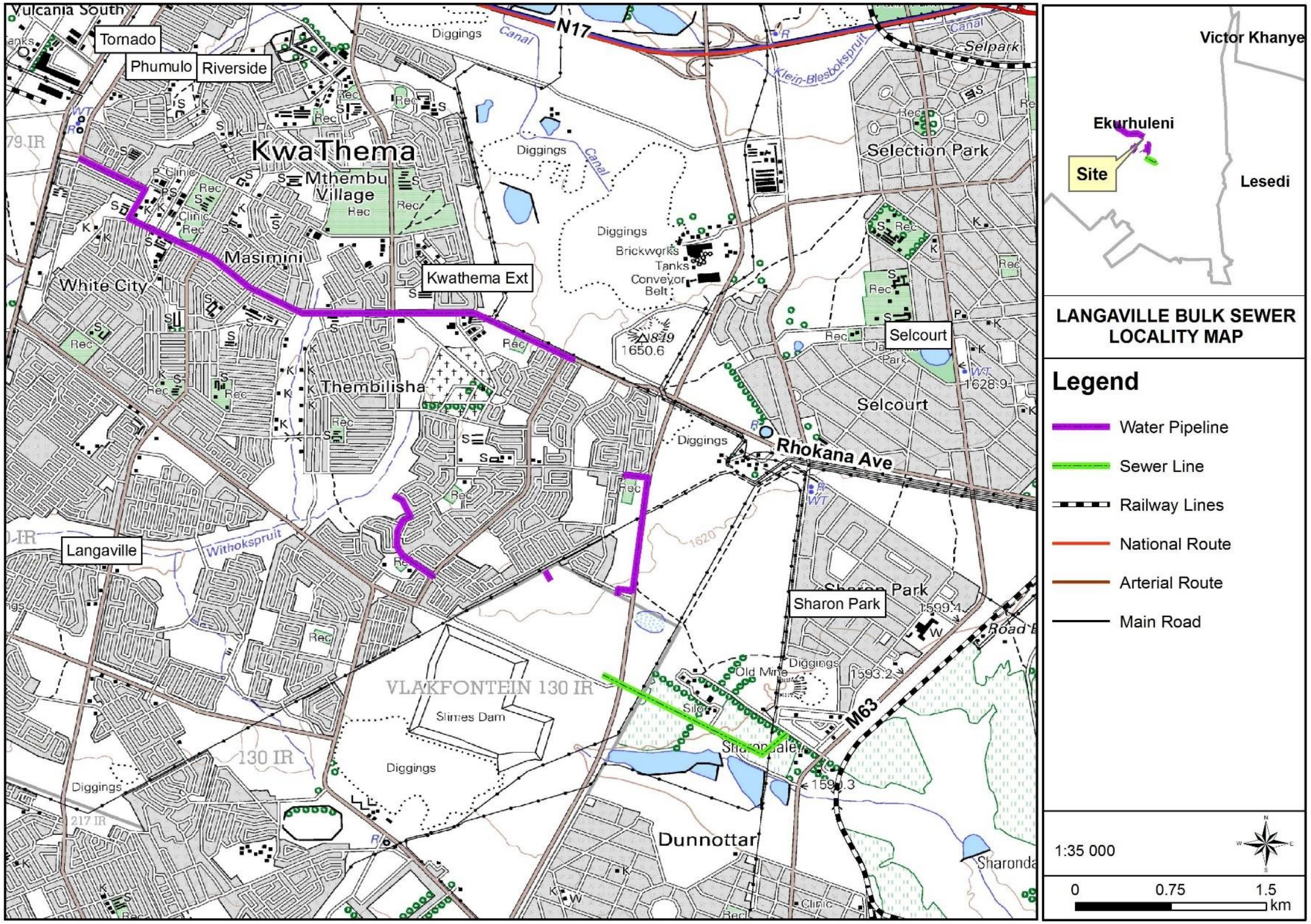


Figure 1: Locality Map

1.5 Description of the Receiving Environment

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state. Table 1 below provides a summary of the important aspects.

Table 2: A summary of relevant site information obtained from a review of available spatial data

DEA screening Tool (Https://screening.environment .gov.za/screeningtool	
https://screening.environment.gov.za/ screeningtool/#/app/screen_tool	The 500m area of investigation around each section of pipeline reflected various watercourses classified as **Very High** Aquatic Biodiversity. A Strategic Water Source area lies on the eastern section of the study area is classified as **Very High** Sensitivity
General Description (Mucina & Rutherford, 2006)	
Broad Vegetation Units (Figure 2)	Tsakane Clay Grassland, Gm 9
Topography	Flat to slightly undulating plains and low hills. Vegetation is short, dense grassland.
Climate	Strongly seasonal summer rainfall, with very dry winters. MAP 630–720 mm. The overall MAT of 15°C indicates a transition between a cool-temperate and warm-temperate climate.
Conservation Status	Endangered
Hydrology and National Freshwater Ecosystem Priority Area (NFEPA) (2011) Database	
Important Rivers (CDSM, 1996) (Figure 3)	Watercourses in quarternary catchment C21E drain into the Nigel dam which in turn drains into the Blesbokspruit River. Watercourses in quarternary catchment C22C drain into a tributary of the Rietspruit
Aquatic Ecoregions of South Africa	The subject property falls within the Highveld Ecoregion
Quaternary Catchment	C21E and C22C
WMA (Government Gazette, 16 September 2016)	#5, Vaal Major: rivers include the Wilge-, Liebenbergsvlei-, Mooi-, Renoster-, Vals-, Sand-, Vet-, Harts-, Molopo and Vaal River.
Wetland Ecosystem Type	Mesic Highveld Grassland Group 2
NFEPA Wetlands	A wetland lies south of the pipeline. This wetland is listed as a channelled valley bottom, artificial wetland, Rank 6 (no known biodiversity elements A flat lies to the northwest. This natural wetland is classified as Rank 5 (within a sub-quaternary catchment identified by experts at the regional review workshops as containing impacted Working for Wetland sites)
Geology and Soils	
Soils (Figure 4)	The pipeline lies on soil predominantly classified as mAV27 (Avalon) with small sections extending onto dHU27 (Hutton) and dRg20 (Rensburg). Sections of the water pipelines lie on Unconsolidated soil (U)
Geology (Figure 5)	The geology of the study sites is predominantly Vryheid geology with smaller sections located on Alberton, Dwyka and Turfontein
Gauteng Conservation Plan (CPlan)	

C-plan V3.3 (Figure 6)	The pipelines lie on unclassified area with watercourse crossing classified as Important and Ecological Support Areas

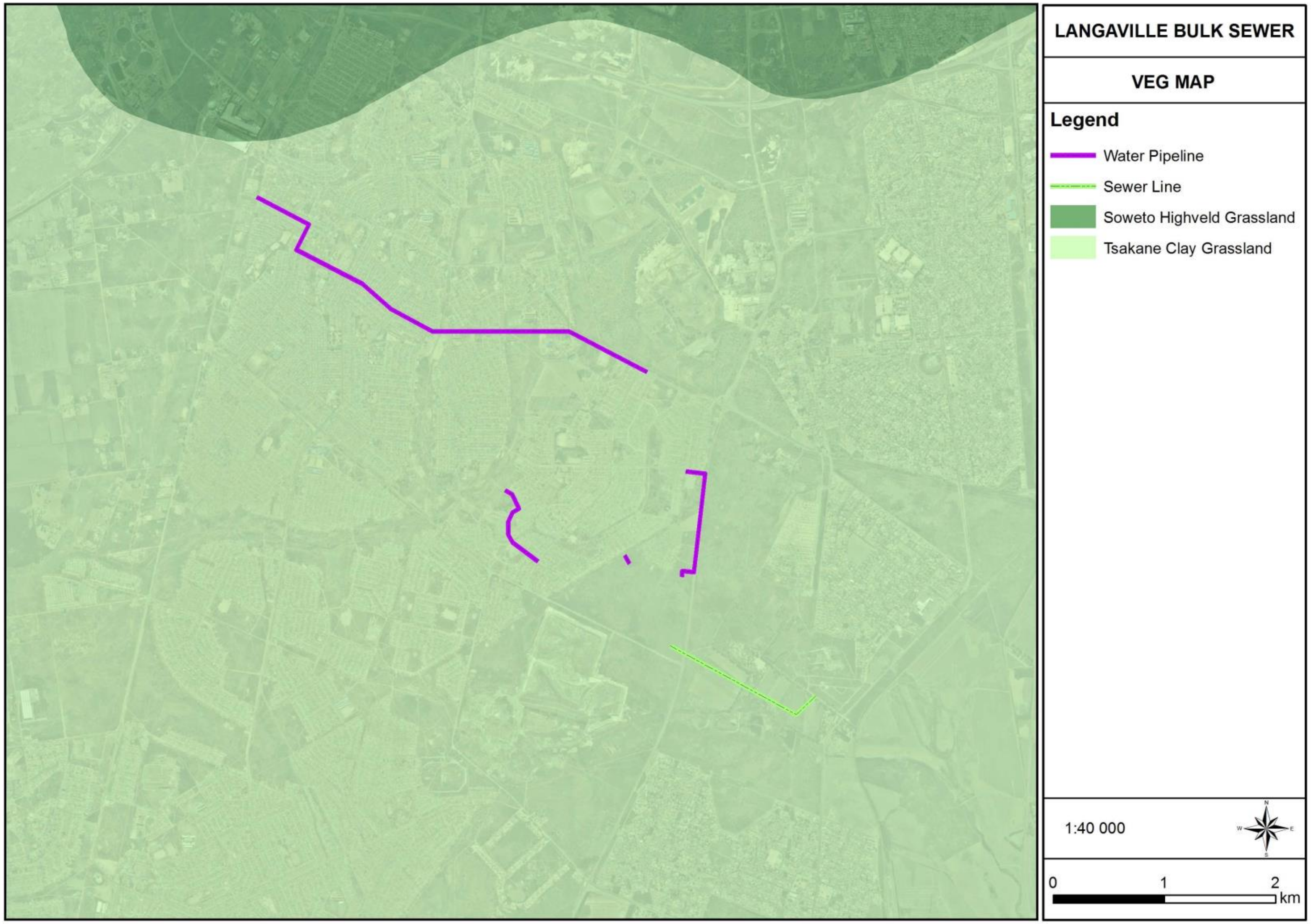


Figure 2: Regional Vegetation Classification

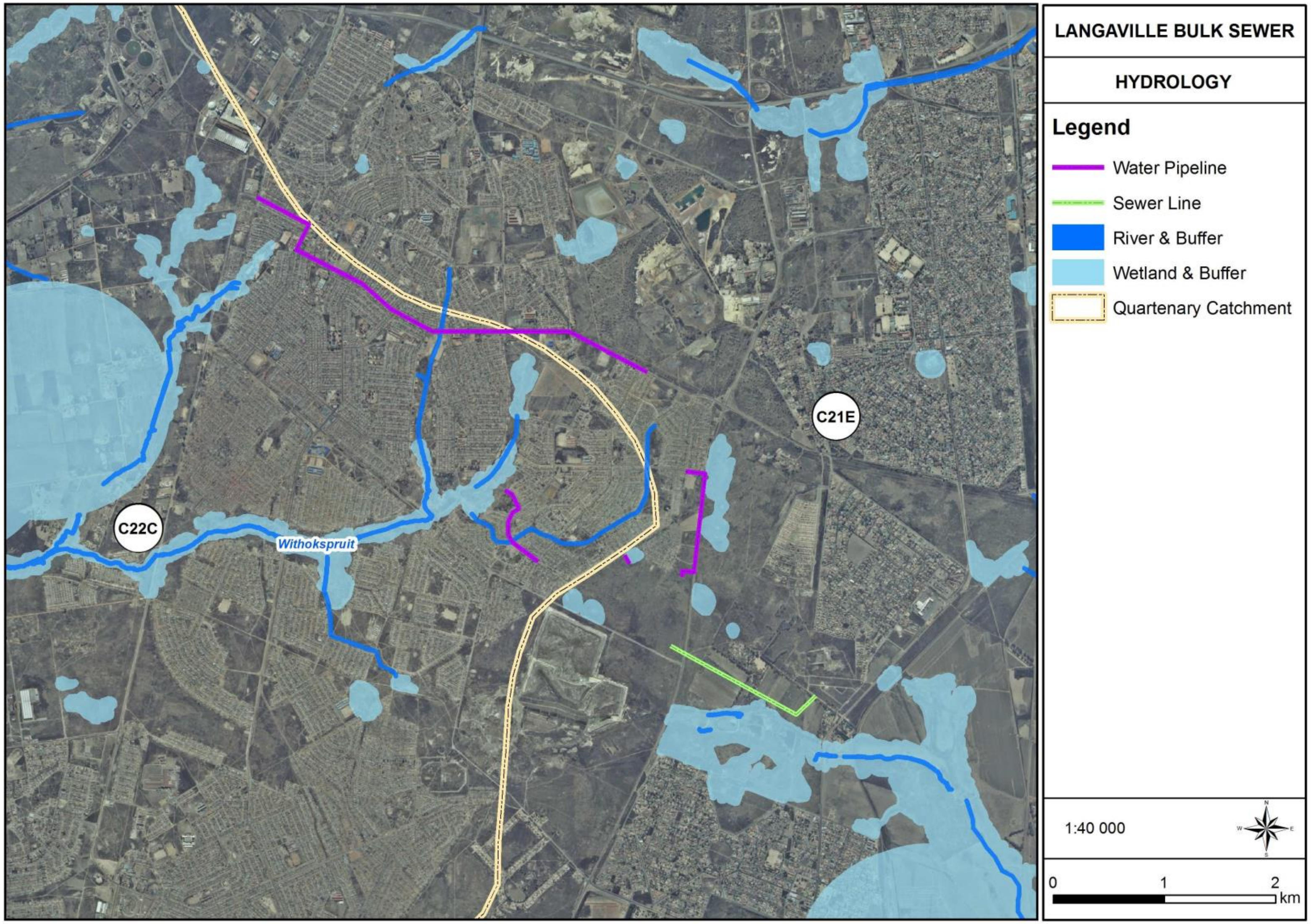


Figure 3: Regional hydrology

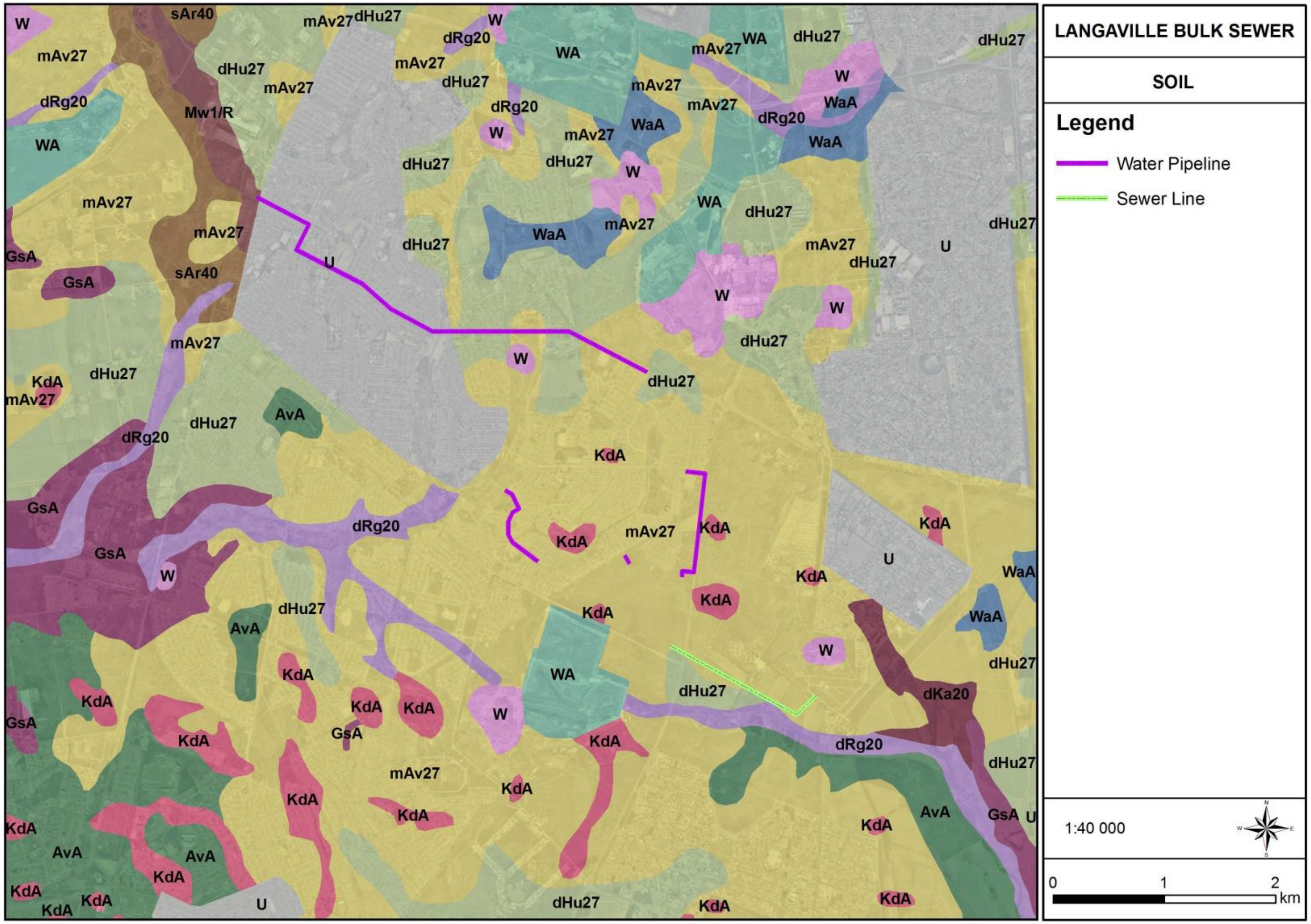


Figure 4: Regional soil classification of the study site and surroundings.

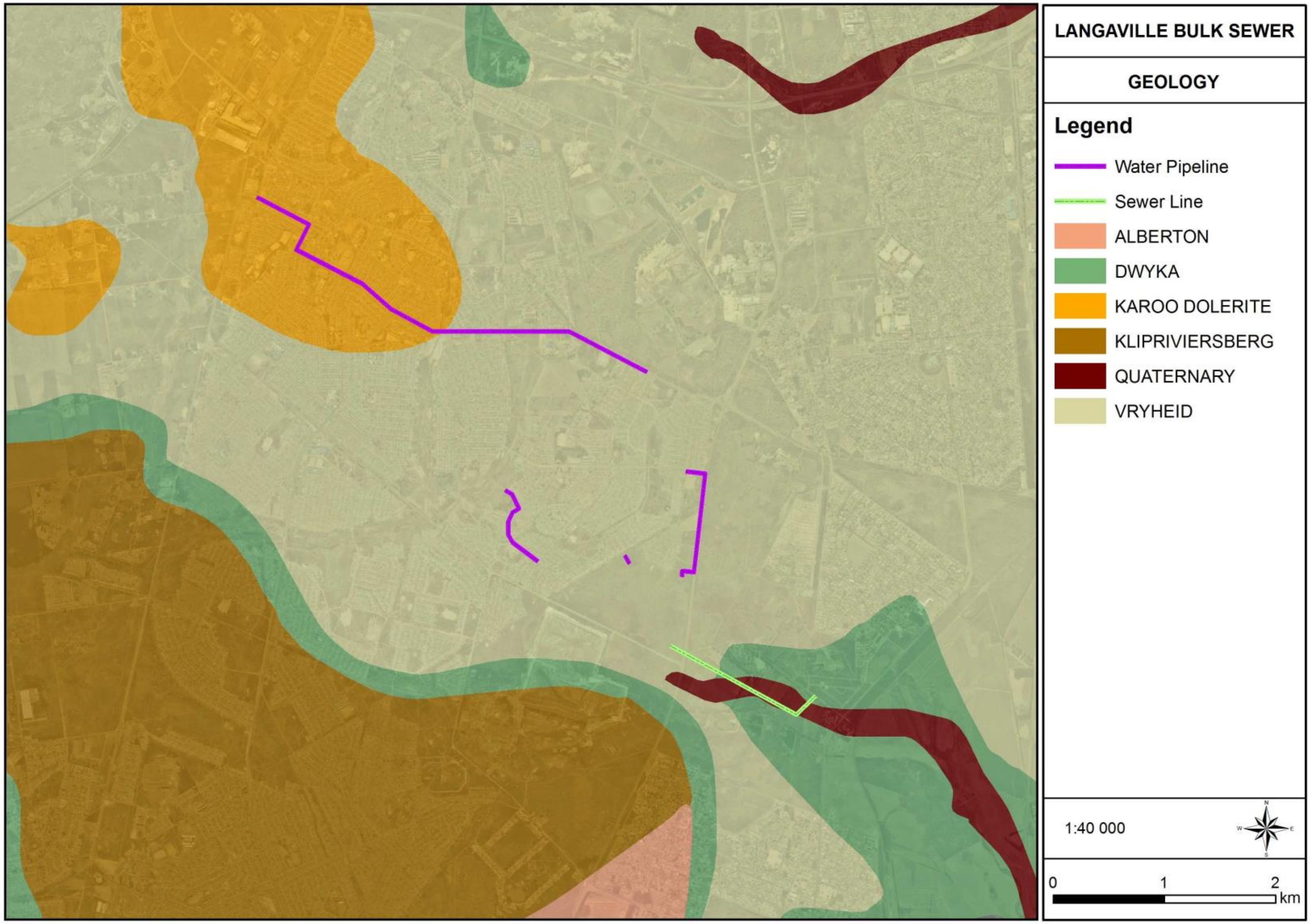


Figure 5: Geology of the study site.

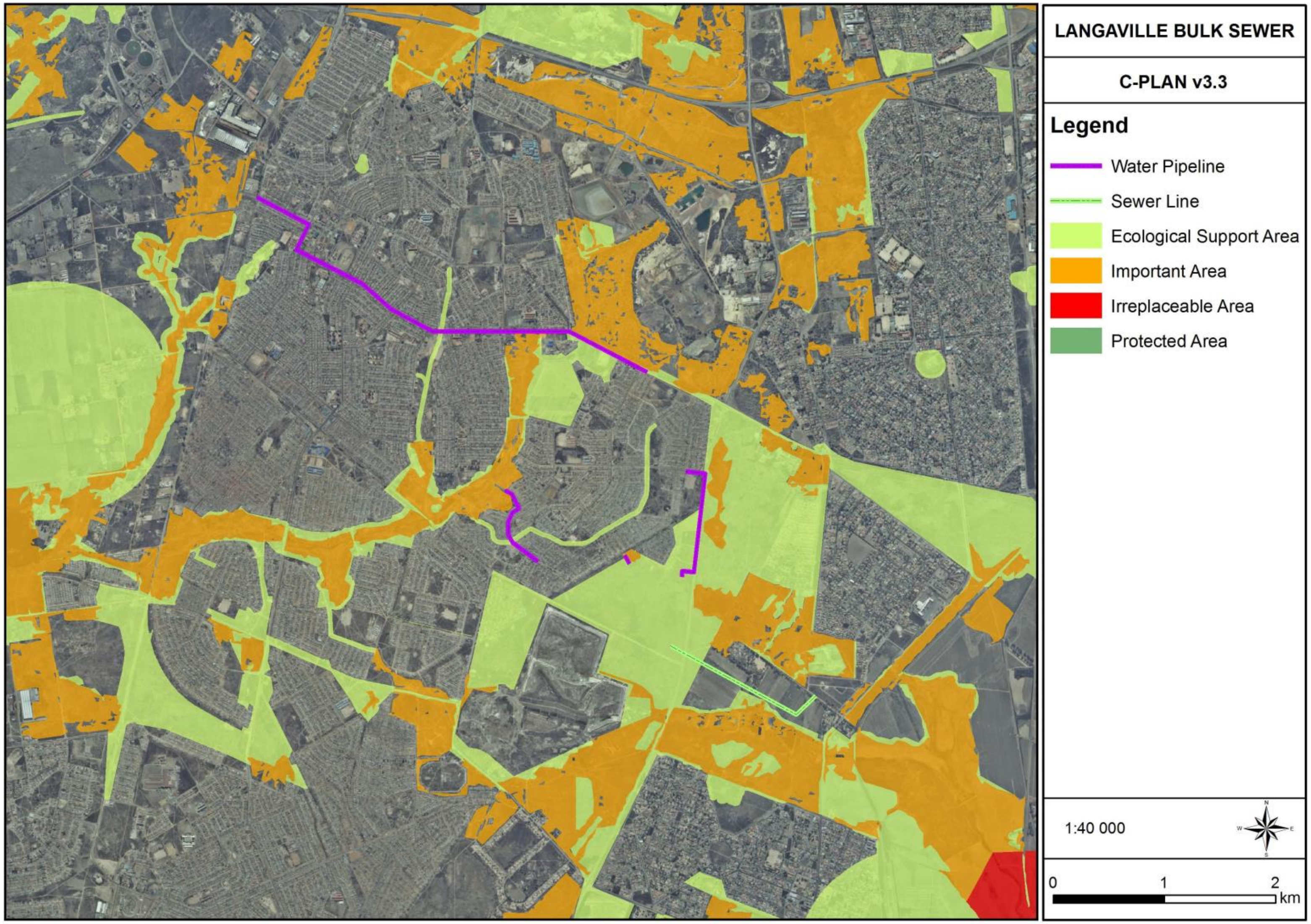


Figure 6: C-Plan classification of the study area and surroundings.

2 METHODOLOGY

The Aquatic Biodiversity Assessment report complies with Appendix 6 of the 2017 EIA Regulations and GN320, March 2020. A summary table indicating the minimum requirements indicated in these documents, and their relevance to this report, is presented in Annexure A.

The delineation method documented by the DWS in their document "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2014) as well as the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al*, 2013) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held Garmin Montana 650 and/or a Samsung S10 smartphone was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary watercourse boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey. Applications used on the smartphone includes GPX Viewer Pro and Google Earth.

Following a desktop assessment highlighting wetland and riparian areas to be groundtruthed in the field, soil and vegetation sampling on site informed a fine scale delineation. Functional and integrity assessments were conducted to indicate the baseline status of the watercourses identified. No wetland conditions were recorded on the site. The riparian habitat was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) Kleynhans *et al*, 2008.

In order to ease the legibility of the report, details regarding the methods used in each phase of the watercourse assessment are presented in Appendix A.

2.1 Conducting the 2021 Baseline Aquatic Assessment

In South Africa, the River Health Programme (under the Department of Water Affairs) has developed a suite of different programs to rapidly assess the quality of aquatic systems. One of the most popular and robust indicators of aquatic ecology health is the South African Scoring System or SASS currently in version 5 (SASS5).

The South African Scoring System is a biotic index initially developed by Chutter (1998). It has been tested and refined over several years and the current version is SASS5 (Dickens and Graham, 2002). This technique is based on a British biotic index called the Biological Monitoring Working Party (BMWP) scoring system and has been modified to suit South African aquatic micro-invertebrate fauna and conditions. SASS5 is a rapid biological assessment method developed to evaluate the impact of changes in water quality using aquatic macro-invertebrates as indicator organisms. SASS is widely used as a bio-assessment tool in South Africa because of the following reasons:

- It does not require sophisticated equipment

- Method is rapid and relatively easy to apply.

This method is very cheap in comparison to chemical analysis of water samples and analysis and interpretation of output data is simple. Sampling is generally non-destructive, except where representative collections are required, (the biodiversity index of SASS5 is described in Dickens and Graham (2002).
It provides some measure of the biological status of rivers in terms of water quality.

SASS is therefore a method for detection of current water quality impairment and for monitoring long-term trends in water from an aquatic invertebrate’s perspective. Although SASS5 is user-friendly and cheap, it has some limitations. The method is dependent on the sampling effort of the operator and the total SASS score is greatly affected by the number of biotopes sampled.

SASS5 is not accurate for lentic conditions (standing water) and should be used with caution in ephemeral rivers (systems that do not always flow) (Dickens and Graham, 2002) The resolution of SASS5 is at family level; therefore, changes in species composition within the same family due to environmental changes cannot be detected.

Although the SASS5 score acts as a warning ‘red flag’ for water quality deterioration, it cannot pinpoint the exact cause and quantity of a change. SASS5 does not cover all invertebrate taxa. SASS also cannot provide information about the degradation of habitat, so habitat assessment also indices, to show the state of the habitat. The initial SASS protocol was described by Chutter (1998) and refined by Dickens and Graham (2002) require collections of macro-invertebrates from a full range of biotopes available at each site.

The biotopes sampled include vegetation both in and out of current (VG- aquatic and marginal), stones (S- both stones in current and out of current) and gravel, sand and mud (GSM) (Dickens & Graham, 2002). The standardised sampling methods allow comparisons between studies and sites. Macro-invertebrate sampling is done using a standard SASS net (mesh size 1000 mm, and a frame of 30 cm x 30 cm). There are nineteen (19) possible macro-invertebrates from each biotope that are tipped into a SASS tray half filled with water and families are identified for not more than 15 minutes/biotype at the streamside.

Invertebrates encountered from each biotope are recorded on a SASS5 score sheet, with their abundance being noted on the sheet. Each taxon (usually a family) of invertebrates from South African rivers has been allocated a score ranging from 1 for those taxa that are most tolerant of pollutants, to 15 for those that are most sensitive to pollutants (Chutter, 1998). To complete the SASS exercise the scores for all the taxa are added together (total score). The average score per taxon (ASPT) is calculated by dividing the total score by the number of taxa. All three scores (SASS5, ASPT and number of families) are used in the interpretation of the status of the site or river being assessed dependant on operator choice.

Table 3: Ecological Categories for interpreting SASS data

Ecological Category	Ecological Category Name	Description	Colour
A	Natural	Unmodified natural	Blue
B	Good	Largely natural with few modifications	Green
C	Fair	Moderately modified	Yellow
D	Poor	Largely modified	Red
E	Seriously modified	Seriously modified	Purple
F	Critically modified	Critically or extremely modified	Black

2.2 Invertebrate Habitat Assessment System (IHAS)

Invertebrate Habitat Assessment System (IHAS) was specifically developed to be used in conjunction with SASS, based on habitat availability (McMillan, 1998). The scoring system is based on sampling habitat (i.e. availability of a range of habitats, which could be utilized by in-stream invertebrates) and more general stream characteristics such as anthropogenic or natural impacts (McMillan, 1998). This habitat scoring system is based on 100 points (or percentage) and is divided into two sections reflecting the sampling habitat (50 points) and stream characteristics (50 points).

The sampling habitat section is further broken down into three subsections: stones in current (20 points), vegetation (15 points) and other habitats (15 points) (McMillan, 1998). Very specific questions and answers score between 0 and 5. Higher scores indicate better habitat for macro-invertebrates. The ideal condition is not based on the ultimate pristine stream, but rather on the representation of all habitats adequately and in reasonable conditions. The IHAS form must be completed for each site sampled during each sampling season. This index is mostly subjective with the data collected dependent on the assessor's visual observation and level of expertise. IHAS data was to aid the interpretation of SASS data. As the site has not yet been developed this assessment is seen as a reference condition assessment of the macroinvertebrate assemblages of the site.

2.3 Sample assessment methodology and site selection

Due to the fixed location of the pipeline the placement of the sample sites was done in accordance with the distance to the impact rather than in terms of the habitat requirements. During the site visit of April 2021 only a single reference point was viable for analysis. The locations of the sample point are illustrated in Figure 7. This will serve as reference conditions for monitoring during construction and operational phases as required.

Figure 7: Sampling points for biomonitoring at the proposed study area

3 RESULTS

3.1 Land Use, Cover and Ecological State

Historical mining forms and important context of the land use of the site. To the south, the Vlakfontein Gold Mine which was mined from 1942-1977. Mine dumps are also visible to the west of the site. Water from this mine likely leaches into the watercourse directly south of the pipeline. Current land use is dominated by residential infrastructure, roads and associated commercial activities including cemeteries, retail and community centres. The lands traversed by the proposed sewer pipe are clearly ploughed. High density residential areas have established over several decades and include roads, schools, retail and commercial components.

3.2 Watercourse Classification and Delineation

Watercourses in the 500m area of investigation around each section of pipeline discussed in this report lie in two quarternary catchments. In quarternary catchment C21E 2 valley bottom and 3 pan wetlands drain into the Blesbokspruit. In Quarternary catchment C22C 3 valley bottom wetlands drain into a tributary of the Rietspruit. A canalised watercourse extends across both catchments. Figure 8 below shows the delineated watercourses, their associated generic and calculated buffer zones as well as the DWS 500m regulated area around each watercourse. Each wetland is discussed in more detail below.

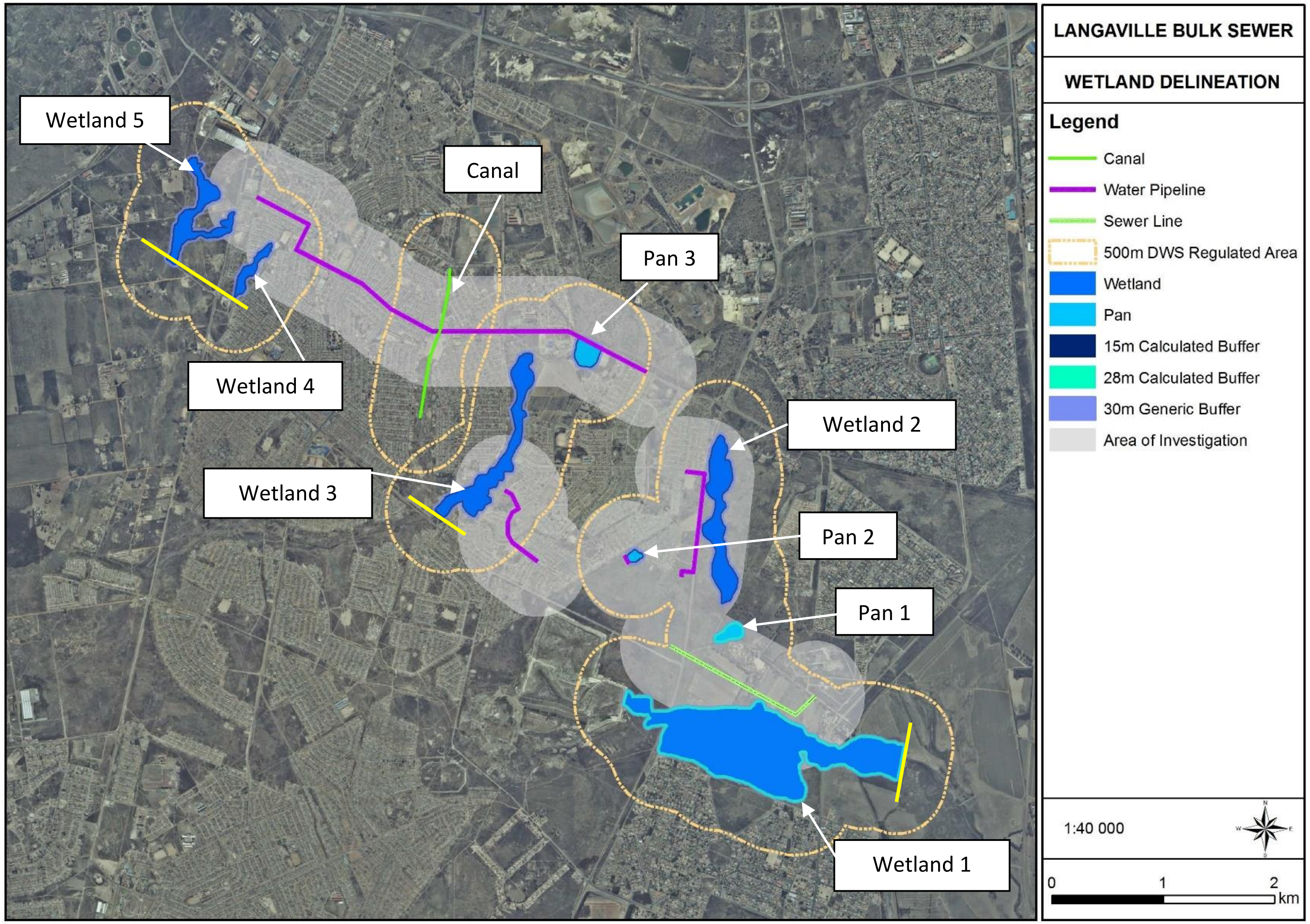


Figure 8: Wetland delineation also showing buffer zones and DWS regulated zones

3.2.1 Wetland 1

The channelled valley bottom wetland associated with the proposed sewer pipeline lies in a valley and flows from the mine spoils to the west (Figure 9). A section of this wetland is clearly channelled and it is consequently classified as a channelled valley bottom wetland. However, it is likely that the mine dump to the west has significantly affected the hydrology of this wetland. A small flat wetland lies approximately 340m north of the pipeline. Due to elevation changes in the landscape, it is unlikely that this wetland will be affected by the proposed sewer pipeline.

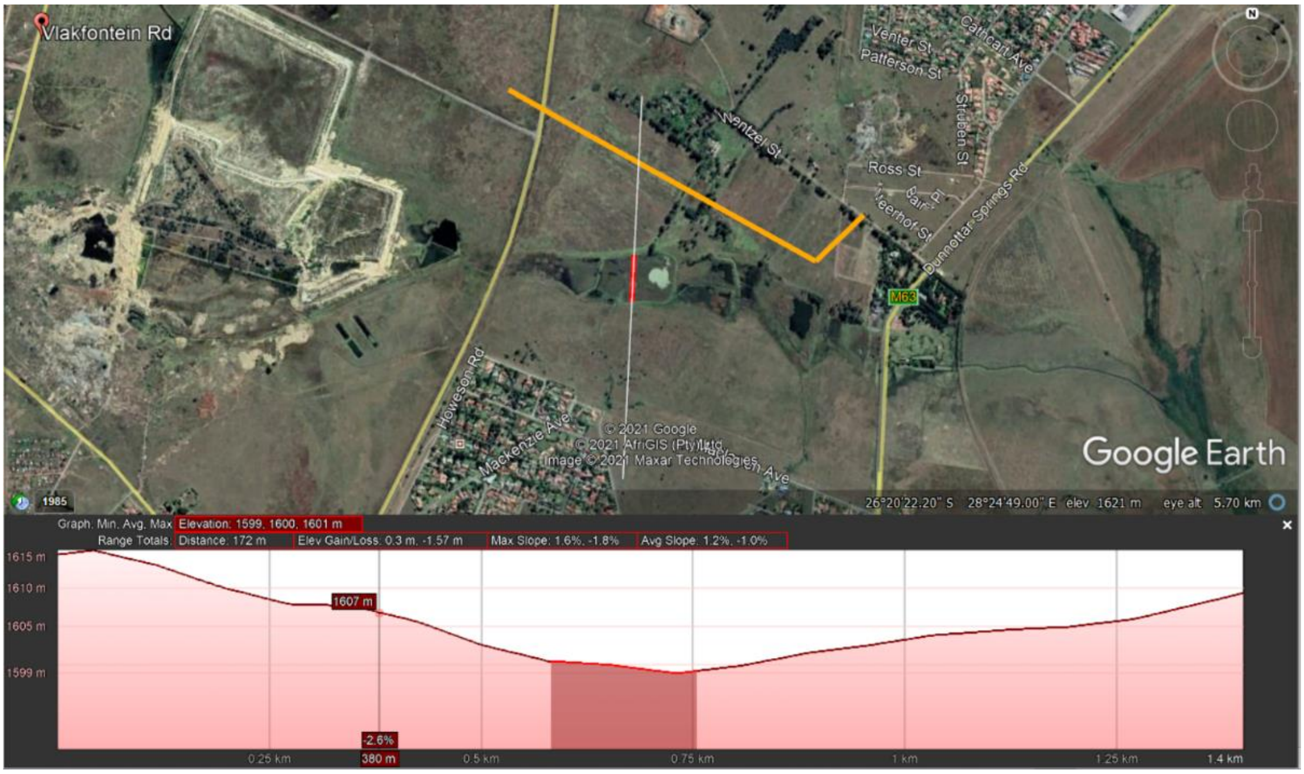


Figure 9: The elevation profile showing the valley in which the wetland lies

A calculated 18m buffer zone following Macfarlane *et al* (2015) was calculated for the wetland, based on site specific characteristics and the expected risks associated with a sewage pipeline. This buffer zone is relevant to authorisation from the DWS. A generic 50m buffer zone, relevant to wetlands outside the urban edge is required in the GDARD (2014) guidelines.

The soil in wetland 1 was dominated by clay and/or loam that has some degree of water retention properties. It should be noted that the historical mining and other impacts has caused pronounced changes in large sections of the soil profile (Figure 10).

Figure 10: Soil samples taken in wetland 1

The vegetation in proximity to wetland 1 was characterised by large sections of disturbed vegetation growth surrounding areas such as the old mine dump and remnant infrastructure as well as large areas that has been recently burnt subsequently not all the vegetation could be identified. The burnt area does however provide some benefits such as exposing gullies, trenches, broken dam walls and other infrastructure that would likely not have been seen when vegetation growth is robust. The wetland indicators species (Figure 11) that was recorded include *Juncus effesus, Schoenoplectus corymbosus, Typha capensis* and *Berkeya* sp. Some of the grass species *include Imperata cylindrical, Leersia hexandra, Paspalum dilatatum, Cynodon dactylon* and *Pennisetum clandestinum*. The exotic woody species recorded include *Pinus* sp., *Eucayptus* sp. and *Quercus* sp.

Figure 11: Vegetation characteristics of the wetland

3.2.1.1 Wetland 1 Function and Integrity

The increased hardened surfaces in its catchment due to residential development development as well as the intensive changes to the geomorphology and hydrology of the system have significantly impacted the functionality of the wetland. The hydrology has been significantly impacted by the mining in the wetland and its catchment. The vegetation was significantly impacted by overgrazing and a recent burn. The vegetation surrounding the relic infrastructure is also predominantly exotic.

The mine dump is likely to lead to an increase in sedimentation in the downstream watercourses. Lastly, the footpaths, dirt roads, dumping and littering also has some impacts on the watercourses.

3.2.1.1.1 Overall Wetland Health Scores

Impacts to the hydrology, geomorphology, water quality and vegetation components of the valley bottom wetland to the south of the proposed sewage pipeline were assessed, also considering the larger topographic catchment and the area 200m adjacent to the delineated wetland. Impacts (identified as disturbance units) included in this assessment included mining, agriculture, residential settlements and impoundments. Sources of pollution include runoff from the mine and stormwater outlets from residential areas into the wetland.

The results of the Wet-Health (Version 2) assessment indicate that the wetland falls within a combined EC Category D, having obtained a combined impact score of 5.2 (Present Ecological Status 48%) (Table 4). Wetlands in this category are considered to be **Largely modified**. A large change in ecosystem processes and loss of natural habitat and biota has occurred (Kotze *et al*., 2020).

Table 4: Summary of hydrology, geomorphology, water quality and vegetation health assessment for Wetland 1 (Macfarlane *et al*, 2020).

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	5.6	4.8	4.3	5.9
PES Score (%)	44%	52%	57%	41%
Ecological Category	D	D	D	D
Trajectory of change	↓	→	↓	↓↓
Confidence (revised results)	Medium	Medium	Medium	Medium
Combined Impact Score	5.2			
Combined PES Score (%)	48%			
Combined Ecological Category	D			
Hectare Equivalents	46.9 Ha			

3.2.1.1.2 WetEcoServices Kotze et al., (2020)

The ecosystem services provided by the valley bottom wetland associated with the sewer pipeline is presented in Table 5 below. Most ecosystem services score Very Low. The highest scores was obtained for Nitrate Assimilation, Sediment Trapping and Toxicant Assimilation which scored Moderate and Moderately High. The Regulating and Supporting Services obtained relatively high values relative to the other ecosystem services (Figure 12).

Table 5: Summary of the Ecosystem Services provided by Wetland 1

	ECOSYSTEM SERVICE	Present State: Supply	Present State: Demand	Present State: Importance Score	Present State: Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1.5	2.0	1.0	Low
	Stream flow regulation	0.6	3.0	0.6	Very Low
	Sediment trapping	2.3	3.0	2.3	Moderate
	Erosion control	1.3	3.0	1.3	Low
	Phosphate assimilation	2.2	0.0	0.7	Very Low
	Nitrate assimilation	2.3	3.0	2.3	Moderately High
	Toxicant assimilation	2.3	3.0	2.3	Moderate
	Carbon storage	1.3	0.0	0.0	Very Low
	Biodiversity maintenance	0.2	1.0	0.0	Very Low
PROVISIONING SERVICES	Water for human use	0.0	0.3	0.0	Very Low
	Harvestable resources	0.5	0.0	0.0	Very Low
	Food for livestock	0.5	0.3	0.0	Very Low
	Cultivated foods	1.4	0.0	0.0	Very Low
CULTURAL SERVICES	Tourism and Recreation	0.0	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.0	Very Low

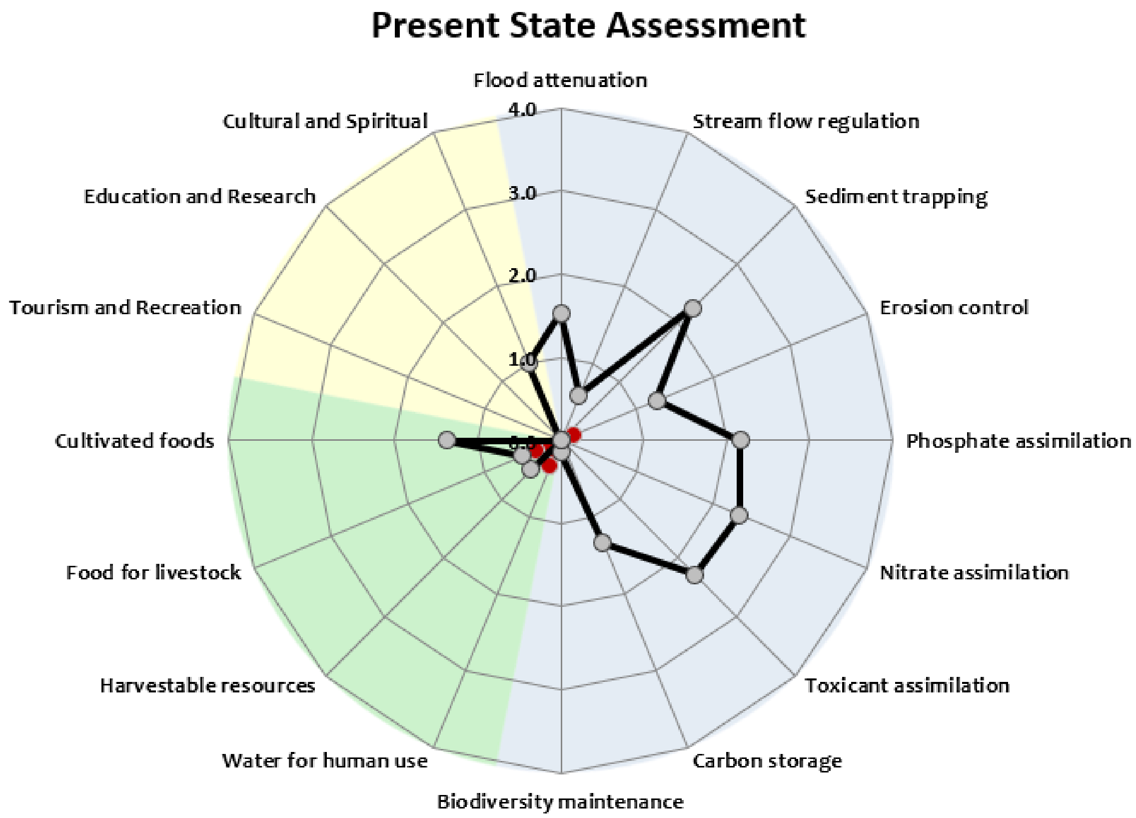


Figure 12: Graph showing the relative importance of ecosystem services provided by Wetland 1

3.2.1.1.3 Ecological Importance and Sensitivity (EIS)

Integrating the following ecosystem service scores to determine the ecological importance (EI) category for the valley bottom wetland as proposed in Kotze *et al.,* (2020) reflect a score of 0.6 – **Low/Marginal** EI category:

- ***Biodiversity maintenance importance***: 0.2
- ***Regulating services importance***: 1.2
- ***Provisioning and cultural services importance:*** 0.5

Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers (DWAF, 1999)

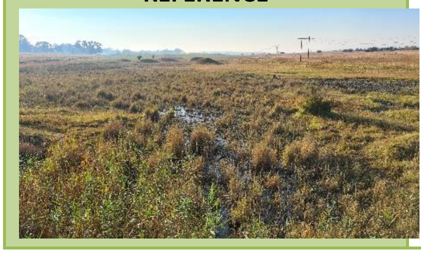
3.2.1.1.4 Baseline Freshwater Aquatic Invertebrate Assessment

This section includes a discussion of the results obtained, both with regard to the evaluation of habitat conditions and disturbances, as well as the species response of the assessed aquatic biota by determining their occurrence and composition at the sampling points described below.

3.2.1.1.5 Overview of Sampling Points

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 6.

Table 6: Evaluation of Suitability and Impacts at each Sampling Point

SURVEY SITE	SITE DESCRIPTION	HABITAT DESCRIPTION	IMPACTS/OBSERVATIONS
LANGAVILLE WETLAND 1 REFERENCE 	Upstream of proposed impact. Drains from tailings facility under Tonk meter drive.	▪ Poor, ▪ Very low base flow, ▪ Impacted by Cattle drinking from the point, ▪ Only GSM and Vegetation sample	▪ Urbanization of the catchment, ▪ Impoundment, ▪ Alteration of flow paths, ▪ Impacted and degraded water quality- from tailings facility

3.2.1.1.6 In situ drivers

No water samples were taken and only in site assessments was competed using a Hanna HI 9813-6 portable probe[1]. Aspects measured included pH, electrical conductivity, Total dissolved solids, and temperature. See Table 7 for the results.

Table 7: In situ water quality results

	Langaville Reference
pH	6.2
TDS (in ppm)	513
Electrical conductivity (mS)	0.69
Temperature	17.1

3.2.1.1.7 Habitat assessment using the IHAS system

The sample site only consisted of slow-moving water with little depth (>200mm). The system was not in flood or recently in flood. Habitats consisted only of mud with some gravel and standing vegetation. No fringing vegetation was observed. The IHAS score was calculated to 44.7% for the

[1] Calibration of the device was completed by the author on 2 April 2021

upper sample site (Table 8). This indicates the habitat is not acceptable for supporting a diverse macroinvertebrate community.

Table 8: Langaville Wetland 1 Reference IHAS results

SAMPLING HABITAT RATING (K)						
SCORE	0	1	2	3	4	5
Stones in current (SIC)						
Total lengths of white water rapids (riffles)(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 sizes kicked (in cm's)(< 2>10<2or>10)(<2=gravel)	None	<2>10	2-5	5-10	2-10	
Amount of stone surface clear (of algae,sediment,etc)(in percent)		0-25	25-50	50-75	>75	
PROTOCOL: time spent actually kicking SIC's (in minutes	0	<1	1	2	3	>3
Subtotal	0	0	0	0	0	0
(A=SIC boxes total; B=adjustment to equal 20 PERCENT C=final total)	0	A	0	B	0	C
Vegetation						
Length of fringing vegetation sampled (banks) (in metres)	None	0-0.5	0.5-1	1-2	2	>2
Amount of aquatic vegetation/algaesampled (underwater)(in m²)	None	0-0.5	0.5-1	>1		
Fringing vegetation sampled in: (none, pool or still only, mixture or both)	None		run	pool		mix
Type of veg (% leafy vegetation as opposed to stems/shoots)(aq.veg.only=50)		0	1-25	25-50	50-75	>75
Subtotal	0	0	2	3	0	5
(D=veg. boxes total; E=adjustment to equal 15 PERCENT; F=final total)	10	D	1,5	E	11,5	F
Other Habitat						
Stones out of Current (SOOC) sampled: PROTOCOL in m²	None	0-0.5	0.5-1	1	>1	
Sand Sampled (PROTOCOL in Minutes)	None	0-0.5	0.5-1	1	>1	
Mud sampled (PROTOCOL in minutes)	None	0-0.5	0,5	>0.5		
Gravel sampled (PROTOCOL in minutes)	all	None	0-0.5	0,5	>0.5	
Bedrock sampled (all=no SIC,sand, gravel)	None	Some			all	
Tray identification (PROTOCOL using time corr = correct times		Under		corr		over
Subtotal	0	0	2	6	0	0
(G= O>H boxes total; H=adjustment to equal 15 PERCENT; I=final total)	8	G	1,2	H	9,2	I
(J=Total adjustment (B+E+H) K=Total habitat (C+F+I)			2,7	J	20,7	K
STREAM CHARACTERISTICS (L)						
Physical						
River make up (pool=pool/stil/dam only; run only; rapid only: 2 mix=2 types etc)	pool		run	rapid	2mix	3mix
Average width of stream: (meters)		>10	5-10	<1	1-2	2-5
Average depth of stream: (meters)	>2	1-2	1	0.5-1	0,5	<0.5
Approximately velocity of stream (slow = 0.5m/s fast = 1m/s)	still	slow	fast	med		mix
Water colour (disc=discoloured with visible colour but still clearish	silly	opaq		discol	clear	crystal
Visible disturbance due to: (constr. = ongoing construction)	flood	constr	livest	other		none
Bank/riparian vegetation is: (grass=includes reeds, shrubs=includes trees)	none		grass	shrub		mix
Surrounding impacts:(erosn=erosion, informal settlements, farmland, nature.	erosn	settle	farm	trees	clear	nature
Left bank cover (rocks and vegetation): in % (shear =0%)	shear	<50	50-80		80-95	>95
Right bank cover (rocks and vegetation): in % (shear =0%)	shear	<50	50-80		80-95	>95
Subtotal	0	1	2	3	8	10
(L=Physical boxes final total) **Stream Characteristics Total;**					24	L
Total IHAS Score: (K+L)					44,7	

3.2.1.1.8 Aquatic macroinvertebrates using the SASS 5 methodology

The SASS 5 protocol was complete within the parameters of the methodology. See Table 9 for the results. The sample site had a SASS score of 18 with 8 species. The ASPT was calculated to 2.3. The taxa observed are all hardy and able to survive in difficult conditions.

3.2.1.1.8.1 SASS5 EC

Using the "Dallas Bands" (Dallas, 2007) the SASS5 Ecological Category was determined in (Figure 13) to E/F classification. The classification suggests that the system is in poor condition. This assessment is in line with the site observations.

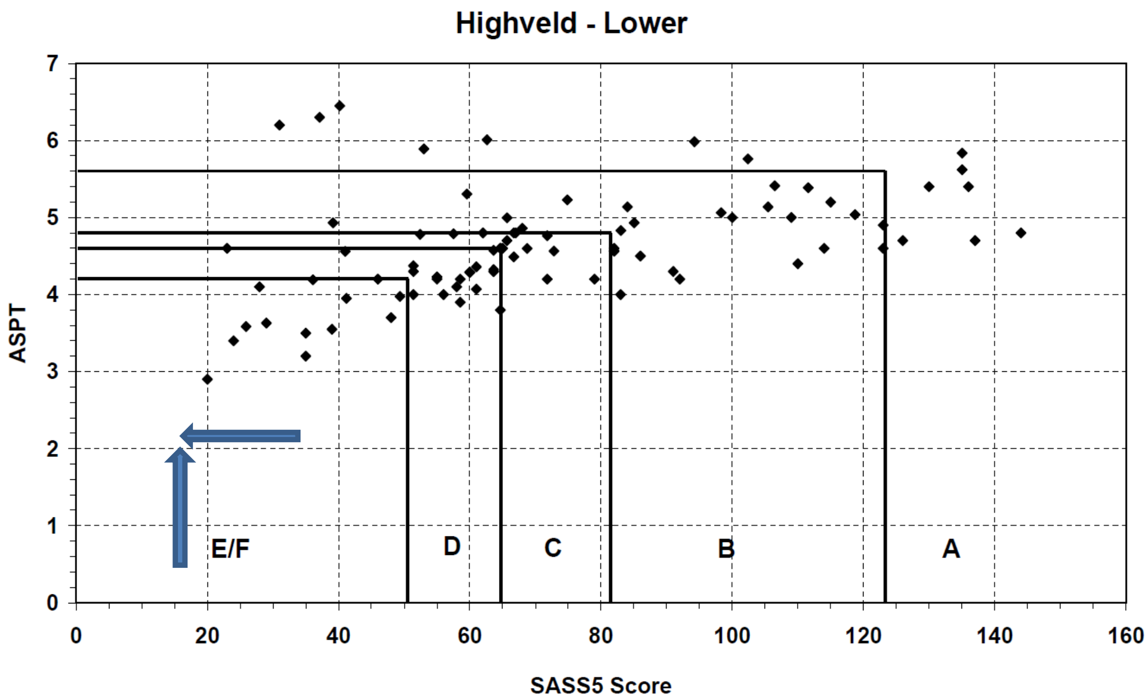


Figure 13: SASS5 Score and ASPT Plot for sampling points during the survey (blue arrows)

Table 9: SASS 5 Upper results

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1			A	A
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
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				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4			A	A
Lestidae (Emerald Damselflies/Spreadwin	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				A
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
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				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2		A	A	A
Culicidae* (Mosquitoes)	1		B		B
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1			A	A
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1		A		A
Tabanidae (Horse flies)	5		A		A
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					18
No. of Taxa					8
ASPT					2,3
Other biota:					
Comments/Observations:					

3.2.2 Wetland 2

This wetland lies north of Wetland 1. It slopes to the east, away from a section of water pipeline included in the proposed activity discussed in this report. The pipeline runs parallel to Wetland 2 in the existing servitude of Tonk Meter Drive. The pipeline lies close to the wetland in two places, one of which is approximately 32m and the other approximately 38m west of wetland 2. No aquatic habitat occurs in this wetland. Vegetation is dominated by mosaics of grassland species with very little woody vegetation (Figure 14).

Figure 14: General characteristics of Wetland 2

3.2.2.1.1 Overall Wetland Health Scores

Impacts (identified as disturbance units) in this wetland included agriculture, road crossings, residential infrastructure and extensive digging and earthworks related to unknown activities. Sources of pollution include runoff from the adjacent Tonk Meter Road.

The results of the Wet-Health (Version 2) assessment indicate that the wetland falls within a combined EC Category D, having obtained a combined impact score of 4.7 (Present Ecological Status 53%) (Table 10). Wetlands in this category are considered to be **Largely modified**. A large change in ecosystem processes and loss of natural habitat and biota has occurred (Kotze *et al*., 2020).

Table 10: Summary of hydrology, geomorphology and vegetation health assessment for Wetland 2 associated with the proposed water pipeline (Macfarlane *et al.*, 2020).

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	5.7	5.3	3.9	3.2
PES Score (%)	43%	47%	61%	68%
Ecological Category	D	D	C	C
Trajectory of change	↓	↓	→	→
Confidence (revised results)	3	3	3	3
Combined Impact Score	4.7			
Combined PES Score (%)	53%			
Combined Ecological Category	D			

3.2.2.1.2 WetEcoServices Kotze et al., (2020)

The ecosystem services provided by the valley bottom wetland associated with the sewer pipeline is presented in Table 11 below. Most ecosystem services score Very Low. The highest scores was obtained for Nitrate Assimilation, Sediment Trapping and Toxicant Assimilation which scored Moderate and Moderately High. The Regulating and Supporting Services obtained relatively high values relative to the other ecosystem services.

Table 11: Summary of the Ecosystem Services provided by Wetland 2

		Present State			
ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1.5	2.5	1.3	Low
	Stream flow regulation	0.6	3.5	0.8	Low
	Sediment trapping	2.3	2.5	2.0	Moderate
	Erosion control	1.3	2.5	1.0	Low
	Phosphate assimilation	2.2	0.0	0.7	Very Low
	Nitrate assimilation	2.3	2.5	2.1	Moderate
	Toxicant assimilation	2.3	2.5	2.0	Moderate
	Carbon storage	1.3	0.0	0.0	Very Low
	Biodiversity maintenance	0.2	1.0	0.0	Very Low
PROVISIONING SERVICES	Water for human use	0.0	0.3	0.0	Very Low
	Harvestable resources	0.5	0.0	0.0	Very Low
	Food for livestock	0.5	0.3	0.0	Very Low

	Cultivated foods	1.4	0.0	0.0	Very Low
CULTURAL SERVICES	Tourism and Recreation	0.0	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.0	Very Low

3.2.2.1.3 Ecological Importance and Sensitivity (EIS)

Integrating the following ecosystem service scores to determine the ecological importance (EI) category for the valley bottom wetland as proposed in Kotze *et al.,* (2020) reflect a score of 0.4 – **Low/Marginal** EI category:

- ***Biodiversity maintenance importance***: 0.0
- ***Regulating services importance***: 1.1
- ***Provisioning and cultural services importance:*** 0.15

Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers (DWAF, 1999)

3.2.3 Wetland 3

This wetland falls in quaternary catchment C22C and drains into a tributary Rietspruit. It an unchanneled valley bottom wetland although a channel forms south of the study area. Similar to other wetlands in the area, it is dominated by grass and sedge species and supports little woody (Figure 15). Several stormwater outlets from adjacent residential areas flow into this wetland. Littering is an obvious impact to habitat integrity. This wetland lies approximately 90m west of the western extent of the water pipeline that lies along Matlala Street. It further extends to approximately 210m south of the water pipeline that lies along Rhokana Street.

Figure 15: General characteristics of Wetland 3 as seen from Vlakfontein Road south of the pipeline

3.2.3.1.1 Overall Wetland Health Scores

Impacts (identified as disturbance units) in this wetland included road crossings and footpaths, residential infrastructure, numerous stormwater outlets into the wetland from adjacent residential areas and extensive littering.

The results of the Wet-Health (Version 2) assessment indicate that the wetland falls within a combined EC Category D, having obtained a combined impact score of 4.5 (Present Ecological Status 52%) (Table 12). Wetlands in this category are considered to be **Largely modified**. A large change in ecosystem processes and loss of natural habitat and biota has occurred (Kotze *et al*., 2020).

Table 12: Summary of hydrology, geomorphology and vegetation health assessment for Wetland 3 associated with the proposed water pipeline (Macfarlane *et al*., 2020).

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	5.7	5.1	3.9	3.0
PES Score (%)	43%	42%	61%	66%
Ecological Category	D	D	C	C
Trajectory of change	↓	↓	→	→
Confidence (revised results)	3	3	3	3
Combined Impact Score	4.5			
Combined PES Score (%)	52%			
Combined Ecological Category	D			

3.2.3.1.2 WetEcoServices Kotze et al., (2020)

The ecosystem services provided by the valley bottom wetland associated with the sewer pipeline is presented in Table 13 below. Most ecosystem services score Very Low. The highest scores was obtained for Nitrate Assimilation, Sediment Trapping and Toxicant Assimilation which scored Moderate and Moderately

High. The Regulating and Supporting Services obtained relatively high values relative to the other ecosystem services.

Table 13: Summary of the Ecosystem Services provided by Wetland 3

		Present State			
	ECOSYSTEM SERVICE	**Supply**	**Demand**	**Importance Score**	**Importance**
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1.5	2.5	1.3	Low
	Stream flow regulation	0.6	3.5	0.8	Low
	Sediment trapping	2.3	2.5	2.1	Moderate
	Erosion control	1.3	2.5	1.3	Low
	Phosphate assimilation	2.2	0.0	0.8	Very Low
	Nitrate assimilation	2.3	2.5	2.1	Moderate
	Toxicant assimilation	2.3	2.5	2.1	Moderate
	Carbon storage	1.3	0.0	0.0	Very Low
	Biodiversity maintenance	0.2	1.0	0.0	Very Low
PROVISIONING SERVICES	Water for human use	0.0	0.3	0.0	Very Low
	Harvestable resources	0.5	0.0	0.0	Very Low
	Food for livestock	0.5	0.3	0.0	Very Low
	Cultivated foods	1.4	0.0	0.0	Very Low
CULTURAL SERVICES	Tourism and Recreation	0.0	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.8	Low

3.2.3.1.3 Ecological Importance and Sensitivity (EIS)

Integrating the following ecosystem service scores to determine the ecological importance (EI) category for the valley bottom wetland as proposed in Kotze *et al.,* (2020) reflect a score of 0.5 – **Low/Marginal** EI category:

- ***Biodiversity maintenance importance***: 0.0
- ***Regulating services importance***: 1.2

- ***Provisioning and cultural services importance:*** 0.2

Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers (DWAF, 1999).

3.2.4 Wetland 4

This wetland falls in quaternary catchment C22C and drains into a tributary Rietspruit. It an unchanneled valley bottom wetland although a channels have been dug in this wetland. Impacts to this wetland are similar to the others discussed above and include road crossings, drains, significant infilling and littering (Figure 16). Again, vegetation cover is dominated by grass and sedge species with a sparse woody component. No aquatic habitat occurs in this wetland which is dominated by seasonal zones of wetness. This wetland lies approximately 220m southwest of the water pipeline that lies along Joe Maseko and Kgawsane Streets. No aquatic habitat occurs in this wetland.

Figure 16: General characteristics of Wetland 4 as seen from Thema Road

3.2.4.1.1 Overall Wetland Health Scores

Impacts (identified as disturbance units) in this wetland included road crossings and footpaths, residential infrastructure, numerous stormwater outlets into the wetland from adjacent residential areas and extensive littering.

The results of the Wet-Health (Version 2) assessment indicate that the wetland falls within a combined EC Category E, having obtained a combined impact score of 6.5 (Present Ecological Status 35%) (Table 14). Wetlands in this category are considered to be **Seriously modified**. The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable (Kotze *et al*., 2020).

Table 14: Summary of hydrology, geomorphology and vegetation health assessment for Wetland 3 associated with the proposed water pipeline (Macfarlane *et al.*, 2020).

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	7.1	6.9	5.6	5.4
PES Score (%)	29%	31%	44%	46%
Ecological Category	E	E	D	D
Trajectory of change				
Confidence (revised results)	3	3	3	3
Combined Impact Score	6.5			
Combined PES Score (%)	35%			
Combined Ecological Category	E			

3.2.4.1.2 WetEcoServices Kotze et al., (2020)

The ecosystem services provided by the valley bottom wetland associated with the sewer pipeline is presented in Table 15 below. Most ecosystem services score Very Low. The highest scores was obtained for Nitrate Assimilation, Sediment Trapping and Toxicant Assimilation which scored Moderate and Moderately High. The Regulating and Supporting Services obtained relatively high values relative to the other ecosystem services.

Table 15: Summary of the Ecosystem Services provided by Wetland 4

		Present State			
	ECOSYSTEM SERVICE	Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1.5	2.5	0.8	Low
	Stream flow regulation	0.6	3.5	0.7	Low
	Sediment trapping	2.3	2.5	2.0	Moderate
	Erosion control	1.3	2.5	1.3	Low
	Phosphate assimilation	2.2	0.0	0.7	Very Low
	Nitrate assimilation	2.3	2.5	2.0	Moderate
	Toxicant assimilation	2.3	2.5	2.0	Moderate
	Carbon storage	1.3	0.0	0.0	Very Low
	Biodiversity maintenance	0.2	1.0	0.0	Very Low
PROVISIONING SERVICES	Water for human use	0.0	0.3	0.0	Very Low
	Harvestable resources	0.5	0.0	0.0	Very Low
	Food for livestock	0.5	0.3	0.0	Very Low

	Cultivated foods	1.4	0.0	0.0	Very Low
CULTURAL SERVICES	Tourism and Recreation	0.0	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.9	Low

3.2.4.1.3 Ecological Importance and Sensitivity (EIS)

Integrating the following ecosystem service scores to determine the ecological importance (EI) category for the valley bottom wetland as proposed in Kotze *et al.,* (2020) reflect a score of 0.4 – **Low/Marginal** EI category:

- ***Biodiversity maintenance importance***: 0.0
- ***Regulating services importance***: 1.1
- ***Provisioning and cultural services importance:*** 0.2

Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers (DWAF, 1999)

3.2.5 Wetland 5

This wetland joins with wetland 4 to drain into a tributary of the Rietspruit. It lies west of the residential built-up area and the western extent of the water pipeline. The area to the west and south of this wetland was affected by gold mining in the past. Currently, small-holdings dominate land-use. The wetland is also unchanneled and is impacted by road crossings, grazing and dumping (Figure 17). This wetland lies approximately 240m west of the water pipeline in Joe Maseko Street. This wetland is dominated by seasonal and temporary zones of wetness. Although some trees grow here, plant species composition remains dominated by grass and sedges.

Figure 17: General characteristics of Wetland 5 as seen from Rademan Street

3.2.5.1.1 Overall Wetland Health Scores

The results of the Wet-Health (Version 2) assessment indicate that the wetland falls within a combined EC Category E, having obtained a combined impact score of 4.3 (Present Ecological Status 57%) (Table 16). Wetlands in this category are considered to be **Largely modified**. A large change in ecosystem processes and loss of natural habitat and biota has occurred (Kotze *et al*., 2020).

Table 16: Summary of hydrology, geomorphology and vegetation health assessment for Wetland 5 associated with the proposed water pipeline (Macfarlane *et al*., 2020).

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	6.0	3.2	1.7	5.5
PES Score (%)	40%	68%	83%	45%
Ecological Category	D	C	B	D
Trajectory of change	→	→	→	→
Confidence (revised results)	Medium	Medium	Medium	Medium
Combined Impact Score	4.3			
Combined PES Score (%)	57%			
Combined Ecological Category	D			

3.2.5.1.2 WetEcoServices Kotze et al., (2020)

The ecosystem services provided by the valley bottom wetland associated with the sewer pipeline is presented in Table 17 below. The Ecosystem Services for Sediment Trapping and Toxicant Assimilation score Very High, reflecting the historic mining in the wetland's catchment. Most ecosystem services score Very Low. The Provisioning and Cultural Services scores are Very Low.

Table 17: Summary of the Ecosystem Services provided by Wetland 5

		Present State			
	ECOSYSTEM SERVICE	Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1.5	3.0	1.5	Moderately Low
	Stream flow regulation	0.6	3.5	0.8	Low
	Sediment trapping	3.5	3.0	3.5	Very High
	Erosion control	1.4	2.5	1.1	Low
	Phosphate assimilation	3.6	0.0	2.1	Moderate
	Nitrate assimilation	3.5	1.0	2.5	Moderately High
	Toxicant assimilation	3.7	4.0	3.7	Very High
	Carbon storage	1.3	0.0	0.0	Very Low
	Biodiversity maintenance	0.2	2.0	0.8	Low
PROVISIONING SERVICES	Water for human use	0.0	0.3	0.0	Very Low
	Harvestable resources	1.0	0.0	0.0	Very Low
	Food for livestock	1.0	0.3	0.0	Very Low
	Cultivated foods	1.4	0.0	0.0	Very Low
CULTURAL SERVICES	Tourism and Recreation	0.0	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	1.0	0.0	0.0	Very Low

3.2.5.1.3 Ecological Importance and Sensitivity (EIS)

Integrating the following ecosystem service scores to determine the ecological importance (EI) category for the valley bottom wetland as proposed in Kotze *et al.,* (2020) reflect a score of 0.4 – **Low/Marginal** EI category:

- ***Biodiversity maintenance importance***: 0.0
- ***Regulating services importance***: 1.1
- ***Provisioning and cultural services importance:*** 0.2

Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers (DWAF, 1999)

3.2.6 Pans 1, 2 and 3

Three pan wetlands occur on the site. Pan 1 lies approximately 260m north of the sewer pipeline (upslope) and 577m south of the water pipeline along Tonk Meter Drive. This wetland is unlikely to be affected by the development and is not discussed in more detail. Pan 2 lies approximately 20m east of the 100m long water pipeline located northeast of Langaville Ext 12. Pan 3 lies immediately adjacent to the section of water pipeline located in Rhokana Steet. Both pan 2 and 3 are located adjacent to densely developed areas. Consequently vegetation cover is significantly altered, water that drains into these depressions is likely to be polluted and daily human activities including use of footpaths and littering affect their integrity (Figure 18). Since the impacts to the tow pans are similar, they are assessed together.

Figure 18: Characteristics of Pan 2 from Rhokana Street

3.2.6.1.1 Overall Wetland Health Scores

The overall wetland health score for the two pans aggregates the scores for the four modules, namely hydrology, geomorphology, water quality and vegetation. The trajectory of change serves as a prediction of the future status of the wetland. The PES scores obtained are shown in Table 18. The scores fall in the D class, Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.

Table 18: Summary of the results of the WetHealth (Version 2) assessment conducted for the pan wetlands

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	4.8	4.3	8.4	5.4
PES Score (%)	52%	57%	16%	46%
Ecological Category	D	D	F	D
Trajectory of change	↓	↓	↓↓	↓
Confidence (revised results)	Medium	Medium	Medium	Medium
Combined Impact Score	5.6			
Combined PES Score (%)	44%			
Combined Ecological Category	D			
Hectare Equivalents	2.3 Ha			

3.2.6.1.2 WetEcoServices Kotze et al., (2020)

The ecosystem services provided by the wetlands reflects disturbed nature of the area (Table 19). Most ecosystem services score Very Low. Low scores were obtained for sediment trapping Phosphate and Nitrate Assimilation.

Table 19: Summary of the Ecosystem Services provided by the pan wetlands

ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0.0	0.8	0.2	Very Low
	Stream flow regulation	0.0	0.0	0.0	Very Low
	Sediment trapping	0.6	0.3	0.6	Low
	Erosion control	0.1	0.1	0.1	Very Low
	Phosphate assimilation	0.7	0.5	0.7	Low
	Nitrate assimilation	0.6	0.4	0.5	Low
	Toxicant assimilation	0.7	0.2	0.5	Very Low
	Carbon storage	0.7	0.2	0.4	Very Low
	Biodiversity maintenance	0.2	0.0	0.0	Very Low
PROVISIONING SERVICES	Water for human use	0.0	0.0	0.0	Very Low
	Harvestable resources	0.0	0.0	0.0	Very Low
	Food for livestock	0.0	0.0	0.0	Very Low
	Cultivated foods	0.7	0.0	0.3	Very Low

CULTURAL SERVICES	Tourism and Recreation	0.1	0.0	0.0	Very Low
	Education and Research	0.0	0.0	0.0	Very Low
	Cultural and Spiritual	0.0	0.0	0.0	Very Low

3.2.6.1.3 *Ecological Importance and Sensitivity (EIS)*

Integrating the following ecosystem service scores to determine the ecological importance (EI) category for the valley bottom wetland as proposed in Kotze *et al.,* (2020) reflect a score of 0.1 – **Low/Marginal** EI category:

- ***Biodiversity maintenance importance***: 0.0
- ***Regulating services importance***: 0.3
- ***Provisioning and cultural services importance:*** 0.1

Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers (DWAF, 1999).

3.2.7 Canal

A canalised watercourse west of Wetland 3 confluences with this wetland to drain into a tributary of the Rietspruit. This canal received stormwater from the adjacent residential areas. Isolated wetland conditions may persist along the canal, but this watercourse no longer functions as a wetland (Figure 18). This canal does not provide ecosystem services and it does not contribute to support of biodiversity.

Figure 19: Characteristics of the canal from Kgaswane Street

3.2.7.1.1 Overall Wetland Health Scores

The overall wetland health score is calculated which aggregates the scores for the four modules, namely hydrology, geomorphology, water quality and vegetation (Table 20). A score of F reflects a wetland that has been critically modified. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota (Macfarlane *et al.* 2020).

Table 20: Summary of the results of the WetHealth (Version 2) assessment conducted for the pan wetlands

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	10.0	8.3	5.0	10.0
PES Score (%)	0%	17%	50%	0%
Ecological Category	**F**	**F**	**D**	**F**
Combined Impact Score	8.9			
Combined PES Score (%)	11%			
Combined Ecological Category	**F**			

3.3 Summary of Findings

Table 21 provides a summary of the results recorded for the wetland units potentially affected by the proposed sewage and water pipelines earmarked for repair and replacement.

Table 21: Summary of results for each watercourse unit discussed

Wetland 1	**PES: 48% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D** **Instream habitat (IHAS):** The IHAS score was calculated to 44.7% for the sample site. This indicates the habitat that not suitable for supporting a diverse macroinvertebrate community. **Aquatic macroinvertebrate assemblages:** The number of taxa observed on site were 8 with a combined SASS score of 18. The Average score per taxon (ASPT) was 2.3- this is low but is mainly driven by the lack of stones habitat and decreased water quality. The taxa observed are all hardy and able to survive in difficult conditions.
Wetland 2	**PES: 53% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**

Wetland 3	**PES: 52% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**
Wetland 4	**PES: 35% - EC = E: Seriously Modified**. The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**
Wetland 5	**PES: 57% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very High scores are obtained for Toxicant Assimilation and Sediment Trapping. Provisioning and Cultural services score Very Low **Recommended Ecological Management Category: D**
Pan 2 and 3	**PES: 52% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**
Canal	**PES: 11% - EC = F: Critically Modified**. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.

3.4 Impacts and Mitigations

The recently gazetted requirements for specialist studies GN320 of March 2020 requires specialist to comment on specific impacts. The expected impacts and risks to the wetland resulting from the proposed sewage pipeline are presented in Section 3.5.1 below. It is important to note that this section aims to highlight areas of concern. The details of the mitigation measures will require input from engineers and architects. 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.

Since the proposed sewer pipeline is located outside the delineated boundaries of Wetland 1 and its buffer zone, it is unlikely that the construction related activities will affect this wetland. However, spills of sewage into the downslope wetland will have a significant effect on aquatic biota and water quality.

The water pipelines earmarked for repair and upgrade are all located in existing servitudes. The wetlands closest to the water pipelines, and consequently the most likely to be impacted are Pans 2 and 3. Particularly Pan 3 lies immediately adjacent to a section of pipeline. Earthworks associated with removal of old pipes and replacement with new pipes may negatively affect the wetland unless care is taken to implement effective mitigation as set out below.

3.4.1 NEMA (2014) Impact Assessment

Table 22 to Table 2727 below indicate the impact scores for the potential impacts relevant to the proposed activities. These impacts include aspects of the aquatic environment as specified in GN350 of March 2020.

Table 22: Impacts to hydrological function at a landscape level

Nature Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes) as well as the extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). Changes to base flow and hydroperiod.		
ACTIVITY: The sources of this impact include the compaction of soil, the removal of vegetation, surface water redirection, changes to watercourse morphology or input of high energy surface water, particularly at Pan 3.		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly Probable (4)	Probable (3)
Duration	Short term (2)	Short term (2)
Extent	Regional (3)	Limited to Local Area (2)
Magnitude	Low (4)	Low (4)
Significance	**36 (medium)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly Probable (4)	Probable (3)

Duration	Medium term (3)	Medium term (3)
Extent	Limited to Local Area (2)	Limited to Local Area (2)
Magnitude	Low (4)	Low (4)
Significance	**36 (medium)**	**27 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes	
Mitigation: • The position of the structures should avoid the delineated watercourses of their buffer zones • At Pan 3, take particular care to ensure that only the minimum are required for pipeline replacement is disturbed. The adjacent wetland must be fenced off and entry into this sensitive area must be prevented and monitored • Dewatering from trenches during the pipe implementation phase should not be discharged directly into watercourse. Dewatering discharge must be routed through properly constructed silt traps and erosion control measures. • A temporary fence or demarcation must be erected around No-Go Areas outside the proposed works area prior to any construction taking place as part of the contractor planning phase when compiling work method statements to prevent access to the adjacent portions of the watercourse. • Where disturbance of wetland habitat occurs, rehabilitation should be implemented		
Cumulative impacts: Low to moderate and could include edge effects to remaining natural vegetation as the footprint of the activities may result in vegetation clearing. This may lead to sedimentation and establishment of alien plant species		
Residual Risks: Expected to be low given that structures fall outside the delineated sensitive areas and that stormwater is effectively managed.		

Table 23: Changes in sediment regime

Nature: Changes in sediment regimes of the aquatic ecosystem and its sub -catchment by for example sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns		
Activity: Construction and maintenance activities will result in earthworks and soil disturbance as well as the disturbance of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourse and increase the turbidity of the water. Possible sources of the impacts include: • Earthwork activities during construction • Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, 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 adjacent to the watercourse • Erosion (e.g. gully formation, bank collapse)		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly Probable (4)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Limited to Local Area (2)	Regional (3)

Magnitude	Low (4)	Low (4)
Significance	**36 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Possible (2)
Duration	Medium term (3)	Short-term (2)
Extent	Limited to Local Area (2)	Regional (3)
Magnitude	Low (4)	Low (4)
Significance	**27 (low)**	**18 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	High	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Store topsoil and subsoil stockpiles from the trench outside of buffered the watercourse
- Dewatering from trenches during the pipe implementation phase should not be discharged directly into wetland or river systems. Dewatering discharge must be routed through properly constructed silt traps.
- These dewatering silt traps should be located outside of the buffered watercourse areas and be frequently monitored to ensure they remain effective.
- Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area.
- Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover.
- 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 adjacent 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.
- Monitoring should be done to ensure that sediment pollution is timeously dressed

Cumulative impacts: Expected to be limited provided that the mitigation measures are implemented effectively and sedimentation is appropriately managed.

Residual Risks: Expected to be limited provided that the mitigation measures are implemented effectively and sedimentation is appropriately managed.

Table 24: Introduction and spread of alien vegetation impact ratings.

Nature: Introduction and spread of alien vegetation.

Activity: The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plans can easily colonise and impact on downstream users.

	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (3)	Probable (3)
Duration	Long term (4)	Short term (2)
Extent	Regional (3)	Local (2)
Magnitude	Moderate (6)	Low (4)

Significance	**39 (moderate)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Possible (2)
Duration	Medium-term (3)	Medium term (3)
Extent	Regional (4)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**33 (moderate)**	**18 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Undertake an Alien Plant Control Plan which specifies actions and measurable targets
- Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area and returning it where possible afterwards.
- Long-term monitoring for the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish, as specified in the Alien Vegetation Management Pan
- Rehabilitate or revegetate disturbed areas

Cumulative impacts: Since alien vegetation is already present in the catchment, cumulative impacts can be Moderate to High. Regular monitoring should be implemented during construction, rehabilitation including for a period after rehabilitation is completed.

Residual Risks: Expected to be limited provided that alien plants are effectively controlled

Table 25: Loss and disturbance of wetland habitat and fringe vegetation impact ratings.

Nature: Loss and disturbance of watercourse habitat and fringe vegetation including impact on fixed and dynamic ecological processes and impact on key ecosystem regulating and supporting services

Activity: Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation. Earthworks in close proximity to Pan 3 is a particular risk to habitat loss in this wetland.

	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Highly Probable (4)	Probable (3)
Duration	Medium term (3)	Short duration (2)
Extent	Local (2)	Local (2)
Magnitude	Low (4)	Low (4)
Significance	**36 (medium)**	**24 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Possible (3)	Possible (2)
Duration	Medium term (3)	Medium-term (3)
Extent	Local (2)	Limited to the local area (2)
Magnitude	Low (4)	Low (4)
Significance	**27 (low)**	**18 (low)**
Status (positive or negative)	Negative	Negative

Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- The development footprint should remain outside the delineated wetland and buffer zones.
- Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas
- Implement an Alien Plant Control Plan
- 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 take immediate corrective action where invasive species are observed to establish

Cumulative impacts: Expected to be Low. Should degradation occur, it may result in a high degree of irreplaceable loss of resources.

Residual Risks: Expected to be limited provided that the mitigation measures are implemented correctly and effective rehabilitation of the site is undertaken where necessary.

Table 26: Changes in water quality.

Nature: Changes in water quality due to input of foreign materials.

Activity: Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/rivers and a reduction in watercourse function.

	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**20 (low)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (4)	Probable (4)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)
Magnitude	Moderate (6)	Moderate (6)
Significance	**40 (moderate)**	**40 (moderate)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation: • Locate the infrastructure outside the calculated buffer zone • Implementation of appropriate stormwater management around the excavation to prevent the ingress of run-off into the excavation and to prevent contaminated runoff into the watercourse. • Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone • The development footprint must be fenced off from the watercourses and no related impacts may be allowed into the watercourse e.g. water runoff from cleaning of equipment, vehicle access etc. • 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 / equipment should not take place within the watercourse • Measures should be put in place to prevent spills or water contaminated by waste material by for example constructing sumps or drains which can contain any spills in order for contaminated water to be isolated from the watercourse and removed from the site for appropriate disposal • A lined holding tank must have sufficient pumps and other measures to ensure that any spills are contained and can be safely removed without impact to the watercourse. • The design of the holding tank must accommodate 1:50 year flood lines to ensure that realistic flooding does not result in the release of contaminants downstream. • A warning system, for example a float switch with alarm should ensure that any spills are timeously identified. • Any spills should be cleared by effective methods to ensure no release occurs into the watercourse. • Standard Operating procedures, training drills and audits should be put in place and revised annually. • A detailed rehabilitation plan should be drawn up with the input from a water quality, soil contamination assessment and ecologist should any spills occur. • Independent water quality analyses should be undertaken annually, or as specified by an aquatic specialist, to demonstrate and audit compliance of effective pollution control measures
Cumulative impacts: Decreased water quality from spills of contaminants will contribute to regional water quality decrease, therefore should be considered a significant cumulative impact
Residual Risks: Although it may be controlled and largely prevented, the impact of a single spill will have a significant residual effect on the local watercourse integrity. Residual risks should therefore be considered significant

Table 27: Loss of aquatic biota

Nature: 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		
Activity: Loss and disturbance of biota due to direct development on the watercourse as well as changes in habitat including water quality, the water column, increased sediment, increased alien vegetation fire regime and habitat fragmentation		
	Without mitigation	**With mitigation**
CONSTRUCTION PHASE		
Probability	Probable (4)	Possible (2)
Duration	Medium-term (2)	Medium-term (2)
Extent	Local (2)	Local (2)

Magnitude	Moderate (6)	Moderate (5)
Significance	**48 (moderate)**	**30 (moderate)**
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Possible (3)	Possible (2)
Duration	Medium-term (3)	Short term (2)
Extent	Regional (3)	Local (2)
Magnitude	Moderate (4)	Moderate (2)
Significance	**36 (moderate)**	**12 (low)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	

Mitigation:

- Ensure that no additional vegetation is removed,
- Avoid unnecessary aquatic ecosystem crossing - limit work within the stream, river or wetland. The use of single access points for crossings.
- 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 development within wetlands and riparian areas as no-go areas.
- Weed control in aquatic ecosystem and 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
- Installation of early warning systems to detect possible leakage in the sewer pipeline

Cumulative impacts: Irreplaceable loss of the aquatic biota

Residual Risks: Due to the already seriously modified nature of the aquatic ecosystems surrounding the proposed development it is expected to be limited provided that the mitigation measures are implemented correctly, and effective rehabilitation of the site is undertaken where necessary

4 CONCLUSION

Watercourses in the 500m area of investigation around each section of pipeline discussed in this report lie in two quarternary catchments. In quarternary catchment C21E 2 valley bottom and 3 pan wetlands drain into the Blesbokspruit. In Quarternary catchment C22C 3 valley bottom wetlands drain into a tributary of the Rietspruit. A canalised watercourse extends across both catchments.

Since the proposed sewer pipeline is located outside the Wetland 1 and its buffer zone, it is unlikely that the construction related activities will affect the wetland. However, spills of sewage into the downslope wetland will have a significant effect on aquatic biota and water quality. The reference site condition (as presented in this report) must be used as baseline for the construction and operational phases of the proposed sewage pipeline. The Average Score Per Taxon of aquatic biota of 2.8 must be maintained or improved. Biomonitoring should be undertaken on a quarterly basis during construction and bi-annually during the operational phase to demonstrate that water quality is maintained.

The water pipelines earmarked for repair and upgrade are all located in existing servitudes. The wetlands closest to the water pipelines, and consequently the most likely to be impacted are Pans 2 and 3. Particularly Pan 3 lies immediately adjacent to a section of pipeline. Earthworks associated with removal of old pipes and replacement with new pipes may negatively affect the wetland unless care is taken to implement effective mitigation.

Table 28 below presents a summary of the results relevant to Environmental Authorisation.

Table 28: Summary of relevant results

	Quaternary Catchment and WMA areas	Important Rivers possibly affected
	C21E and C22C – #5 WMA, Vaal Major	The wetlands in catchment C21E on the study site drains into the Nigel dam which in turn drains into the Blesbokspruit River. Wetlands in catchment C22C drain into a tributary of the Rietspruit
Watercourse classification	Catchment C21E: – Channelled valley bottom wetland 1 – Unchannelled valley bottom wetland 2 – Pan 1 – Pan 2 – Pan 3 – A section of a canal Catchment C22C: – Unchannelled valley bottom wetland 3 – Unchannelled valley bottom wetland 4 – Unchannelled valley bottom wetland 5	
Buffer Zones	Wetland 1 is potentially affected by a sewer pipeline. The calculated buffer zone for this wetland is 18m. The generic buffer is 30m. All other wetlands are potentially affected by water pipeline replacement. Their calculated	

		buffer zones are 15m, generic buffer zones are 30m.
Watercourse function and integrity	**Channelled valley bottom wetland 1**	**PES: 48% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D** **Instream habitat (IHAS):** The IHAS score was calculated to 44.7% for the sample site. This indicates the habitat that not suitable for supporting a diverse macroinvertebrate community. **Aquatic macroinvertebrate assemblages:** The number of taxa observed on site were 8 with a combined SASS score of 18. The Average score per taxon (ASPT) was 2.3- this is low but is mainly driven by the lack of stones habitat and decreased water quality. The taxa observed are all hardy and able to survive in difficult conditions.
	Unchannelled valley bottom wetland 2	**PES: 48% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D** **Instream habitat (IHAS):** The IHAS score was calculated to 44.7% for the sample site. This indicates the habitat that not suitable for supporting a diverse macroinvertebrate community. **Aquatic macroinvertebrate assemblages:** The number of taxa observed on site were 8 with a combined SASS score of 18. The Average score per taxon (ASPT) was 2.3- this is low but is mainly driven by the lack of stones habitat and decreased water quality. The taxa observed are all hardy and able to survive in difficult conditions.
	Unchannelled valley bottom wetland 3	**PES: 53% - EC = D: Largely modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred. **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**
	Unchannelled valley bottom wetland 4	**PES: 35% - EC = E: Seriously Modified**. The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable **EIS: Low/Marginal.** Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers **ES:** Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping **Recommended Ecological Management Category: D**

<table>
<tr><td rowspan="3"></td><td>wetland 5</td><td colspan="4">PES: 57% - EC = D: Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.
EIS: Low/Marginal. Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers
ES: Very High scores are obtained for Toxicant Assimilation and Sediment Trapping. Provisioning and Cultural services score Very Low
Recommended Ecological Management Category: D</td></tr>
<tr><td>Pan 2 and 3</td><td colspan="4">PES: 52% - EC = D: Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.
EIS: Low/Marginal. Wetlands in this category are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers
ES: Very Low with Moderate to Moderately High scores for Toxicant and Phosphate Assimilation and Sediment Trapping
Recommended Ecological Management Category: D</td></tr>
<tr><td>Canal</td><td colspan="4">PES: 11% - EC = F: Critically Modified. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.</td></tr>
<tr><td colspan="2" rowspan="13">NEMA 2014 Impact Assessment</td><td colspan="2">The impact scores for the following aspects are relevant to the operational phase:</td><td>Without Mitigation</td><td>With Mitigation</td></tr>
<tr><td rowspan="2">Impacts to hydrological function at a landscape level</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operation</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Changes to sediment regimes</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operation</td><td>L</td><td>L</td></tr>
<tr><td rowspan="2">Establishment of alien plants</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operation</td><td>M</td><td>L</td></tr>
<tr><td rowspan="2">Loss of wetland habitat</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operation</td><td>L</td><td>L</td></tr>
<tr><td rowspan="2">Pollution of regional watercourses</td><td>Construction</td><td>M</td><td>L</td></tr>
<tr><td>Operation</td><td>M</td><td>M</td></tr>
<tr><td rowspan="2">Loss of aquatic biota</td><td>Construction</td><td>M</td><td>M</td></tr>
<tr><td>Operation</td><td>M</td><td>L</td></tr>
<tr><td colspan="2">Does the specialist support the development?</td><td colspan="4">Yes. Given that the mitigation measures are adhered to and release of pollutants into the watercourses is prevented and the baseline aquatic integrity is maintained</td></tr>
<tr><td colspan="2">Recommendations</td><td colspan="4">Biomonitoring should be conducted on a quarterly basis during construction and bi-annually during the operational phase.</td></tr>
</table>

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APPENDIX A: Compliance with Appendix 6 of the 2017 EIA regulations and GN320, March 2020

NR.	CONTENT	REFERENCE
a	A specialist report prepared in terms of these Regulations must contain— details of— i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Appendix C
2.7	SACNASP Qualification and field of practice	Page 3
b	A declaration that the specialist is independent in a form as may be specified by the competent authority;	Page 3
2	The assessment must be undertaken on the preferred site and within the proposed development footprint	Section1.4
2,3	Threat status of the ecosystem and species as identified by the DEA screening tool	Section 1.5
c	An indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
cA	An indication of the quality and age of base data used for the specialist report;	Section 1.1
cB	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 3
d	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 1.1
e	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Appendix B
2.3	Description of the aquatic biodiversity and ecosystems on the site including: • aquatic ecosystem types • Presence of aquatic species, and compositions of aquatic species communities their habitat, distribution and movement patterns	Section 3
2,3,4	A description of the ecological importance and sensitivity of the aquatic ecosystem including: • a) The description (spatially if possible) of the ecosystem process that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface water and subsurface water, recharge, discharge, sediment transport etc.); • b) The historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and or estuaries in terms of possible changes to channel and flow regime (surface and groundwater)	Section 3
f	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 1,3
g	An identification of any areas to be avoided, including buffers;	Section 3,4
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 3
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1
j	A description of the findings and potential implications of such findings on the impact of the proposed activity (including identified alternatives on the environment) or activities;	executive Summary, Section 4
	The following questions should be answered:	Section 4

	• Is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal? • Is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	
	How will the development impact on fixed and dynamic ecological processes that operate within or across the site: • a. Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); and • b) Change in the sediment regime (e.g. sand movement, meandering river mouth /estuary, changing flooding or sedimentation patterns) of the aquatic ecosystem and its sub -catchment; • c) The extent of the modification in relation to the overall aquatic ecosystem (i.e. at the source, upstream or downstream portion, in the temporary, seasonal, permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.). • d) to what extent will the risk associated with water uses and related activities change?	Section 3.6
2,5	How will the proposed development impact on the functioning of the aquatic feature? This must include: • a) Base flows (e.g. too little/too much water in terms of characteristics and requirements of system) • b) Quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over - abstraction or instream or off -stream impoundment of a wetland or river) • c) Change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchannelled valley -bottom wetland to a channelled valley -bottom wetland). • d) Quality of water (e.g. due to increased sediment load, contamination by chemical and /or organic effluent, and /or eutrophication) • e) Fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal). • f) The loss or degradation of all or part of any unique or important features (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.) associated with or within the aquatic ecosystem.	Section 3.6
2,5	How will the development impact on key ecosystem regulating and supporting services especially: • a) Flood attenuation • b) Stream flow regulation • c) Sediment trapping • d) Phosphate assimilation • e) Nitrate assimilation • f) Toxicant assimilation • g) Erosion Control • h) Carbon Storage?	Section 3.6
2,5	How will the proposed development impact community composition (numbers and	Refer to

	density of species) and integrity (condition, viability, predator - prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	terrestrial biodiversity report
k	Any mitigation measures for inclusion in the EMPr;	Section 3
l	Any conditions for inclusion in the environmental authorisation;	Section 3
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 3
n	A reasoned opinion— i. [as to] whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Executive Summary
o	A description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
p	A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
q	Any other information requested by the competent authority.	None

APPENDIX B: Detailed Methodology

Wetland and Riparian Delineation

Wetlands are delineated based on scientifically sound methods, and utilizes a tool from the DWS 'A practical field procedure for identification and delineation of wetlands and riparian areas' (DWAF, 2005) as well as the "Updated manual for identification and delineation of wetlands and riparian areas" (DWAF, 2008). The delineation of the watercourses presented in this report is based on both desktop delineation and groundtruthing.

Desktop Delineation

A desktop assessment was conducted with wetland and riparian units potentially affected by the proposed activities identified using a range of tools, including:

- 1: 50 000 topographical maps;
- Recent, relevant aerial and satellite imagery, including Google Earth;
- NFEPA wetlands and Rivers (http://bgisviewer.sanbi.org/)
- Municipal and DWS spatial datasets.

All areas suspected of being wetland and riparian habitat based on the visual signatures on the digital base maps were mapped using google earth.

Ground Truthing

Field investigations confirmed fine-scale wetland and riparian boundaries.

Wetland Indicators

Wetlands were identified based on one or more of the following characteristic attributes (DWAF, 2005) (Figures 20 & Figure 21):

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

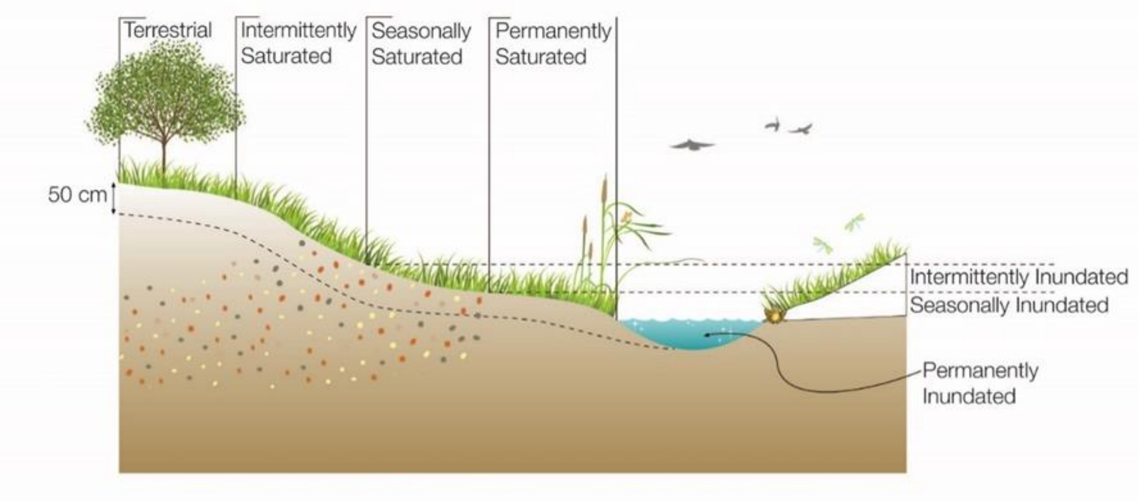


Figure 20: Typical cross section of a wetland (Ollis, 2013)

The terrain unit indicator is an important guide for identifying the parts of the landscape where wetlands might possibly occur and is relevant to the hydropedological setting of a wetland. For example, some wetlands occur on slopes higher up in the catchment where groundwater discharge is taking place through seeps. The type of wetland which occurs on a specific topographical area in the landscape is described using the Hydrogeomorphic classification which separates wetlands into 'HGM' units. The classification of Ollis, *et al*. (2013) is used, where wetlands are classified on Level 4 as either Rivers, Floodplain wetlands, Valley-bottom wetlands, Depressions, Seeps, or Flats.

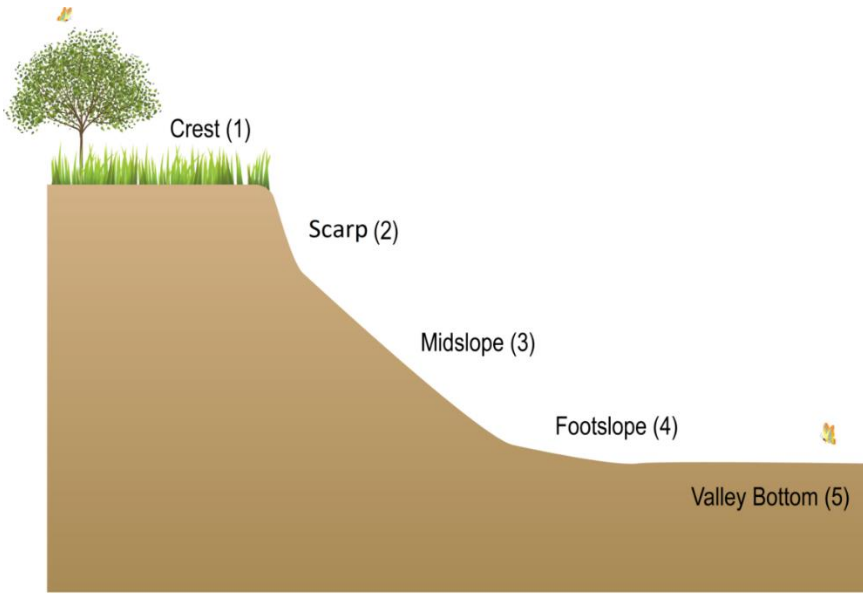


Figure 21. Terrain units (DWAF, 2005).

Riparian Indicators

A riparian area can be defined as a linear fluvial, eroded landform which carries channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The "river" includes both the active channel (the portion which carries the water) as well as the riparian zone (Kotze, 1999).

Riparian habitat is classified primarily by identifying riparian vegetation along the edge of the macro stream channel. The macro stream channel is defined as the outer bank of a compound channel and should not be confused with the active river bank. The macro channel bank often represents a dramatic change in the energy with which water passes through the system. Rich alluvial soils deposit nutrients making the riparian area a highly productive zone. This causes a very distinct change in vegetation structure and composition along the edges of the riparian area (DWAF, 2008). The marginal zone includes the area from the water level at low flow, to those features that are hydrologically activated for the greater part of the Year (WRC Report No TT 333/08 April, 2008). The non-marginal zone is the combination of the upper and lower zones (Figure 22).

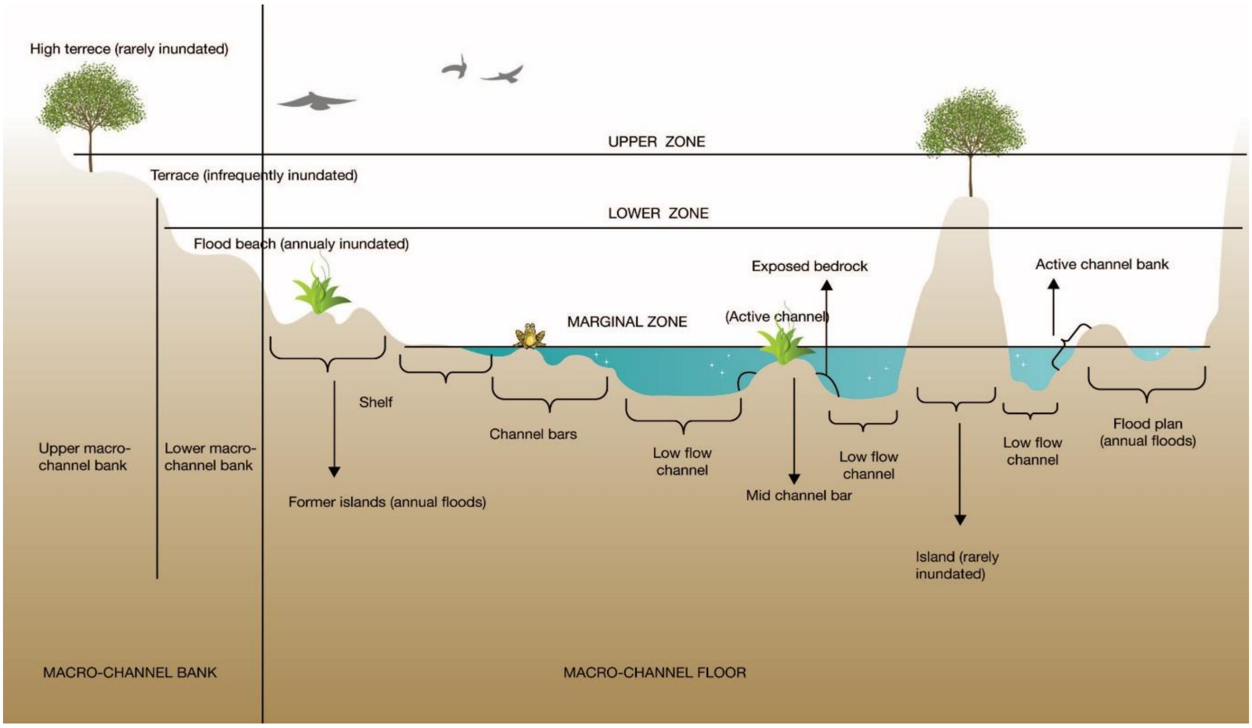


Figure 22: Schematic diagram illustrating an example of where the 3 zones would be placed relative to geomorphic diversity (Kleynhans *et al*, 2007)

Riparian areas can be grouped into different categories based on their inundation period per year. Perennial rivers are rivers with continuous surface water flow, intermittent rivers are rivers where surface flow disappears but some surface flow remains, temporary rivers are rivers where surface flow disappears for most of the channel (Figure 23). Two types of temporary rivers are recognized, namely “ephemeral” rivers that flow for less time than they are dry and support a series of pools in parts of the channel, and “episodic” rivers that only flow in response to extreme rainfall events, usually high in their catchments (Seaman *et al*, 2010).

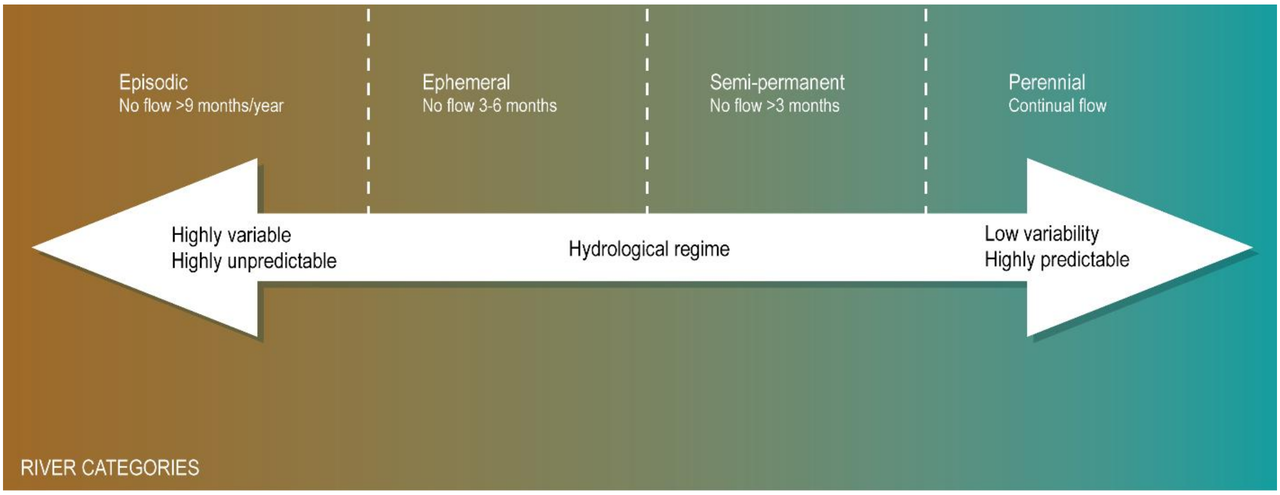


Figure 23: The four categories associated with rivers and the hydrological continuum. Dashed lines indicate that boundaries are not fixed (Seaman *et al*, 2010).

Wetland/Riparian Classification

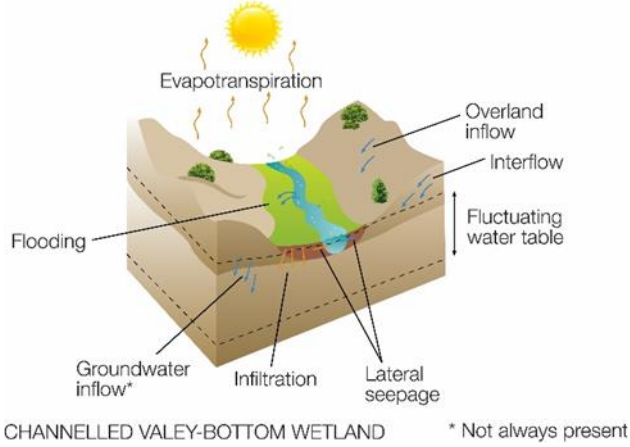
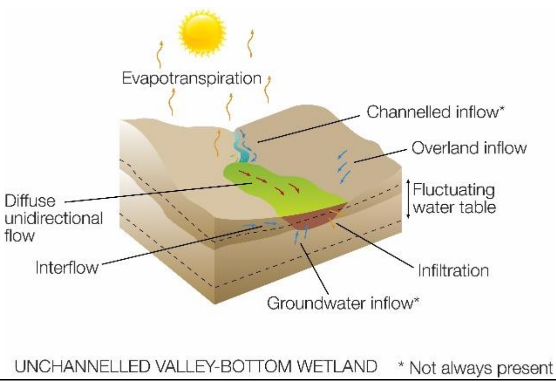
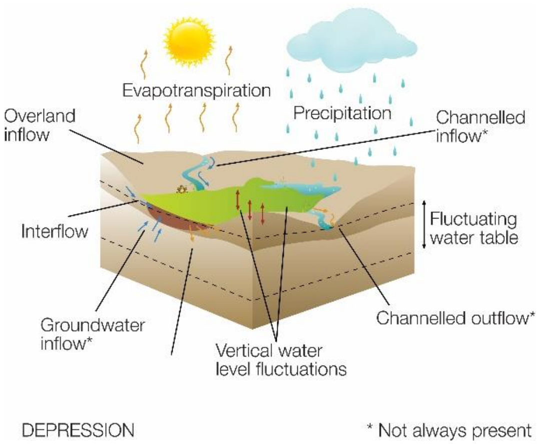
The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (SANBI, 2013). The current watercourse assessment follows the same approach by classifying watercourses in terms of a functional unit recognised in the classification system proposed in SANBI (2013). HGM units take into consideration factors that determine the nature of water movement into, through and out of the watercuorse system. In general, HGM units encompass three key elements (Kotze *et al*, 2005):

- Geomorphic setting - This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
- Water source - There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
- Hydrodynamics - This refers to how water moves through the wetland.

The classification of watercourse areas found within the study site and/or within 500 m of the study site (adapted from Brinson, 1993; Kotze, 1999, Marneweck and Batchelor, 2002 and DWAF, 2005) are as follows (Table 29):

Table 29: Watercourse Types and descriptions

Watercourse Type:	**Description:**

Watercourse Type:	Description:
Valley bottom with a channel 	Linear fluvial, net depositional valley bottom surfaces which have a straight channel with flow on a permanent or seasonal basis. Episodic flow is thought to be unlikely in this wetland setting. The straight channel tends to flow parallel with the direction of the valley (i.e. there is no meandering), and no ox-bows or cut-off meanders are present in these wetland systems. The valley floor is, however, a depositional environment such that the channel flows through fluvially-deposited sediment. These systems tend to be found in the upper catchment areas.
Valley bottom without a channel 	Linear fluvial, net depositional valley bottom surfaces which do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas, or at tributary junctions where the sediment from the tributary smothers the main drainage line.
Depressional pans 	Small (deflationary) depressions which are circular or oval in shape; usually found on the crest positions in the landscape. The topographic catchment area can usually be well-defined (i.e. a small catchment area following the surrounding watershed). Although often apparently endorheic (inward draining), many pans are “leaky” in the sense that they are hydrologically connected to adjacent valley bottoms through subsurface diffuse flow paths.

Buffer Zones and Regulated Areas

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a watercourse. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is, therefore, often characteristic of transformed catchments. The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land uses / activities planned adjacent to water resources. Although buffer zones can be effective in addressing diffuse source pollution in storm water run-off, they should typically be seen as part of a treatment train designed to address storm water impacts (MacFarlane & Brendin, 2017).

Generic buffer zones are specified in regional and local policies including GDARD (2014). These include 30m for wetlands and 50m for rivers inside the urban edge within which development is not supported.

Authorisation from the DWS requires calculation of a site-specific buffer zone (General Notice 267 of 24 March 2017), following Macfarlane *et al* 2015. This Excel-based tool calculates the best suited buffer for each wetland or section of a wetland based on numerous on-site observations. The resulting buffer zone can thus have large differences depending on the current state of the wetland as well as the nature of the proposed development. Developments with a high-risk factor such as mining are likely to have a larger buffer area compared to a residential development with a lower risk factor.

Figure 24 images represent the buffer zone setback for the watercourse types discussed in this report.
It should be noted that the buffer calculation tool does not take into account the effects of climate change or cumulative impacts to floodflows resulting from transformed catchments. Therefore, a conservative approach to the application of buffer zones is encouraged.

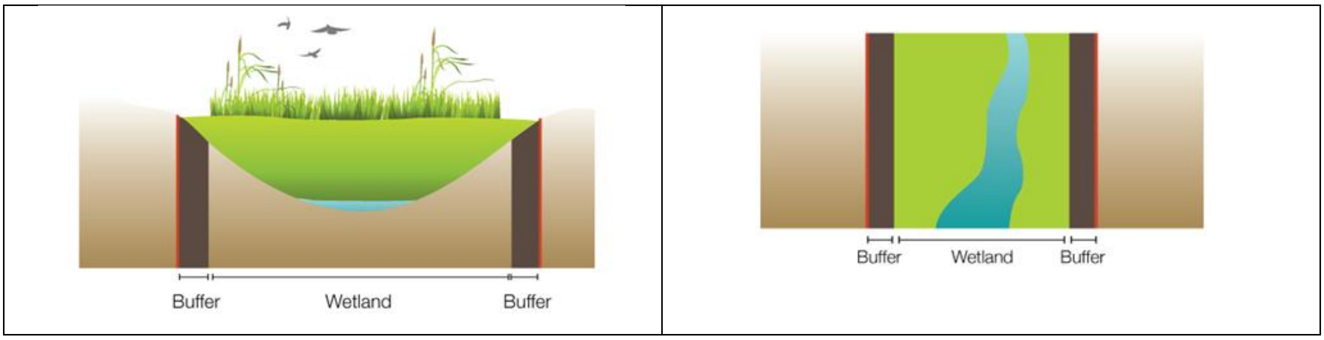


Figure 24: A represent the buffer zone setback for the wetland discussed in this report

Regulated areas are zones within which authorisation is required. The DWS specify a 500m regulated area around all wetlands and 100m around all riparian zones within which development must be authorised from their department. Development within 32m of the edge of the watercourse triggers the requirement for authorisation under the National Environmental Management Act (NEMA): Environmental Impact Assessment (EIA) Regulations of 2014 (GNR 326) as amended.

Watercourse Functionality, Status and Sensitivity

Watercourse functionality is defined as a measure of the deviation of structure and function from its natural reference condition. The natural reference condition is based on a theoretical undisturbed state extrapolated from an understanding of undisturbed regional vegetation and hydrological conditions.

The allocations of scores in the functional and integrity assessment are somewhat subjective and are thus vulnerable to the interpretation of the specialist. With the exception of the assessment of water quality and invertebrates, collection of empirical data is precluded at this level of investigation due to project constraints including time and budget. Water quality values, species richness and abundance indices, surface and groundwater volumes, amongst others, should ideally be used rather than a subjective scoring system such as is presented here.

The functional assessment methodologies presented below take into consideration subjective recorded impacts to determine the scores attributed to each functional Hydrogeomorphic (HGM) unit. Following the calculation of PES and EC scores, a Recommended Ecological Category can be obtained. This score reflects an auditable management or rehabilitation target to be achieved by the proposed project. The sections below provide a brief description of each method.

Present Ecological Status (PES) – WET-Health

A summary of the three components of the WET-Health Namely Hydrological; Geomorphological and Vegetation Health assessment for the wetlands found on site is described in Table 30. A Level 1 assessment was used in this report. Level 1 assessment is used in situations where limited time and/or resources are available.

Table 30: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al*, 2007)

Description	Impact Score Range	PES Score	Summary
Unmodified, natural.	0.0.9	A	Very High
Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B	High
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C	Moderate
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D	Moderate
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E	Low
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8.10	F	Very Low

A summary of the change class, description and symbols used to evaluate wetland health are summarised in Table 31

Table 31: Trajectory class, change scores and symbols used to evaluate Trajectory of Change to wetland health (Macfarlane *et al*, 2007)

Change Class	Description	Symbol
Improve	Condition is likely to improve over the over the next 5 years	(↑)
Remain stable	Condition is likely to remain stable over the next 5 years	(→)
Slowly deteriorate	Condition is likely to deteriorate slightly over the next 5 years	(↓)
Rapidly deteriorate	Substantial deterioration of condition is expected over the next 5 years	(↓↓)

Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both PES and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance.
- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors.
- Basic human needs including subsistence farming and water use.

The Ecological Importance and Sensitivity of the wetlands is represented are described in the results section. Explanations of the scores are given in Table 32

Table 32: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating

Ecological Importance and Sensitivity Categories	**Rating**
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands 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
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1

Ecosystem Services (ES)

The DWS authorisations related to wetlands are regulated by Government Notice 267 published in the Government Gazette 40713 of 24 March 2017. Page 196 of this notice provides a detailed "terms of reference" for wetland assessment reports and includes the requirement that the ecological integrity and function of wetlands be addressed. This requirement is addressed through the WetEcoServices toolkit (Kotze *et al*. 2006). This wetland assessment method is an excel based tool which is based on the integral function of wetlands in terms of their hydrogeomorphic setting. Each of seven benefits are assessed based on a list of characteristics (e.g. slope of the wetland) that are relevant to the particular benefit. Scores are subjectively awarded to characteristics of the wetland and its catchment relative to the proposed activity. Scores are ranked as High, Moderate or Low.

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

<u>In Situ Water Quality</u>

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.

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 in Table 33 below (DWAF 1996):

Table 33: TWQR for select parameters

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.

SASS5

SASS5 is a rapid bioassessment 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 alterations in ecological drivers such as pollutants or flooding events. 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 (1^{st} and 2^{nd} 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 is 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

Recommended Ecological Category (REC)

The REC is determined by the Present Ecological State of the water resource and the importance and/or sensitivity of the water resource. Water resources which have Present Ecological State categories in an E or F ecological category are deemed unsustainable by the DWS. In such cases the REC must automatically be increased to a D.

Where the PES is in the A, B, C, D or E the EIS components must be checked to determine if any of the aspects of importance and sensitivity (Ecological Importance; Hydrological Functions and Direct Human Benefits) are high or very high. If this is the case, the feasibility of increasing the PES (particularly if the PES is in a low C or D category) should be evaluated. This is recommended to enable important and/or sensitive wetland water resources to maintain their functionality and continue to provide the goods and services for the environment and society.

If (

Table 34):

- PES is in an E or F category:
  The REC should be set at least a D, since E and F EC's are considered unsustainable.
    - The PES category is in an A, B, C or D category, AND the EIS criteria are low or moderate OR the EIS criteria are high or even very high, but it is not feasible or practicable for the PES to be improved:
- The REC is set at the current PES.
    - The PES category is in a B, C or D category, AND the EIS criteria are high or very high AND it is feasible or practicable for the PES to be improved:
- The REC is set at least one Ecological Category higher than the current PES." (Rountree *et al,* 2013).

Table 34: Generic Matrix for the determination of REC and RMO for water resources

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	A Improve	A/B Improve	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

Impact Assessments

NEMA (2014) Impact Ratings with reference to aquatic aspects specified in GN320 of March 2020

As required by the 2014 NEMA regulations (as amended), impact assessment should provide quantified scores indicating the expected impact, including the cumulative impact of a proposed activity. Specific aspects of the aquatic environment that should be assessed are set out in GN 320. These are listed in Appendix A. The impact assessment should follow the format presented below. Impact scores are calculated using the following parameters:

- Direct, indirect and cumulative impacts of the issues identified through the specialist study, as well as all other issues must be assessed in terms of the following criteria:
  - The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
  - The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
  - The **duration**, wherein it will be indicated whether:
    - The lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
    - The lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
    - Medium-term (5–15 years) – assigned a score of 3;
    - Long term (> 15 years) - assigned a score of 4; or
    - Permanent - assigned a score of 5;
  - The consequences (magnitude), quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
  - The probability of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is

probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- The significance, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- The status, which will be described as either positive, negative or neutral.
- The degree to which the impact can be reversed.
- The degree to which the impact may cause irreplaceable loss of resources.
- The degree to which the impact can be mitigated.

The **significance** is calculated by combining the criteria in the following formula:

- S=(E+D+M)P
- S = Significance weighting
- E = Extent
- D = Duration
- M = Magnitude
- P = Probability

The **significance weightings** for each potential impact will be determined as follows (Table 35):

Table 35: Significance Weightings

Points	Significant Weighting	Discussion
< 30 points	Low	This impact would not have a direct influence on the decision to develop in the area.
31-60 points	Medium	The impact could influence the decision to develop in the area unless it is effectively mitigated.
> 60 points	High	The impact must have an influence on the decision process to develop in the area.

APPENDIX C: Abbreviated CVs of participating specialists

CURRICULUM VITAE (CV) OF ANTOINETTE BOOTSMA 2021

DIRECTOR and SENIOR WETLAND SPECIALIST at Limosella Consulting since 2009.
16 Years experience as an ecologist

Professional Affiliations:
Professional Natural Scientist (SACNASP) # 400222-09 Botany and Ecology
South African Wetland Society # NA6RY2FP
Grassland Society of South Africa

Highest Qualification - M.SC (Environmental Science), University of South Africa, 2017. *Awarded with distinction*. Project Title: Natural mechanisms of erosion prevention and stabilization in a Marakele peatland; implications for conservation management

Latest Publication - A.A. Boostma, S. Elshehawi, A.P. Grootjans, P.L Grundling, S. Khosa, M. Butler, L. Brown, P. Schot. 2019. Anthropogenic disturbances of natural ecohydrological processes in the Matlabas mountain mire, South Africa. South African Journal of Science Volume 115| Number 5/6, May/June 2019, P1 to 8

Relevant Employment History:
Director at Limosella Consulting (Pty) Ltd - 2009 – ongoing
Senior Wetland Specialist at Strategic Environmental Focus – 2007 to 2009
Technical Assistant at the Conservation Ecology Research Unit, University of Pretoria, Richards Bay field station, 2005 to 2007

Summary of relevant skills:

- Management of projects in terms of specialist input, including quotations, planning, technical review, submission of reports and invoicing;
- Fine scale wetland delineations and functional assessments;
- Strategic wetland assessments and open space management and planning;
- General Rehabilitation, Monitoring and Mitigation assessments.
- Wetland offset strategies
- Hydropedological investigations
- Implementation of wetland assessment tools including the DWS (2016) Risk Assessment, Present Ecological Status (PES) Macfarlane et al, (2020), Ecological Importance and Sensitivity (EIS) (DWAF, 1999), Recommended Ecological Category (REC) Rountree et al (2013), Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et al, 2007) and QHI (Quick Habitat Integrity)

Short list of projects to demonstrate experience:

- More than 90 external peer reviews as part of mentorship programs for companies including Galago Environmental Consultants, Lidwala Consulting Engineers, Bokamoso Environmental Consultants, Gibb, 2009 ongoing
- Input into the Environmental Management Plan for repair to 90 bridges in the City of Johannesburg, 2020
- Wetland specialist input into the City of Tshwane Open Space Framework, 2019
- Wetland specialist input into the North West Environmental Outlook, 2018
- Wetland specialist input into the Gauteng Environmental Outlook, 2017

- Wetland specialist input into the Open Space Management Framework for Kyalami and Ruimsig, City of Johannesburg, 2016
- Kangra Maquasa East and Maquasa West and Nooitgesien Mine, Mpumalanga Province: Rehabilitation and Monitoring Assessment. June 2018
- Mbuyelo Coal Welstand Reserve Amendment: Wetland assessment. June 2017
- Proposed mining right to mine on portion of the remaining extent of the farm Dingwell No. 276 JT, Barberton Magisterial District, in Mpumalanga Province: Wetland Delineation and Assessment. January 2017
- Fine scale wetland specialist input including General Rehabilitation Plan into the ESKOM Bravo Integration Project 3, 4, 5 and Kyalami – Midrand Strengthening, December 2017
- Fine scale wetland specialist input including General Rehabilitation Plan into 3 Eskom Projects to lay underground power cables in Gauteng; Craighall to Sandton, Croyden to Germiston and Randburg, November 2017
- Dama Colliery, Near Utrecht, KwaZulu-Natal Province: Preliminary Wetland Delineation& Functional Assessment Report. February 2015
- Harmony Gold Mining co Ltd's Evander Operations Property Area, Mpumalanga Province: Wetland Delineation and Functional Assessment. February 2011

Curriculum Vitae

Bertus Fourie

Updated: July 2019

082 921 5445

Tertiary Education

M. Sc.	M.Sc. Aquatic Health at University of Johannesburg, 2014. Research project title: *Biological aspects of the Mutale, Tshinane and Mutshundudi Rivers, Limpopo*
B Tech.	Nature Conservation, 2009 specialization in Environmental Education& Freshwater management. Project title: *Ndumo Game count: A critical review of game count data 1999-2009.*
National diploma	Nature Conservation, 2005

Accreditation:

SASS 5 (Dickens & Graham, 2002)

SACNASP registered as Professional Natural scientist in the field of Ecology (SACNASP Pr.Sci.Nat. Reg. No: 400126/17)

Training:

Mine closure and land rehabilitation	Enterprises at the University of Pretoria, 2020
Freshwater fish identification course	South African Institute of Aquatic Biodiversity, 2016
Wetland Rehabilitation	Centre for Environmental Management, University of Free State
Introduction to wetland soils and delineation	South African soil surveyor's organization (SASSO)
Wetland Management: Introduction and Delineation	Centre for Environmental Management, University of Free State
SASS 5 training	Nepid consultants (2011), Ground Truth (2013)
Environmental Law for Environmental Managers:	Centre for environmental studies (CEM) @ North West University

FGASA level 1 FGASA 2006

Work Experience
My work includes all aspects of ecology including terrestrial and aquatic. Main project involvements include:

- Veld and Game management plans (including Veld condition and plant diversity assessments)
- Environmental impact assessments
- Environmental Education
- Ecological Management Plans
- Monitoring Planning
- Aquatic Environmental Control Officer (AECO)
- Environmental Control officer
- Rehabilitation implementation
- Ridges Studies
- Wetland rehabilitation planning
- Aquatic ecosystem delineation (including wetlands and riparian)

Computer proficiency in programs designed specifically for ecological assessments
Distance 5.0: used to analyse distance sampling surveys of wildlife populations.

FRAI: (Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2)). Kleynhans CJ. , 2007. WRC Report No. TT330/08

FROC: (Reference frequency of occurrence fish species in South Africa). Kleynhans CJ, Louw MD, Moolman J. 2007. WRC Report No TT331/08.

Google Earth and QGIS programming

MIRAI: Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Thirion, C. 2007. WRC Report No. TT 332/08.

VEGRAI: (Riparian Vegetation Response Assessment Index in River Eco Classification: Manual for Eco Status Determination (version 2)). Kleynhans CJ, MacKenzie J, Louw MD. 2007. WRC Report No. TT 333/08.

WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. Kotze DC, Marneweck GC, Batchelor AL, Lindley DS and Collins NB, 2007. WRC Report No TT 339/08.

WET-Health: A technique for rapidly assessing wetland health Macfarlane DM, Kotze DC, Ellery WN, Walters D, Koopman V, Goodman P and Goge C. 2007.. WRC Report No TT 340/08.

Aquatic ecosystem buffer calculation tool: Macfarlane, D.M., Bredin, I.P., Adams, J.B., Zungu, M.M., Bate, G.C. and Dickens, C.W.S. (2014). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. Final Consolidated Report. WRC Report No TT 610/14, Water Research Commission, Pretoria.

Scientific societies Membership
Grassland Society of Southern Africa
South African Society of Aquatic Scientists
South African Wetland Society
Society of Wetland Scientist

Presenting of Wetland related training
Advanced Wetland course at the Centre for continued education at the University of Pretoria

APPENDIX D: Glossary of Terms

Baseflow	
Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area
Hydrophyte	any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats
Hydromorphic soil	soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils)
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows
Sedges	Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.
Soil profile	the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991)
Wetland:	"*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*." (National Water Act; Act 36 of 1998).
Wetland delineation	the determination and marking of the boundary of a wetland on a map using the DWAF (2005) methodology. This assessment includes identification of suggested buffer zones and is usually done in conjunction with a wetland functional assessment. The impact of the proposed development, together with appropriate mitigation measures are included in impact assessment tables

APPENDIX E: Abbreviations

ASPT	Average score per taxon
CBAs	Critical Biodiversity Areas
DEA	Department of Environmental Affairs
DO	Dissolved Oxygen
DWAF	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
GDARD	Gauteng Department of Agriculture and Rural Development
IHAS	Integrated Habitat Assessment System
PES	Present Ecological Category

EC	Ecological Category
EIA	Environmental Impact Assessment
EIS	Ecological Integrity and Sensitivity
ES	Ecosystem Services
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NEMA	National Environmental Management Act 107 of 1998
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act 36 of 1998
PES/C	Present Ecological State/Category
RHP	River Health Programme
REC	Recommended Ecological Category
SASS5	South African Scoring System version 5
SAWQG	South African Water Quality Guideline
TDS	Total Dissolved Salts
TWQR	Target Water Quality Range
UJ	University of Johannesburg
UP	University of Pretoria
VEGRAI	Riparian Vegetation Response Assessment Index
WMA	Water Management Area