DIGBY WELLS
ENVIRONMENTAL

Proposed Coal-fired Mutsho Power Project near Makhado, Limpopo Province

Aquatic Biodiversity, Groundwater, Surface Water and Wetland Impact Assessments

Project Number:
SAV4689

Prepared for:
Mutsho Power (Pty) Ltd
On behalf of Savannah Environmental (Pty) Ltd

February 2018

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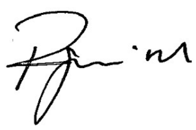

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EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Savannah Environmental (Pty) Ltd (Savannah) to undertake several specialist studies for the proposed Mutsho Power Project near Makhado, in Limpopo Province. The following specialist studies have been undertaken:

- Groundwater Impact Assessment;
- Surface Water Impact Assessment;
- Baseline Aquatic and Impact Assessment; and
- Wetlands Impact Assessment.

These specialist studies, as noted above forms part of the environmental regulatory process to assess the potential impacts and mitigation plans pertaining to the receiving environment during the construction, operation and decommissioning phases of the project.

The proposed project area is situated in the magisterial district of Vhembe, in the Limpopo Province, approximately 40 km north of the town Makhado (Louis Trichardt) and 7 km south-west of Mopane Town. The regional and local setting is illustrated in Figure 1 and Figure 2.

Mutsho Power (Pty) Ltd is investigating the feasibility of developing a new coal-fired power plant, which is envisaged to utilise coal mined at the MC Mining Ltd (MCM) (previously known as Coal of Africa Limited (CoAL))- Makhado Colliery. The facility will comprise of a Circulating Fluidised Bed (CFB) coal-fired power plant. The type of infrastructure required would ultimately be dependent on the type of technology selected for implementation. A coal-fired power plant would typically comprise of the following key components and associated infrastructure:

- Power generation units:
  - Circulating Fluidised Bed (CFB);
- Coal crusher;
- Coal stockpile;
- Limestone storage area;
- Ash dump (dry ashing has been proposed for the plant in order to reduce the project's water requirements, which is in alignment with the recommendations of the National Development Plan (NDP) and Integrated Energy Plan (IEP));
- Water infrastructure (e.g. water supply pipeline(s), bulk water storage dam, Pollution control dams, water treatment plant (WTP), etc.);
- Substation;
- Power lines;

- Office and administration buildings; and
- Access roads.

A minimum footprint of approximately 350 ha would be required for the power plant and associated infrastructure. While the power generation components require limited space, supporting areas for the establishment of coal and other raw material stockpiles, and an ash dump increase the development footprint. There are three proposed options for infrastructure layout and as part of the assessments conducted all three were considered, with a recommendation provided with respect to the most suitable option considered based on all the specialist findings.

The project area falls within the Musina Mopane Bushveld vegetation type (Mucina and Rutherford, 2012), which is characterised by undulating plains ranging from open savanna to open woodland to moderately closed shrubveld, dominated by *Colophospermum mopane*. In areas with dense cover of *Colophospermum mopane* shrubs, the herbaceous layer is poorly developed. Musina Mopane Bushveld is considered 'Least threatened' but only 2% of it is statutorily conserved. Large areas have been converted tor cultivation. Erosion is considered to be high to moderate.

The National Freshwater Ecosystem Priority Areas (NFEPA) provide strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable use of water resources (Nel *et al.,* 2011). Demarcation of these areas is firmly rooted in the National Water Act (No. 36 of 1998) and the National Environmental Management Biodiversity Act (No. 10 of 2004). Conservation importance of the wetlands was based on their designated status as NFEPA wetlands (Nel *et al.,* 2011).

The project area and its surrounds are characterised by a number of NFEPA wetlands as shown in Figure 9. Based on the NFEPA data the landscape is dominated by hillslope seep wetlands, followed by bench wetlands and to a very smaller extent channel valley bottom.

All the identified wetlands in the study area are rank 6. Rank 6 wetlands are all other wetlands that are identified as NFEPA wetland but do not fall within rank 1 to 5

South Africa is divided into 9 Water Management Areas (WMA) (Revised National Water Resource Strategy, 2012), managed by their own water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A to X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment; A2 for example will represent the secondary catchment; A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the Water Resources of South Africa, 2012 manual. Each of the quaternary catchments has associated hydrological parameters.

The project area is located in the A71K quaternary catchments of the Limpopo WMA as revised in the 2012 water management area boundary descriptions (government gazette No. 35517). The surface water attributes of the affected quaternary catchment; namely Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual

Evaporation (MAE) were obtained from the Water Resources of South Africa 2012 Study (WR2012).

The Sand (Polokwane River) River Catchment (SRC) is a major tributary of the Sabie River located in the north-eastern part of South Africa, spanning Limpopo and Mpumalanga Provinces (Pollard, 2008). The major tributaries of this river catchment are Brak, Hout, Dwars and Dorp rivers. This catchment spans an area of 1910 km² and is subdivided into 9 quaternary catchments (Smits et al., 2004). The source of the Sands River is located in the hills at the edge of Yserberg. It must be noted, however, that the majority of this catchment lies in the dry Lowveld, where the mean annual rainfall is only 500 mm/yr (Pollard and Walker, 2000).

This catchment is the driest catchment in the Limpopo WMA North with limited surface water resources. Despite this there is a high demand for water in this catchment compared to the rest of the WMA with agriculture (irrigation) being the largest user. Water requirements of this area include activities such as power generation; irrigated agriculture, forestry; mining, domestic use and industrial and residential developments. The major land-uses of this catchment include commercial forestry, dryland and irrigated agriculture, dense rural settlements, state and privately owned conservation areas and mineral resource extraction. The surface water resources in this catchment are heavily utilized and severely limited. Conversely to this, groundwater resources are being fully extracted and possibly over-exploited (DWA 2016).

Based on current outputs of the NFEPA project (Nel et al., 2011; Figure 3), the sub-quaternary catchment associated with the proposed Mutsho Power Project was defined as a FEPA catchment, as a result of river ecosystem type. These catchments help to achieve national biodiversity targets, as the ecological condition of the associated systems are currently regarded as being in a good condition (A or B ecological category) and as such, these catchments and adjacent areas should be managed in a way that maintains their ecological condition, so as to conserve freshwater ecosystems and protect water resources for sustainable human use (Nel et al., 2011).

The predominant present land use in the wider area is agriculture with potential for mining, whilst the main use of surface water in the area is agricultural (irrigation) and possibly limited abstraction for mining activity.

The water requirements within the Sand catchment are large compared to the rest of the WMA, with irrigation comprising the largest water user. The majority of the irrigation sector's water requirements are met by the extraction of groundwater reserves via boreholes in the Sand / Limpopo Rivers which have been over-exploited. Although the urban requirements are high, a large portion of water is supplied through transfers from other WMAs (Savannah Environmental, March 2017).

Aquatics Findings

With the exception of Site DU3, each of the selected sampling sites was observed to be dry at the time of the survey despite the rains expected throughout the summer months. While this was to be expected as a result of the semi-arid nature of the study area and in light of the drought experienced across much of the country during the previous two years, only selected parameters could subsequently be measured and a limited number of assessment indices could be applied at the time of the survey. This was a notable limitation to the baseline assessment, as the only site that could be assessed was characteristic of a lentic (or standing) system, which inherently supports a lower diversity of aquatic biota, and as such, provides no insight regarding the Present Ecological State (PES) of two of the biological components (i.e. aquatic macroinvertebrates and fish) of the associated watercourses, as well as in the overall integrated EcoStatus. Consequently, for the purpose of determining a PES at the time of the survey, the only available desktop data indicated that the mainstem Sand River is representative of a moderately modified condition (i.e. Ecological Category C). This was largely confirmed by the small- to large- impacts originating from surrounding land-use activities, including the most notable agricultural activities (i.e. crop cultivation and livestock watering).

With regards to the mainstem Sand River, the Ecological Importance was defined to be high due to a moderate-to-high likelihood of occurrence for *Oreochromis mossambicus* (listed as Near Threatened) during periods of flow, a moderate-to-high representivity and rarity within the secondary catchment, as well as the occurrence of the study area within a Fresh Water Ecosystem Priority Area and provincially determined Ecological Support Area 1. Also, the Ecological Sensitivity was defined to be moderate-to-high, which was attributed to an elevated number of highly sensitive flow-dependent species, a number of species that were regarded as moderate-to-highly sensitive to water quality impairment, and a riparian vegetation component is well adapted to the fluctuating water levels within the associated alluvial system.

Wetlands Findings

Two HGM units were identified in the vicinity of the project area, both characterised as pan wetlands. However, most of the freshwater features within project area consist of ephemeral drainage lines that cannot be defined as wetland or riparian resources. The freshwater features cover an approximate 147.5 ha.

The wetlands within the Project area exhibit Category B (*Largely Natural*) and Category C (*Moderately Modified*) PES values. The pans have not been impacted on to a great extent aside for grazing which alters the vegetation structure and composition. The geomorphological and Hydrological health has been altered minimally. The ephemeral drainage lines are considered to be Category C. They are mostly impacted on hydrologically due to the presence of earthen dams, which restrict the flow of water downstream. The geomorphological score was not impacted on greatly as the only impact was sediment deposition in the dams. Vegetation scores were not altered to a great extent.

EIS scores range from *Very High* (3.7) to *High* (2.5). Hydrological/Functional Importance' values were low as the pans don't perform well for streamflow regulation, erosion control, sediment trapping or phosphate assimilation. The drainage lines also have limited hydrological function in terms of true wetland systems. However, in terms of catchment yield and surface water recharge to the systems further downstream, as well is in the maintenance of healthy stormwater regulation, these systems are considered invaluable. 'Ecological Importance & Sensitivity' for the HGM unit 2 and 3 is Very High as various protected species are present within them or in close proximity. 'Direct Human Benefits' were not high in general. These features are not used culturally or recreationally. The HGM units are utilised for grazing and for watering of cattle and game. The score is higher for the drainage lines as some are dammed and the water is utilised by the farm owners.

EcoServices scores for the various HGM Units range from 1.3 to 1.6 (*Intermediate*).The HGM units provide similar EcoServices. Biodiversity maintenance through the harbouring of protected species, the provision of water sources and the provision of grazing land are important EcoServices. The drainage lines provide surface water recharge and trap sediment. The farms are not accessible for tourism, educational and cultural purposes and as such are not used for these purposes. Historical hunting activities were evident, however, through communication with ground staff, this is no longer common. Due to the nature of the systems, flood attenuation and streamflow regulation is low.

Groundwater Findings

The outcomes of the groundwater impact assessment and associated investigations are the following:

- During the hydrocensus conducted by Digby Wells (January 2018) water levels on site were recorded to range between 23.25 and 35.68 mgbl. Groundwater flow direction on site is found to be towards the north-west.
- Samples were collected and taken to the laboratory for chemical analysis and compared against SAWQG for irrigation and domestic use. All boreholes (5) do not exceed the SAWQG for irrigation however all exceed domestic use standards. Evaluations indicate the following:
  - VRIBH1 exceeds domestic use standards for fluoride;
  - VRIBH2, DUTBH1, DUTBH2 and DUTBH3 exceed domestic use standards for sulphate; and
  - VRIBH1, VRIBH2, DUTBH1 and DUTBH2 exceed domestic use standards for magnesium.
- No boreholes were found to be in excess of the SAWQG for irrigation which is the local groundwater use of all the boreholes with the exception of DUTBH1;
- Groundwater characterisation was conducted and the groundwater quality at VRIBH1 and DUTBH3 are identified to be calcium-magnesium-bicarbonate type which is typically found at freshly recharged aquifers. VRIBH2, DUTBH1 and DUTBH2 are characteristic of calcium/sodium sulphate waters which associated with mining activities; mining activities are observed within a 25 km of the project area.
- The current water quality conditions at the project area are not pristine; this is consistent with the description of the regional hydrogeology. The region is

expected to have poor water quality naturally. Additionally, impacts from mining activities are also observed in the water chemistry.

- All private boreholes with the exception of VRIBH2 are located downstream the ash dump and should be monitored. Losing stream groundwater-surface water interaction is expected at the project area therefore the local non-perennial streams aren't expected to receive the contamination plume via baseflow.
- Analytical model predictions indicate that seepage from both the ash dump and coal stockpile is expected to reach the watertable after approximately 7 years of operation without a liner.
- The liner simulated in the model scenario is a Class C liner, this is assumed based on experience from expected ash material geochemistry. This may vary based on the outcomes of the recommended geochemical studies to be conducted.
- The installation of a liner is observed to restrict leachate seepage significantly and therefore negligible impacts to the groundwater are expected with the installation of a liner.
- Formation of the pozzolanic layer is additional mitigation (to the installation of a liner) and it occurs naturally over time, therefore leachate formation is expected to cease at a certain point therefore reducing the risk to the groundwater over time post-closure.

Surface Water Finings

The establishment of the Coal-Fired Power Station and Associated infrastructure have the potential to negatively impact on the natural water resources. As such, a surface water assessment was undertaken in support of the environmental authorisation applications. A site assessment was conducted on the 18th and 19th of January 2018 to assess and verify the hydrological characteristics of the area together with collection of surface water samples to determine the baseline water quality of the surrounding area prior to commencement of the project.

Sand River is the only major river (ephemeral) within this quaternary catchment (approximately 8 km from the western side of the project area). The Sand River flows from the South-west side of the project area towards the north-east side where it eventually joins the Limpopo River approximately 50 km away from the project area.

Few drainage lines exist within the demarcated project area and runoff from this site drains from the southern side in a north western direction via these drainage line and finally reports to the Sand River approximately 8 km west of the project site.

Water quality in this region or along the Sand River has existing monitoring data which indicated elevated levels of various salts which exceed the South African Water Quality Guidelines for irrigation and livestock use. This is mostly attributed to upstream irrigation activities and domestic effluent from the upper Sand River catchment.

Potential Impacts

The following potential impacts have been identified:

- A number of moderately significant potential impacts were to be expected within the associated ephemeral drainage areas, as well as further downstream along the Sand River and adjoining tributaries;
- Site clearing and associated construction activities could facilitate erosion and increase the risk of sedimentation within the receiving watercourses;
- Spillages of chemicals and hydrocarbons could impact on water resources;
- Loss of biodiversity and fragmentation of habitat;
- Potential altering of the water table;
- Dirty water run-off entering the receiving environment resulting in degradation of water resources;
- Contamination to groundwater resources and impacting on sensitive receptors, such as privately owned boreholes;

A number of moderately significant potential impacts were to be expected within the associated ephemeral drainage areas, as well as further downstream along the Sand River and adjoining tributaries. However, in general, the impact is expected to be limited to the proposed development area following the application of the proposed mitigation measures.

Sensitivity Analysis

Based on the Groundwater Assessment, sensitivities associated with the projects were based on preferential flow paths for groundwater movement, which could result in larger impacts occurring. The sensitivity analysis was based on the findings of the analytical model. The analytical model considered Option 1 as the preferred option based on the location of fault lines within the area and also proximity to potential receptors. The location of boreholes based on Option 1 is listed in Table 36 and the distance from the ash dump is provided.

From a water resource perspective a desktop sensitivity analysis on the affected farms indicates that there are few well-defined drainage lines and several runoff pathways or washes.

Washes can be defined as those areas which show visible signs of occasional water movement and sediment transport, but which do not receive sufficient runoff to develop characteristic soils or vegetation associated with wetlands or drainage lines. These are a characteristic feature of arid and semi-arid environments and are related to the occurrence of occasional intense rainfall events within areas of low total rainfall.

A defined drainage line on the north-western part of Farm Du Toit 563 comprise of a significant floodplain in which an artificial impoundment has also been constructed. This drainage line flows northwards towards the Sand River, and exhibits typical vegetation attributes. The presence and ecological contribution of these attributes increases the habitat diversity of the Farms and, ultimately, the perceived sensitivity (Savannah Environmental, March 2017).

A portion of the Vrienden 589 farm is mainly comprised of the washes. The identified drainage line in this study area has been classified as highly sensitive whilst all the washes are considered moderate or less sensitive.

Two pan systems have been identified on the Farm Du Toit 563 and are located on the northern boundary of the farm. In addition to this the extent of the ephemeral drainage lines has been determined and was undertaken as part of the Wetland Assessment. Based on the findings of the wetland assessment the system located on the Farm Du Toit 563, is considered to be more sensitive and water that flows through the ephemeral drainage lines flow towards the Sand River. The ephemeral drainage lines located on the Farm Vrienden are more isolated. In saying this, every effort should be taken to avoid drainage lines were possible.

From an Aquatic perspective, with regards to the mainstem Sand River, the Ecological Importance was defined to be high due to a moderate-to-high likelihood of occurrence for *Oreochromis mossambicus* (listed as Near Threatened) during periods of flow, a moderate-to-high representivity and rarity within the secondary catchment, as well as the occurrence of the study area within a Fresh Water Ecosystem Priority Area and provincially determined Ecological Support Area 1. Also, the Ecological Sensitivity was defined to be moderate-to-high, which was attributed to an elevated number of highly sensitive flow-dependent species, a number of species that were regarded as moderate-to-highly sensitive to water quality impairment, and a riparian vegetation component is well adapted to the fluctuating water levels within the associated alluvial system.

The above information was then utilised to determine the most suitable location based on the three options provided and is discussed in further detail in the next section of this report, regarding the consideration of infrastructure layout and alternatives.

Assessment of Alternatives

The Mutsho Power Project has three proposed infrastructure locations which are all within the demarcated project area. Considering the nature and activities of this project, the main impacts could be contamination of the natural streams as a result of runoff from the Ash Dump and Coal Stockyard, reporting into these natural streams, which could have implications on biota and cause determination of these systems. In addition to this the potential contamination to groundwater needs to be considered as an impact of concern and when placing infrastructure needs to be taken into consideration.

From a surface water perspective, option 2 and 3 are the most suitable infrastructure areas with negligible or insignificant impacts on the natural surface water resources whilst option 1 is the least suitable since the ash dump is located on top of the drainage lines, please note these the drainage lines that may be affected by Option 1 have been classified as moderate sensitive on the analysis above, and thus the potential impacts on these would not have great or significant impact.

From a wetlands perspective the following was concluded:

- Based on the utilisation of areas of existing anthropogenic disturbance, such as an existing road, fence-lines and powerline servitude, preference is given to Option 2;
- In terms of the extent of the freshwater resources likely to be impacted both in terms of direct loss of surface water drainage areas, as well as due to potential loss of ecological integrity in the downstream aquatic resources, preference is given to layout Option 1, followed by layout Option 2;
- In addition, layout Option 2 is considered the least invasive in terms of hard surface crossings as the access road is constructed from the existing gravel road between Farm Du Toit and Farm Vrienden; and
- Both layout Option 2 and 3, involve a more compact infrastructure footprint, which is likely to result in fewer impacts to the freshwater resources present and will aid in the management and mitigation of impacts during the life of the proposed project.

It is concluded that layout Option 2 is the most suitable in terms of wetland and freshwater ecological integrity.

Looking at aquatics the driving factor would be to place infrastructure as far as possible from the Sand River system, thus Option 1 was considered as the most feasible option.

Lastly for groundwater sensitive receptors, such as boreholes and fault lines were taken into consideration. Private boreholes are located downstream from the proposed ash dump and coal stockpile (with the exception of VRIBH2, for all layout options), the nearest perennial river is located 8 km north west of the project area (Sand River); local streams within the project area are non-perennial, they flow seasonally.

Considering environmental sensitivity a fault located in the northern part of the farm Du Toit was identified. Based on that observation, Option 1 is recommended as the most suitable layout as the location of the ash dump for this option is located furthest from the fault. The ash dump and coal stockpile location is most critical as these facilities are the main concern regarding impacts to groundwater. Structures that could potentially act as preferential pathways should be avoided with regards to the placement of the facilities. No groundwater sensitive areas were identified for the proposed locations of the coal stockpile for all layout options.

Once each specialist assessment considered the respective sensitivities in isolation, all the findings were integrated into one scoring system as noted above. Based on the scoring system, the best option to consider would be Option 1. None of the options avoid impacts completely, however based on the sensitivities and recuing impacts, Option 1 should consider as the preferred option, when considering all the specialist assessments.

Final Conclusion

From a surface water perspective, option 2 and 3 are the most suitable infrastructure areas with negligible or insignificant impacts on the natural surface water resources whilst option 1 is the least suitable since the ash dump is located on top of the drainage lines, please note these the drainage lines that may be affected by Option 1 have been classified as moderate sensitive on the analysis above, and thus the potential impacts on these would not have great or significant impact.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CBIPPPP	Coal Baseload Independent Power Producer Procurement Programme
CFB	Circulating Fluidised Bed
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
ETS	Ecosystem Threat Status
EPL	Ecosystem Protection Level
FEPA	Freshwater Ecosystem Priority Area
FRAI	Fish Response Assessment Index
FGD	Flue Gas Desulphurisation
GPS	Global Positioning System
ha	Hectares
IHAS	Invertebrate Habitat Assessment System, Version 2.2
IPP	Independent Power Producer
IUCN	International Union for Conservation of Nature
km	Kilometres
LMB	Limpopo Mobile Belt
m^2	Square metre
m^3	Cubic metre
m	Metre
Ma	million years
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
mbgl	Meters below ground level
mg/L	Milligram per litre
MIRAI	Macro-Invertebrate Response Assessment Index, Version 2

mm	Millimetres
NBA	National Biodiversity Assessment
NEMWA	National Environmental Management: Waste Amendment Act 26 of 2014
NFEPA	National Freshwater Ecosystem Priority Areas project
PES	Present Ecological State
QDGC	Quarter Degree Grid Cell
REMP (or RHP)	River EcoStatus Monitoring Programme (or River Health Programme)
SAIAB	South African Institute of Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SASS5	South African Scoring System, Version 5
SAWQG	South African Water Quality Guidelines
TEC	Target Ecological Category
ToPS	Threatened and Protected Species Regulation (as described in NEMBA)
VEGRAI	Riparian Vegetation Response Assessment Index, Level 3
WMA	Water Management Area
WRC	Water Research Commission
WSP	Water Service Provider
WWF	Worldwide Fund for Nature
ZLED	Zero Liquid Effluent Discharge

1 INTRODUCTION

Digby Wells Environmental (hereafter Digby Wells) has been appointed by Savannah Environmental (Pty) Ltd (Savannah) to undertake several specialist studies for the proposed Mutsho Power Project near Makhado, in Limpopo Province. The following specialist studies have been undertaken:

- Groundwater Impact Assessment;
- Surface Water Impact Assessment;
- Baseline Aquatic and Impact Assessment; and
- Wetlands Impact Assessment.

These specialist studies, as noted above forms part of the environmental regulatory process to assess the potential impacts and mitigation plans pertaining to the receiving environment during the construction, operation and decommissioning phases of the project.

1.1 Project Description and Local Setting

The proposed project area is situated in the magisterial district of Vhembe, in the Limpopo Province, approximately 40 km north of the town Makhado (Louis Trichardt) and 7 km south-west of Mopane Town. The regional and local setting is illustrated in Figure 1 and Figure 2.

Mutsho Power (Pty) Ltd is investigating the feasibility of developing a new coal-fired power plant, which is envisaged to utilise coal mined at the MC Mining Ltd (MCM) (previously known as Coal of Africa Limited (CoAL))- Makhado Colliery. The facility will comprise of a Circulating Fluidised Bed (CFB) coal-fired power plant. The type of infrastructure required would ultimately be dependent on the type of technology selected for implementation. A coal-fired power plant would typically comprise of the following key components and associated infrastructure:

- Power generation units:
  - Circulating Fluidised Bed (CFB);
- Coal crusher;
- Coal stockpile;
- Limestone storage area;
- Ash dump (dry ashing has been proposed for the plant in order to reduce the project’s water requirements, which is in alignment with the recommendations of the National Development Plan (NDP) and Integrated Energy Plan (IEP));
- Water infrastructure (e.g. water supply pipeline(s), bulk water storage dam, Pollution control dams, water treatment plant (WTP), etc.);
- Substation;

- Power lines;
- Office and administration buildings; and
- Access roads.

A minimum footprint of approximately 350 ha would be required for the power plant and associated infrastructure. While the power generation components require limited space, supporting areas for the establishment of coal and other raw material stockpiles, and an ash dump increase the development footprint. There are three proposed options for infrastructure layout and as part of the assessments conducted all three were considered, with a recommendation provided with respect to the most suitable option considered based on all the specialist findings. The different layout options are indicated in Figure 3, Figure 4 and Figure 5 respectively.

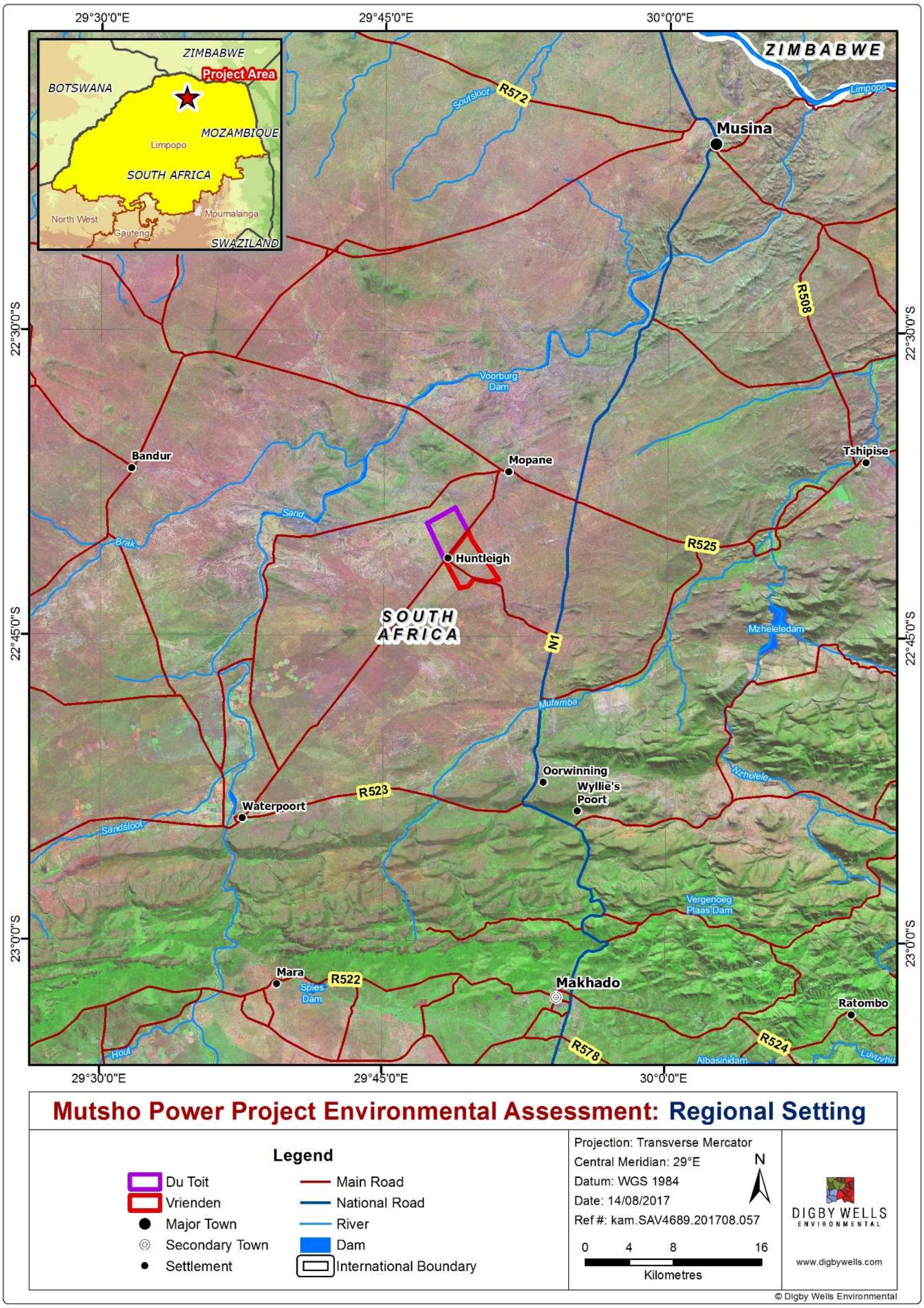


Figure 1: Regional Setting

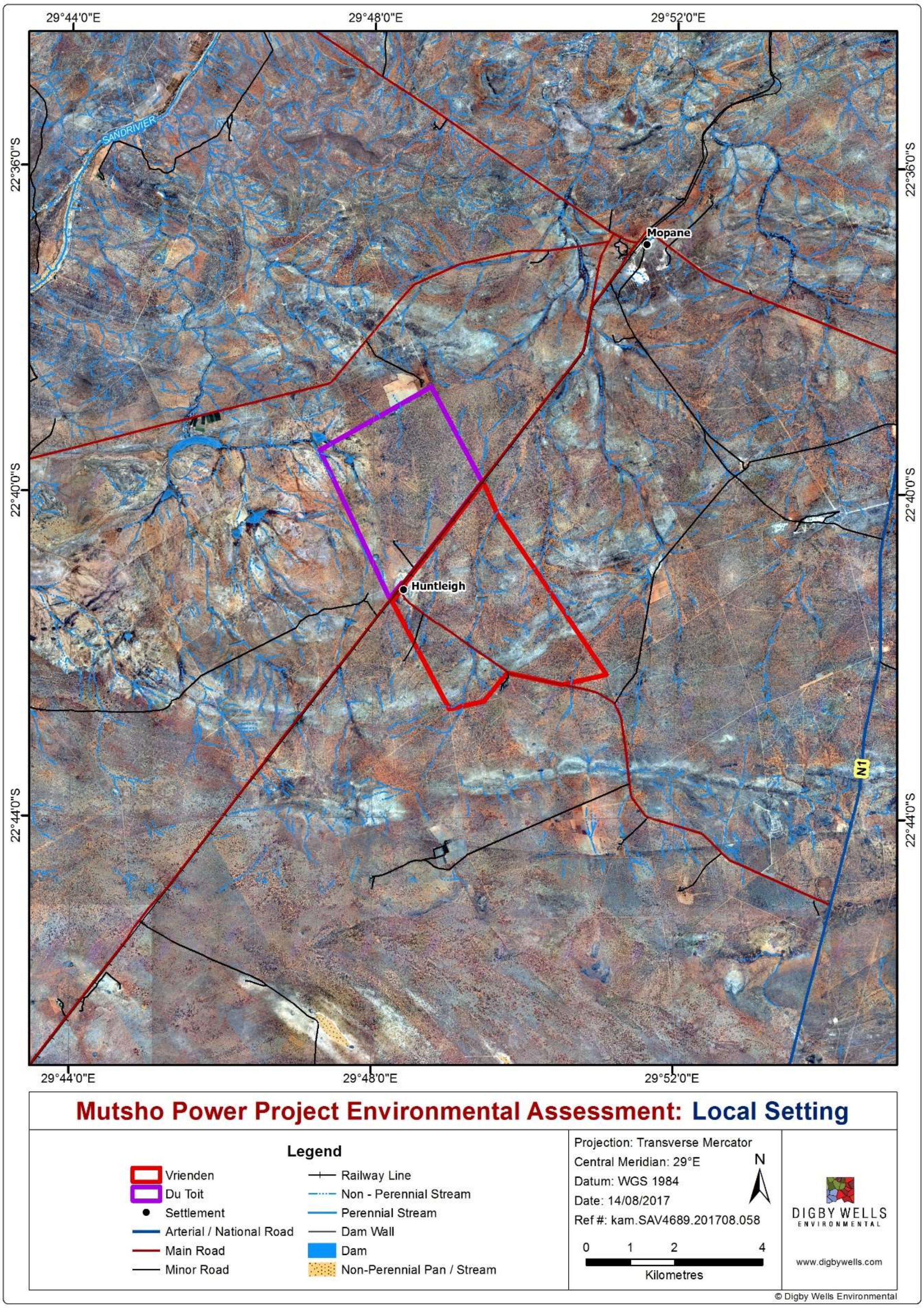


Figure 2: Local Setting

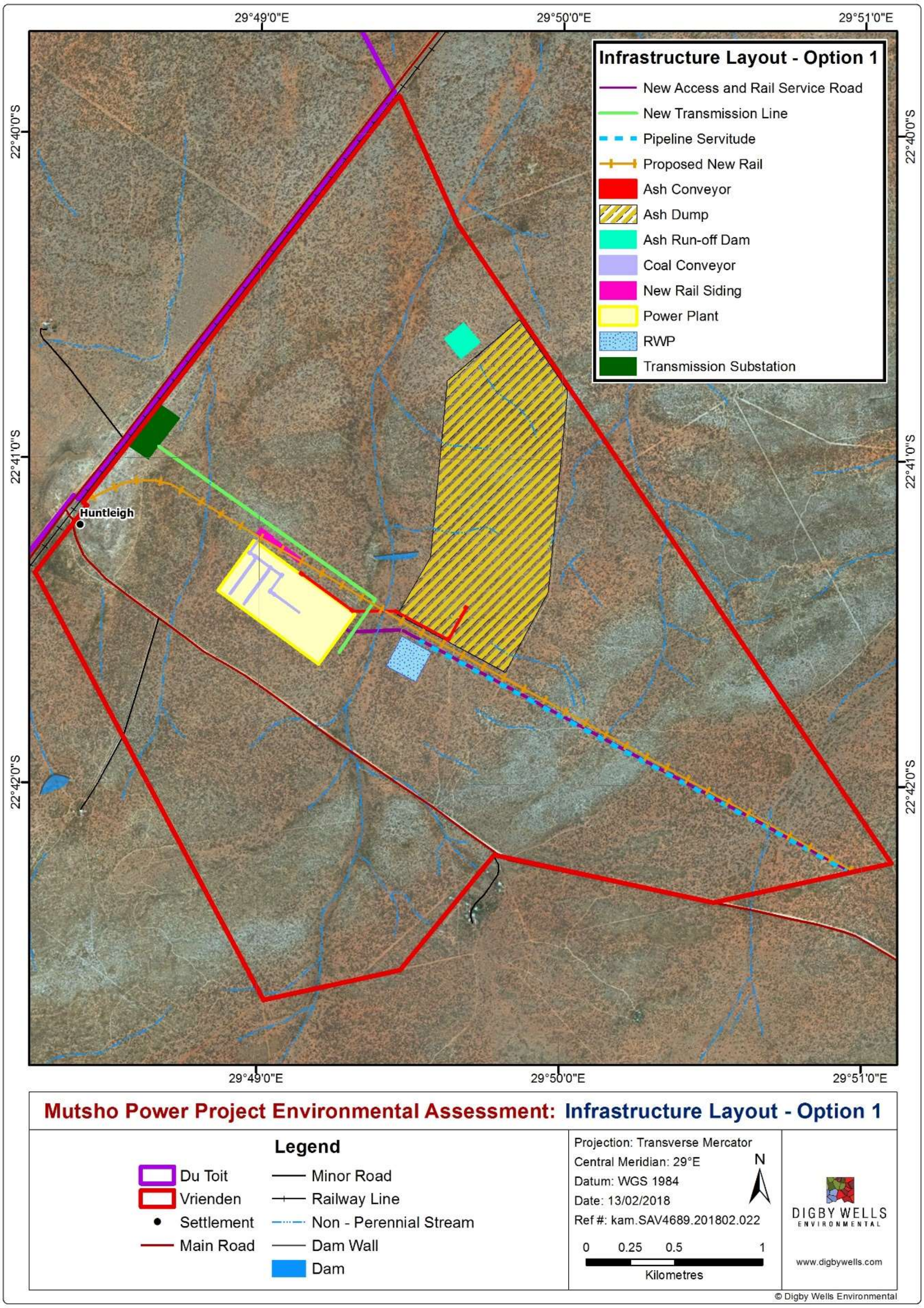


Figure 3: Option 1 layout

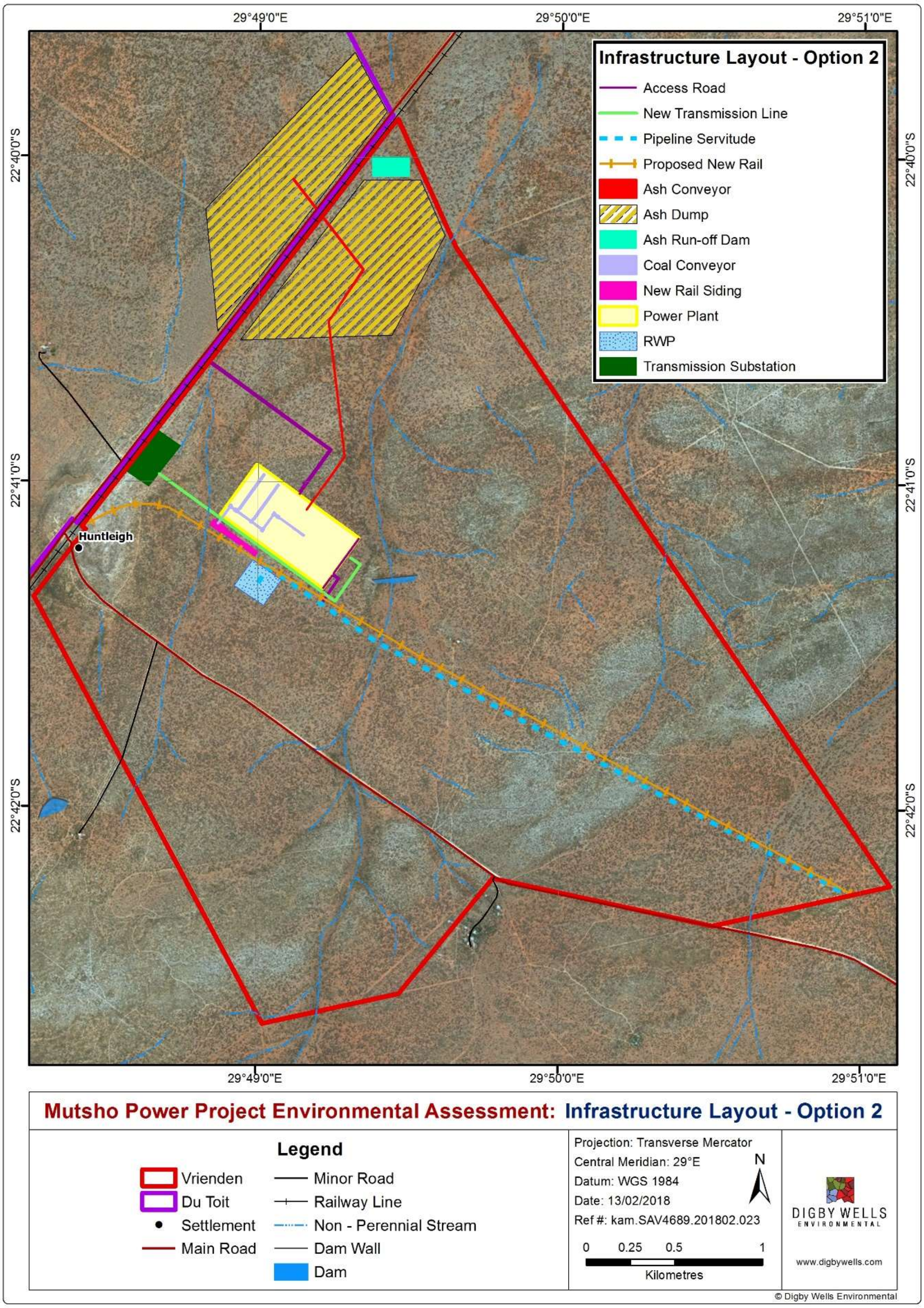


Figure 4: Option 2 layout

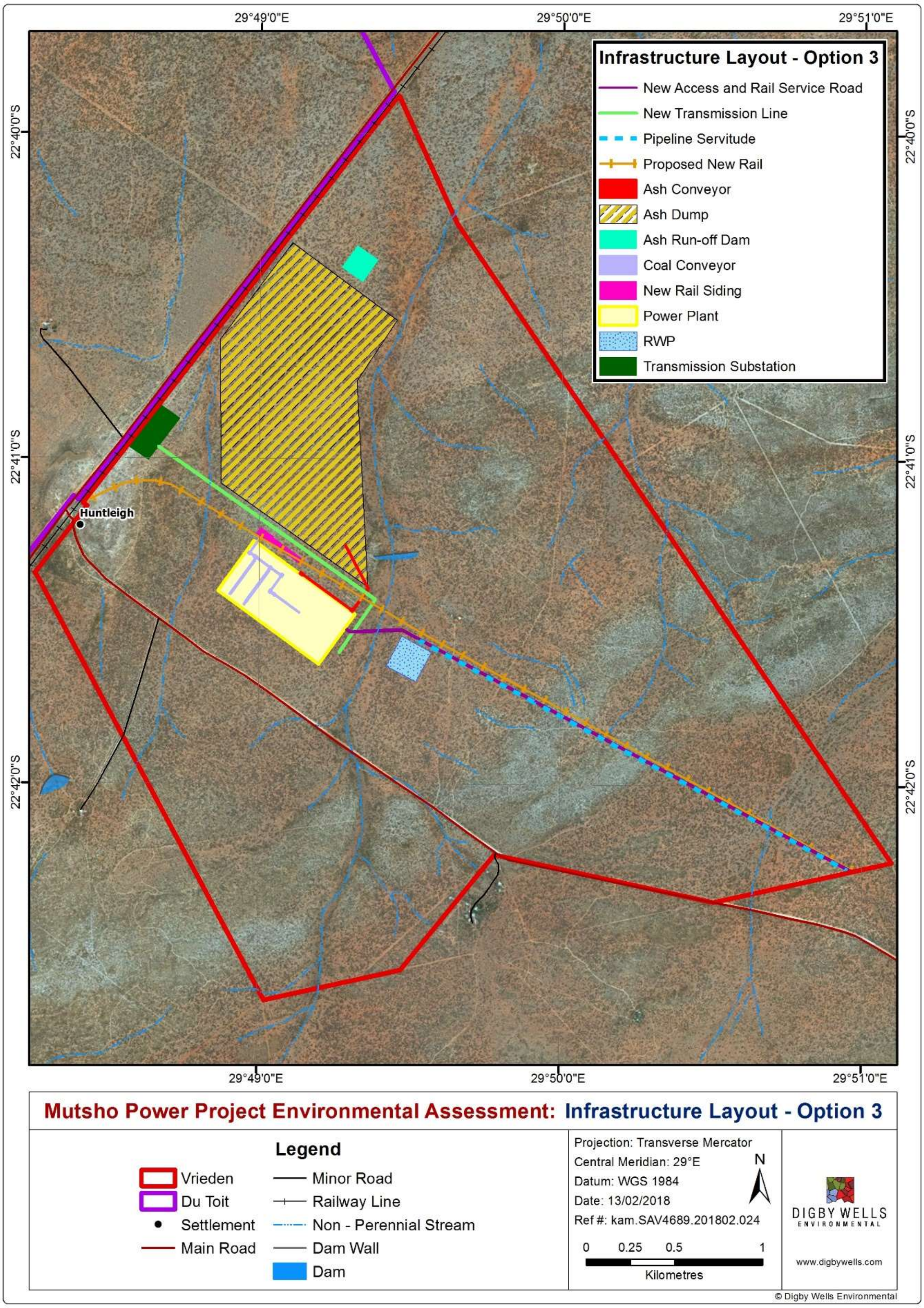


Figure 5: Option 3 layout

2 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations have been made with respect to the specialist assessments that have been undertaken:

- In order to obtain a comprehensive understanding of the dynamics of the aquatic biota present within a watercourse (e.g. migratory pathways, seasonal prevalence, breeding cycles, etc.), studies should include investigations conducted during different seasons, over a number of years and through extensive sampling efforts. Given the time constraints of the baseline assessment, such long-term research was not feasible and could not be conducted. Therefore, the findings presented are based on professional experience, supported by a literature review, and extrapolated from the data collected at the time of the field survey.
- In light of the semi-arid nature of the study area, no sampling can be undertaken at any of the selected aquatic sampling points in the absence of water (i.e. dry sites). However, these conditions are regarded as natural within the study area and as such, are expected to occur irregularly (e.g. 2-year cycles) within these ephemeral watercourses surrounding and within the study area. Many of the associated watercourses were observed to be dry at the time of the survey with the exception of one/two impoundments, which received approximately 14 mm of rain approximately 2/3 days prior to the assessment.
- Although SASS5 is not recommended for use in temporary rivers ((Chutter, 1998; Dickens and Graham, 2002)), to date no other method has been developed, and it was therefore deemed to be the most appropriate tool available at the time of the study (Watson and Dallas, 2013). This limitation extended to a number of the aforementioned assessment indices mentioned above and as such, caution should be applied during interpretation of these results due to highly dynamic changes expected within these systems following sufficient rainfall within the area.
- Due to the large nature of the site, ground-truthing was focussed predominantly in the vicinity of the proposed infrastructure areas;
- For the purposes of the wetland study, all the ephemeral drainage lines were combined and given an average score. Wet-Health, EIS and EcoServices are not prescribed for drainage lines, however, the tools have been applied in order to give an indication of the health and functionality of these systems;
- It must be noted that the ephemeral systems are watercourses. These watercourses must be delineated and their boundaries indicated according to legislation. The purpose of the wetlands assessment is to indicate the boundaries of all the freshwater resources identified, even if they are not all classified as wetlands as for the two pans identified. Department of Water and Sanitation will require the ephemeral streams to be delineated, which has been undertaken as

part of the assessment. Thus, the ephemeral systems indicated fall within the scope of the wetlands assessment for what will be required for the EIA.

- The groundwater impact assessment was conducted based on the provided project description with the associated proposed activities. Any additional activities and infrastructure changes will require an update of this report;
- There are uncertainties associated with the hydraulic conductivity of the aquifer(s) at the project area. An average value was derived from literature. Drilling and aquifer testing of boreholes is required to obtain site-specific hydraulic parameters to improve model accuracy;
- A geochemical study including waste classification and leachate test is required to determine the elements of concerns and expected leachate quality from the ash material and coal stockpile. This will be the basis on which liner recommendations can be made during the final design;
- The liner simulated in the model scenario is a Class C liner as defined in Regulation 634 of August 2013; this may vary based on the outcomes of the recommended geochemical studies to be conducted;
- An analytical model is used as a high level predictive tool for the groundwater environment, assuming a homogeneous aquifer; not taking into account the effective porosity, preferential flow paths and groundwater flow barriers. This implies that there are always errors associated with groundwater models due to uncertainty in the data and the capability of the models to accurately describe real life and natural physical processes.
- The surface water assessment was based on the provided project description with the associated proposed activities, desktop analysis and site assessment that were undertaken. Any additional activities and infrastructure change will require an update of this report;
- Only one surface water sample was collected within the project site (farm Du Toit 563) as the rivers were dry during the site visit. Water quality obtained from this sample cannot be considered as representative of the rivers around the project site, hence a monitoring programme will be recommended in this report; and
- Development of a storm water management plan was not part of Digby Wells scope and it is assumed that this has been developed by the engineers or persons responsible for design of infrastructure layout. Digby Wells conducted a review of the proposed storm water infrastructures and comments have been provided on this report.

3 METHODOLOGY

The methodology for the respective studies are summarised below in further detail.

3.1 Aquatic Ecology

3.1.1 Water Quality Parameters

Selected *in situ* water quality variables were measured at each of the selected sampling sites using water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter and an ExStik DO600 Dissolved Oxygen Meter. Temperature, pH, electrical conductivity and dissolved oxygen were recorded prior to sampling, while the time of day at which the measurements were assessed was also noted for interpretation purposes.

3.1.2 Index of Habitat Integrity, Version 2 (IHI-96-2)

The IHI (Version 2, Kleynhans, C.J., *pers. comm.*, 2015) aims to assess the number and severity of anthropogenic perturbations along a river/stream/wetland and the potential inflictions of damage toward the habitat integrity of the system (Dallas, 2005). Various abiotic (e.g. water abstraction, weirs, dams, pollution, dumping of rubble, etc.) and biotic (e.g. presence of alien plants and aquatic animals, etc.) factors are assessed, which represent some of the most important and easily quantifiable, anthropogenic impacts upon the system (Table 1).

As per the original IHI approach (Kleynhans, 1996), the instream and riparian components were each analysed separately to yield two separate ecological conditions (i.e. Instream and Riparian components). However, it should be noted that the data for the riparian area is primarily interpreted in terms of the potential impact upon the instream component and as a result, may be skewed by a potentially deteriorated instream condition.

While the recently upgraded index (i.e. IHI-96-2; Dr. C. J. Kleynhans, *pers. comm.*, 2015) replaces the aforementioned comprehensive and expensive IHI assessment model developed by Kleynhans (1996), it is important to note that the IHI-96-2 does not replace the IHI model developed by Kleynhans et al. (2008a), which is recommended in instances where an abundance of data is available (e.g. intermediate and comprehensive Reserve Determinations). Accordingly, the IHI-96-2 model is typically applied in cases where a relatively few number of river reaches need to be assessed, the budget and time provisions are limited, and/or any detailed available information is lacking (i.e. rapid Reserve Determinations and for REMP/RHP purposes).

Table 1: Descriptions of criteria used to assess habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Factors	Relevance
Water abstraction	Direct impact upon habitat type, abundance and size. Also impacted in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.

Factors	Relevance
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in the temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included
Water quality modification	Originates from point and diffuse sources. Measured directly, or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments.
Alien/Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Alien/Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced
Bank erosion	Decrease in bank stability will cause sedimentation and possible

Factors	Relevance
	collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

In accordance with the magnitude of the impact created by the abovementioned criterion, the assessment of the severity of the modifications was based on six descriptive categories ranging between a rating of 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact; Table 2). Based on available knowledge of the site and/or adjacent catchment, a confidence level (high, medium, low) was assigned to each of the scored metrics.

Table 2: Descriptive of scoring guidelines for the assessment of modifications to habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Impact Category	Description	Score
None	No discernible impact or the factor is located in such a way that it has no impact on habitat quality diversity, size and variability.	0
Small	The modification is limited to a very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 - 5
Moderate	The modification is present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6 - 10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced	11 - 15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability of almost the whole of the defined section are affected. Only small areas are not influenced.	16 - 20
Critical	The modification is present overall with a high intensity; the habitat quality, diversity, size and variability in almost the whole of the defined section are detrimentally influenced.	21 - 25

Given the subjective nature of the scoring procedure utilised within the general approach to habitat integrity assessment (including IHI-96-2; see Appendix A), the most recent version of the IHI application (Kleynhans *et al*., 2008) and the Model Photo Guides (Graham and Louw, 2008) were used to calibrate the severity of the scoring system. It should be noted that the assessment was limited to observed and/or suspected impacts present within the immediate vicinity of the delineated assessment units, as determined through the use of aerial photography (e.g. Google Earth) and observations made at each of the assessed sampling points during the field survey. However, in cases where major upstream impacts (e.g. construction of a dam, major water abstraction, etc.) were confirmed, potential impacts within relevant sections were considered and accounted for within the application of the method.

Each of the allocated scores was then moderated by a weighting system (Table 3), which is based on the relative threat of the impact to the habitat integrity of the riverine system. The total score for each impact is equal to the assigned score multiplied by the weight of that impact. The estimated impacts (assigned score / maximum score [25] X allocated weighting) of all criteria are then summed together, expressed as a percentage and then subtracted from 100 to determine the Present Ecological State score (PES; or Ecological Category) for the instream and riparian components, respectively.

Table 3: Criteria and weightings used to assess habitat integrity (Kleynhans, 1996; cited in Dallas, 2005)

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality modification	14	Water abstraction	13
Inundation	10	Inundation	11
Alien/Exotic macrophytes	9	Flow modification	12
Alien/Exotic aquatic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	**100**	**TOTAL**	**100**

However, in cases where selected instream component criteria (i.e. water abstraction, flow, bed and channel modification, water quality and inundation) and/or any of the riparian component criteria exceeded ratings of large, serious or critical, an additional negative weight was applied. The aim of this is to accommodate the possible cumulative effect (and integrated) negative effects of such impacts (Kemper, 1999). The following rules were applied in this respect:

- Impact = Large, lower the integrity status by 33% of the weight for each criterion with such a rating.
- Impact = Serious, lower the integrity status by 67% of the weight for each criterion with such a rating.
- Impact = Critical, lower the integrity status by 100% of the weight for each criterion with such a rating.

Subsequently, the negative weights were added for both facets of the assessment and the total additional negative weight subtracted from the provisionally determined integrity to arrive at a final habitat integrity estimate (Kemper, 1999). The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific habitat integrity ecological category (Table 4).

Table 4: Ecological Categories for the habitat integrity scores (Kleynhans, 1999a; cited in Dallas, 2005)

Ecological Category	Description	Score (% of Total)
A	Unmodified, natural.	90 - 100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and there has been an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0 - 19

3.1.3 Invertebrate Habitat Assessment System (IHAS), Version 2.2

Assessment of the available habitat for aquatic macroinvertebrate colonization at each of the sampling sites is vital for the correct interpretation of results obtained following biological assessments. It should be noted that the available methods for determining habitat quality are not specific to rapid biomonitoring assessments and are inherently too variable in their approach to achieve consistency amongst users.

Nevertheless, the Invertebrate Habitat Assessment System (IHAS) has routinely been used in conjunction with the South African Scoring System (SASS) as a measure of the variability of aquatic macroinvertebrate biotopes available at the time of the survey (McMillan, 1998). The scoring system was traditionally split into two sections, namely the sampling habitat (comprising 55% of the total score) and the general stream characteristics (comprising 45% of the total score), which were summed together to provide a percentage and then categorized according to the values in Table 5.

However, the lack of reliability and evidence of notable variability within the application of the IHAS method has prompted further field validation and testing, which implies a cautious interpretation of results obtained until these studies have been conducted (Ollis et al., 2006). In the interim and for the purpose of this assessment, the IHAS method was adapted by excluding the assessment of the *general stream characteristics*, which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned table.

Table 5: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat

IHAS Score (%)	Description
>75	Excellent
65-74	Good
55-64	Adequate / Fair
<55	Poor

3.1.4 South African Scoring System, Version 5 (SASS5)

While there are a number of indicator organisms that are used within these assessment indices, there is a general consensus that benthic macroinvertebrates are amongst the most sensitive components of the aquatic ecosystem. This was further supported by their largely non-mobile (or limited mobility) within reaches of associated watercourses, which also allows for the spatial analysis of disturbances potentially present within the adjacent catchment area. However, it should also be noted that their heterogeneous distribution within the water resource is a major limitation, as this results in spatial and temporal variability within the collected macroinvertebrate assemblages (Dallas and Day, 2004).

SASS5 is essentially a biological assessment index which determines the health of a river based on the aquatic macroinvertebrates collected on-site, whereby each taxon is allocated a score based on its perceived sensitivity/tolerance to environmental perturbations (Dallas, 1997). However, the method relies on a standardised sampling technique using a handheld net (300 mm x 300 mm, 1000 micron mesh size) within each of the various habitats available for standardised sampling times and/or areas. Niche habitats (or biotopes) sampled during SASS5 application include:

- Stones (both in-current and out-of-current);
- Vegetation (both aquatic and marginal); and
- Gravel, sand and mud.

Once collection is complete, aquatic macroinvertebrates are identified to family level and a number of assemblage-specific parameters are calculated including the total SASS5 score, the number of taxa collected, and the Average Score per Taxa i.e. SASS score divided by the total number of taxa identified (C. A. Thirion et al., 1995; Davies and Day, 1998; Dickens and Graham, 2002; Gerber and Gabriel, 2002). The SASS bio-assessment index has been proven to be an effective and efficient means to assess water quality impairment and general river health (Dallas, 1997; Chutter, 1998).

3.1.5 Macroinvertebrate Response Assessment Index (MIRAI)

In order to determine the Present Ecological State (PES; or Ecological Category) of the aquatic macroinvertebrates collected/observed, the SASS5 data is used as a basic input (i.e. prevalence and abundance) into the recently improved MIRAI (Version 2, Thirion. C., *pers. comm.*, 2015). This biological index integrates the ecological requirements of the macroinvertebrate taxa in a community (or assemblage) and their response to flow modification, habitat change, water quality impairment and/or seasonality (C. Thirion, 2008). The presence and abundance of aquatic macroinvertebrates are compared to a derived list of families/taxa that are expected to be present under natural, un-impacted conditions. Consequently, the aforementioned metric groups were combined within the model to derive the ecological condition of the site in terms of aquatic macroinvertebrates (Table 6).

Table 6: Allocation protocol for the determination of the Present Ecological State for aquatic macroinvertebrates following application of the MIRAI

MIRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function are less than the reference condition. Community composition is lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

3.1.6 Fish Response Assessment Index (FRAI)

Fish were collected by means of electro-narcosis (or electro-fishing), whereby an anode and a cathode are immersed in the water to temporarily stun fish in the near vicinity. A photographic record of fish collected was taken. Each of the collected fish specimens were identified in the field, a photograph was taken of each species representative and/or specimens with a notable macroscopic abnormality and released back into the river, where possible.

Assessment of the Present Ecological State (PES; or Ecological Category) of the fish assemblage of the watercourses associated with the study area was conducted by means of the FRAI (Kleynhans, 2008). This procedure is an integration of ecological requirements of fish species in an assemblage and their derived (or observed) responses to modified habitat conditions. In the case of the present assessment, the observed response was determined by means of fish sampling, as well as a consideration of species requirements and driver changes (Kleynhans, 2008). The expected fish species assemblage within the study area was derived from (Kleynhans, Louw, and Moolman, 2008) and aquatic habitat sampled.

Although the FRAI uses essentially the same information as the Fish Assemblage Integrity Index (FAII), it does not follow the same procedure. The FAII was developed for application in the broad synoptic assessment required for the River Health Programme, and subsequently does not offer a particularly strong cause-and-effect basis. The purpose of the FRAI, on the other hand, is to provide a habitat-based cause-and-effect underpinning to interpret the deviation of the fish assemblage from the perceived reference condition(Kleynhans, 2008).

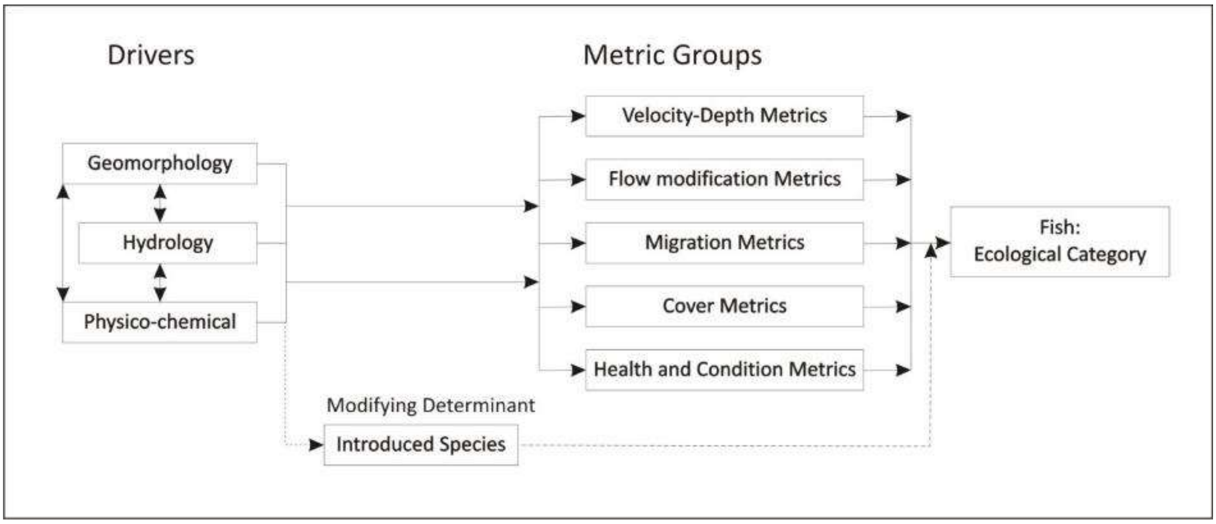


Figure 6: Relationship between drivers and fish metric groups

The FRAI is based on the assessment of selected metrics within metric groups, which are assessed in terms of:

- Habitat changes that are observed or derived;

- The impact of such habitat changes on species with particular preferences and tolerances; and
- The relationship between the drivers used in the FRAI and the various fish response metric groups, as are indicated in Figure 6. Table 7 provides the steps and procedures required for the calculation of the FRAI.

Table 7: Main steps and procedures followed in calculating the Fish Response Assessment Index

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

Interpretation of the FRAI score follows a descriptive procedure in which the FRAI score is classified into a particular PES (or Ecological Category) based on the abovementioned integrity classes of (Kleynhans, 1999b). Each category describes the generally expected conditions for a specific range of FRAI scores (Table 8).

Table 8: Allocation protocol for the determination of the Present Ecological State (or Ecological Category) of the sampled/observed fish assemblage following application of the FRAI

FRAI (%)	Ecological Category	Description
90-100	A	Unmodified and natural. Community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
80-89	B	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60-79	C	Moderately modified. Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. Fewer species present then expected due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
20-39	E	Seriously modified. Few species present due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
0-19	F	Critically modified. Few species present. Only tolerant species present, if any.

3.1.7 EcoStatus4 1.02 Model

For the purpose of the present assessment, the latest ECOSTATUS4 1.02 model was used, which is an upgraded and refined version of the original ECOSTATUS4 model (Kleynhans & Louw,2008). The results obtained from the fish and aquatic macroinvertebrate response indices (i.e. FRAI and MIRAI) are to be integrated within the model to determine an Instream Ecological Category, whereas the riparian elements from the IHI-96-2 model can be used as a surrogate for the Riparian Ecological Category in the following manner (Dr. C.J. Kleynhans, *pers. comm.*, 2015):

*Riparian Vegetation EC = 100-(((IHI 'Natural vegetation removal')+(IHI 'Exotic Vegetation Encroachment'))/50*100)*

3.2 Wetland Assessment

3.2.1 Delineation and Identification

The delineation procedure considers four attributes to determine the limitations of the wetland or other freshwater resource, in accordance with DWAF guidelines (now Department of Water and Sanitation (DWS) (2005)). The four attributes are:

- Terrain Unit Indicator – helps to identify those parts of the landscape where wetlands are more likely to occur;
- Soil Form Indicator – identifies the soil forms, which are associated with prolonged and frequent saturation;
- Soil Wetness Indicator – identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and
- Vegetation Indicator – identifies hydrophilic vegetation associated with frequently saturated soils.

In accordance with the definition of a wetland in the NWA, vegetation is the primary indicator of a wetland, which must be present under normal circumstances. However, the soil wetness indicator tends to be the most important in practice. The remaining three indicators are then used in a confirmatory role. The reason for this is that the response of vegetation to changes in the soil moisture regime or management are relatively quick and may be transformed, whereas the morphological indicators in the soil are significantly more long-lasting and will hold the indications of frequent and prolonged saturation long after a wetland has been drained (perhaps several centuries) (DWAF, 2005). This tends to be very difficult under black clay vertic soil conditions as wetness indicators are lacking, and therefore topography, geomorphology and vegetation indicators play a stronger role (as found in some places of this study).

3.2.1.1 Terrain Unit Indicator

Terrain Unit Indicator (TUI) areas include depressions and channels where water would be most likely to accumulate. These areas are determined with the aid of aerial imagery and regional contours (DWAF, 2005). The HGM Unit system of classification focuses on the hydro-geomorphic setting of wetlands which incorporates geomorphology; water movement into, through and out of the wetland; and landscape / topographic setting. Once wetlands have been identified, they are categorised into HGM Units as shown in Table 9. HGM Units are then assessed individually for Present Ecological State (PES) and ecological services.

Table 9: Description of the different Hydrogeomorphic Units for Wetland Classification

Hydromorphic wetland type	Diagram	Description
Floodplain		Valley bottom areas with a well-defined stream channel stream channel, gently sloped and characterised by floodplain features such as oxbow depression and natural levees and the alluvial (by water) transport and deposition of sediment , usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by the net loss of sediment. Water inputs from the main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and also from adjacent slopes.
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.
Isolated hillslope seepage		Slopes on hillsides that are characterised by colluvial transport (transported by gravity) movement of materials. Water inputs are from sub-surface flow and outflow either very limited or through diffuse sub-surface flow but with no direct link to a surface water channel.

Hydromorphic wetland type	Diagram	Description
Pan/Depression		A basin-shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. It is inward draining). It may also receive subsurface water. An outlet is usually absent and so this type of wetland is usually isolated from the stream network.

3.2.1.2 Soil Form Indicator

Hydromorphic soils are taken into account for the Soil Form Indicator (SFI) which will display unique characteristics resulting from prolonged and repeated water saturation (DWAF, 2005). The continued saturation of the soils results in the soils becoming anaerobic and thus resulting in a change of the chemical characteristics of the soil. Iron and manganese are two soil components which are insoluble under aerobic conditions and become soluble when the soil becomes anaerobic and thus begin to leach out into the soil profile. Iron is one of the most abundant elements in soils and is responsible for the red and brown colours of many soils.

Resulting from the prolonged anaerobic conditions, iron is dissolved out of the soil, and the soil matrix is left a greying, greenish or bluish colour, and is said to be "gleyed". Common in wetlands which are seasonally or temporarily saturated is a fluctuating water table, these result in alternation between aerobic and anaerobic conditions in the soil (DWAF, 2005). Iron will return to an insoluble state in aerobic conditions which will result in deposits in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated (DWAF, 2005).

3.2.1.3 Soil Wetness Indicator

In practice, the Soil Wetness Indictor (SWI) is used as the primary indicator (DWAF, 2005). Hydromorphic soils are often identified by the colours of various soil components. The frequency and duration of the soil saturation periods strongly influences the colours of these components. Grey colours become more prominent in the soil matrix the higher the duration and frequency of saturation in a soil profile (DWAF, 2005). A feature of hydromorphic soils are coloured mottles which are usually absent in permanently saturated soils and are most prominent in seasonally saturated soils, and are less abundant in temporarily saturated soils (DWAF, 2005). For a soil horizon to qualify as having signs of wetness in the temporary, seasonal or permanent zones, a grey soil matrix and/or mottles must be present. This is however difficult in vertic black soil with very high clay content.

3.2.1.4 Vegetation Indicator

As one moves along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas plant communities undergo distinct changes in species composition. Valuable information for determining the wetland boundary and wetness zone is derived from the change in species composition. A supplementary method for employing vegetation as an indicator is to use the broad classification of the wetland plants according to their occurrence in the wetlands and wetness zones (Kotze and Marneweck, 1999; DWAF, 2005). This is summarised in Table 10 below. When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWAF, 2005). Areas where soils are a poor indicator (black clay, vertic soils), vegetation (as well as topographical setting) is relied on to a greater extent and the use of the wetland species classification as per Table 10 becomes more important.

Table 10: Classification of plant species according to occurrence in Wetlands (DWAF, 2005)

Type	Description
Obligate Wetland species (OW)	Almost always grow in wetlands: >99% of occurrences.
Facultative Wetland species (FW)	Usually grow in wetlands but occasionally are found in non-wetland areas: 67 – 99 % of occurrences.
Facultative species (F)	Are equally likely to grow in wetlands and non-wetland areas: 34 – 66% of occurrences.
Facultative dry-land species (fd)	Usually grow in non-wetland areas but sometimes grow in wetlands: 1 – 34% of occurrences.

3.2.2 *Wetland Ecological Health Assessment*

According to Macfarlane *et al.* (2009) the health of a wetland can be defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. A WET-Health assessment was done on the wetlands and freshwater resources in accordance with the method described by Kotze *et al.* (2007) to determine the integrity (health) of the characterised HGM units for the project area. A PES analysis was conducted to establish baseline integrity (health) for the associated wetlands and freshwater resources present.

The health assessment attempts to evaluate the hydrological, geomorphological and vegetation health in three separate modules to attempt to estimate similarity to or deviation from natural conditions. The overall health score of the wetland is calculated using Equation 1, which provides a score ranging from 0 (pristine) to 10 (critically impacted in all respects). The rationale for this is that hydrology is considered to have the greatest contribution to health. The PES is determined according to Table 11.

$$Wetland\ Health = \frac{3(Hydrology)\ + 2(Geomorphology) + 2(Vegetation)}{7}$$

Equation 1: Overall Wetland Ecological Health Score

Table 11: Impact scores and Present Ecological State categories used by Wet-Health

Impact Category	Description	Combined Impact Score	PES Category
None	Unmodified, natural.	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota has taken place.	1-1.9	B
Moderate	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
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.	6-7.9	E
Critical	Modifications have reached a critical level and ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

3.2.3 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) tool was derived to assess the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The purpose of assessing importance and sensitivity of water resources is to be able to identify those systems that provide higher than average ecosystem services, biodiversity support functions or are especially sensitive to impacts. Water resources with higher ecological importance may require managing such water resources in a better condition than the present to ensure the continued provision of ecosystem benefits in the long term.

The methodology outlined by DWAF (1999) and updated in Rountree and Kotze, (2012, in Rountree *et al*. (2012) was used for this study. In this method there are three suites of importance criteria; namely:

- **Ecological Importance and Sensitivity**: incorporating the traditionally examined criteria used in EIS assessments of other water resources by DWA and thus enabling consistent assessment approaches across water resource types;
- **Hydro-functional Importance**: which considers water quality, flood attenuation and sediment trapping ecosystem services that the wetland or freshwater resource may provide; and
- **Importance in terms of Basic Human Benefits**: this suite of criteria considers the subsistence uses and cultural benefits of the wetland or freshwater system.

These determinants are assessed for the wetlands and freshwater resources present on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. It is recommended that the highest of these three suites of scores be used to determine the overall Importance and Sensitivity category of the wetland or freshwater system, as defined in Table 12.

Table 12: Interpretation of overall Ecological Importance and Sensitivity (EIS) scores for biotic and habitat determinants (Rountree & Kotze, 2012)

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

3.2.4 Wetland Functional Assessment

In accordance with the method described by Kotze *et al.* (2007), an ecological functional assessment of the associated wetland was undertaken. This methodology provides for a scoring system to establish the services of the wetland ecosystem. The onsite wetlands are grouped according to homogeneity and assessed utilizing the functional assessment technique, WET-EcoServices, developed by Kotze *et al,* (2007) to provide an indication of the benefits and services. This methodology computes a score out of 4 for each index and provides an indication of the ecological services offered by the different HGM units for the study area. Results are given in the form of a radial plot showing the relative importance of the 15 indices.

3.3 Groundwater Assessment

3.3.1 Desktop Assessment

The desktop assessment included a review of all available data including reports, data sheets and maps. A review process was conducted and interpretations performed to establish a conceptual idea of the groundwater occurrence and dynamics. The findings were used to plan the field survey and incorporated into the environmental impact assessment report.

3.3.2 Field Survey

The field surveying conducted during the study of the project area was a hydrocensus, conducted with the aim of obtaining information pertaining to the current groundwater conditions (water level and quality) and to identify potential receptors (private boreholes and surface water bodies).

3.3.3 Hydrocensus

A hydrocensus was conducted in January 2018, by Digby Wells. During the hydrocensus the following information was collected for each site:

- Borehole co-ordinates;
- The status of borehole and equipment installed;
- Water level;
- Field pH, EC and TDS values; and
- Borehole use.

A total of 6 boreholes were identified (Section 5.3.2) and 5 of those boreholes were selected for groundwater quality analysis and delivered to Aquatico Laboratories (Pty) Ltd in Pretoria for analysis (results found in Appendix B).

Water samples were analysed for the constituents in Table 13.

Table 13: Inorganic constituents

pH	Sulphate (SO_4)
Electrical Conductivity (EC)	Ammonium (NH_4)
P-Alkalinity (PALK)	Potassium (K)
Total Alkalinity (TALK)	Nitrate (NO_3-N)
Iron (Fe)	Chromium (Cr)
Manganese (Mn)	Phosphate (PO_4-P)
Chloride (Cl)	Fluoride (F)
Magnesium (Mg)	Arsenic (As)
Sodium (Na)	Cadmium (Cd)
Aluminum (Al)	Lead (Pb)
Calcium (Ca)	Copper (Cu)
Zinc (Zn)	Cobalt (Co)
Nickel (Ni)	Total anions
Total cations	Ionic balance

3.3.4 Hydrogeological Modelling

3.3.4.1 Conceptual Modelling (Baseline Hydrogeological Environment Description)

The conceptual model was formulated as a description of the groundwater environment in terms of; the local aquifer system, the groundwater sources and potential receptors.

A description of the aquifer system is provided in terms of expected hydraulic parameters (i.e. hydraulic conductivity, storativity, transmissivity) that govern the rate at which groundwater migrates locally. The groundwater sources are described in terms of the contributors to groundwater quantity and groundwater quality, i.e. groundwater recharge, local geology and potential contamination sources. The potential receptors are identified as the various dependants of the groundwater that may be impacted should there be an impact to the groundwater quantity and quality, i.e. surface water bodies and private boreholes users.

3.3.4.2 Analytical Modelling

The conceptual model was transformed into an analytical model. The model was developed to evaluate the potential impact that the identified sources may have on the groundwater environment. The analytical model was formulated based on the fundamental groundwater principles of Darcy's Law.

3.3.5 Methodology for Groundwater Impact Assessment

The groundwater impact assessment was conducted to determine the extent of an impact on the groundwater resource, mitigation measures of the identified expected impacts associated with the power plant and associated infrastructure are provided as part of the impact assessment.

3.3.6 Monitoring Network Design

A groundwater monitoring network is recommended based on the results of the analytical model results and impact assessment. Frequency and methodology of sampling are included as part of the recommendations.

3.4 Surface Water Assessment

3.4.1 Objectives

The objectives of this surface water impact assessment include:

- Site assessments to verify the hydrological characteristics of the project area and the surrounds;
- Describe the hydrological baseline of the project area prior to commencement of the project;
- Conduct a surface water sensitivity analysis to assist with the project site selection;
- Review the proposed storm water management plan to ensure separation of clean and dirty water; and
- Conduct a detailed impact assessment to determine the potential surface water impacts that could emanate from the project and its associated activities.

3.4.2 Desktop Assessment and Literature Review

A desktop assessment was conducted during the scoping phase in order:

- To identify and characterise all surface water features (rivers/streams, pans and dams) that could potentially be affected by the proposed establishment of the Mutsho Power Project within and around the project area;
- To determine and describe the hydrological baseline conditions prior to the onset of the project. This includes a description of the affected catchment characteristics, climate (rainfall and evaporation), topography and baseline water quality; and
- To gain more understanding of the area and its hydrological characteristics.

Existing reports and other literatures were also reviewed as part of this study to gain an understanding and background of the project area, some information from these reports was used for baseline descriptions whilst updating the baseline where necessary with new information. Other reports and documents that were reviewed when compiling this report include:

- Department of Water and Sanitation (formerly DWAF), 2006. Best Practice Guideline Series;
- Savannah Environmental (Pty) Ltd, March 2017. Environmental Site Screening Assessment for the proposed Coal-Fired Power Plant Near Makhado;
- WSM Leshika Consulting (Pty) Ltd, 2013. Greater Soutpansberg Mopane Project, Surface Water Assessment as part of the Environmental Impact Assessment, Coal of Africa Limited; and

- Water Resources of South Africa, 2012 Study (WR2012), Water Research Commission, Pretoria.

3.4.3 Fieldwork Programmes

A site assessment was conducted on the 18th and 19th of January 2018 to verify the hydrological characteristics of the area together with the collection of surface water samples to determine the baseline water quality on the surrounding area prior to the commencement of the project.

However, most of the identified water resources (streams, drainage lines, farm dams and the Sands River) were found to be dry during the site assessment and sampling could not be possible on all of them. Only one sample was collected on the farm dam located within Farm Du Toit 563.

3.4.4 Storm water management plan

A storm water management plan (SWMP) should be developed in accordance with the Government Notice 704 (GN 704) of the National Water Act 1998 (Act 36 of 1998) (NWA), which relates specifically to the separation of clean and dirty water within the boundary of the project footprint or related activities.

With the assumption that this will be developed by the engineers or persons responsible for design of infrastructure layout, the developed SWMP will only be reviewed by Digby Wells to ensure if it fulfils the purpose of clean and dirty water separation.

3.4.5 Impact Assessment

A detailed surface water impact assessment has been conducted and includes:

- Defining potential surface water impacts that could result from the proposed project and its associated activities. Once an impact has been identified, a rating system that takes into consideration the intensity, duration, spatial scale and probability of the impact was utilised to determine the significance of the identified impacts;
- Recommending mitigation measures to prevent and/or minimise the identified potential surface water impacts over the life of the project; and
- Recommending monitoring programmes and Environmental Management Programme (EMPr) that will be used as a tool to detect any surface water impact.

4 DESCRIPTION OF THE ENVIRONMENT

4.1 Climatic Baseline

The project area is situated in a semi-arid zone to the north of the Soutpansberg. The regional climate is strongly influenced by the east-west orientated mountain range which represents an effective barrier between the south-easterly maritime climate that is influenced from the Indian Ocean and the continental climate that has influences (predominantly the Inter-Tropical Convergence Zone and the Congo Air Mass) coming from the north.

The mountains give rise to wind patterns that play an important role in determining local climates. These wind effects include wind erosion, aridification and air warming (WSM LESHIKA, 2013).

Average historic rainfall and evaporation data at the project area is in the sections provided below.

4.1.1 Rainfall

Table 14 presents the average monthly rainfall for the quaternary catchment A71K. This is based on the average monthly rainfall data for the period 1920 to 2009, (WR2012).

Table 14: Summary of rainfall data extracted from the WR2012

Month	MAP (mm)
January	62.6
February	50.8
March	37.4
April	15.1
May	5.7
June	3.9
July	1.8
August	0.9
September	7.8
October	21.4
November	45.8
December	52.0
MAP	**305**

From the data above, higher rainfall values (52 mm, 62.6 mm and 50.8 mm) were recorded for the months of December, January and February respectively whilst the minimum or lowest rainfall was recorded in August. In general, this area receives a MAP of 305 mm per annum.

4.1.2 Evaporation

Monthly evaporation data was obtained from the WR2012 manual. The evaporation obtained is based on Symons Pan evaporation measurements and needs to be converted to lake evaporation. This is due to the Symons Pan being located below the ground surface and painted black which results in the temperature in the water being higher than that of a natural open water body. The Symons Pan figure is then multiplied by a lake evaporation factor to obtain the adopted lake evaporation figure which presents the monthly evaporation rates of a natural open water body. The MAE was calculated to be 1 681 mm per annum. Table 15 is a summary of the average monthly evaporation for the A71K quaternary catchment.

Table 15: Summary of evaporation data

Months	Lake Evaporation Factor	Lake Evaporation (mm)
January	0.84	175.2
February	0.9	149.4
March	0.9	149.4
April	0.9	122.1
May	0.9	114.0
June	0.9	91.8
July	0.8	100.9
August	0.8	120.2
September	0.8	146.3
October	0.8	169.5
November	0.82	164.5
December	0.83	177.3
Total	**N/A**	**1681**

Higher potential evaporation rates are experienced throughout the whole year with the highest being 177 mm during December. The combined or summary of the climatic data for this quaternary has been presented in Figure 7.

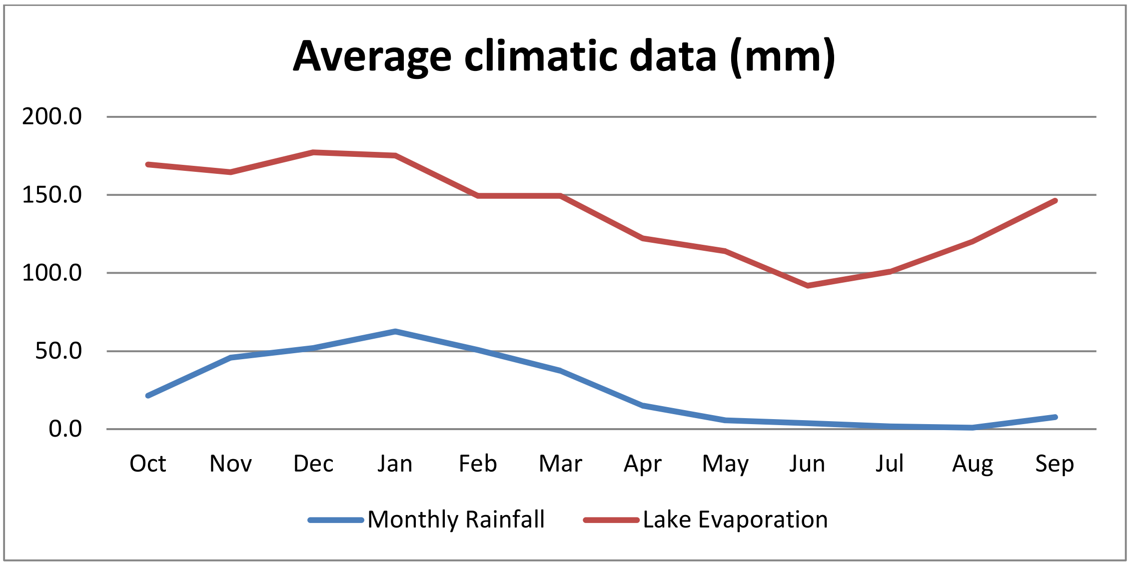


Figure 7: Summary of the average monthly climatic data for A71K quaternary catchment

4.2 Regional Geology

The regional geology is shown in Figure 8 and consists of 3 main lithological groups, i.e. the Limpopo Mobile Belt, the Soutpansberg Group and the Karoo Sequence rocks:

The Limpopo Mobile Belt (LMB); forms the gneissic basement on which the overlying strata (Soutpansberg Group and the Karoo Sequence) was deposited. The LMB rocks are the metamorphic expression of the collision and welding together of the Kaapvaal craton and the Zimbabwe craton. The LMB has a long and complex history of deformation occurring from 3200 Ma (million years) to 2000 Ma ago. The LMB gneisses are made up of inter-cratonic sediments and volcanics, deformed and metamorphosed to granulite facies and intruded by granite bodies which have themselves been metamorphosed to varying degrees. The rift fault systems controlling the various basins, in which the Soutpansberg and Karoo strata have been preserved, are major zones of crustal weakness preferentially re-activated during periods of tectonic instability over time.

The Soutpansberg Group strata were deposited into rift basins controlled by these major fault systems between 1900 Ma and 1600 Ma. The strata consist of basaltic lavas, arenites and shales attaining a maximum preserved thickness of 5000 m. Dips can vary from 20° to 80° to the north.

The Karoo Sequence strata were deposited on LMB basement and/or Soutpansberg Group strata between 300 – 180 Ma. Karoo deposits are preserved in rift basins and are often terminated against major east-west trending faults on their northern margins. The dips are between 3° and 20° to the north with coal located at the base of the sequence. The nature of the coal deposits changes from a multi-seam coal-mudstone association (7 seams) approximately 40m thick in the west (Mopane Coalfield), to two thick seams in the east (Pafuri Coalfield in the Tshikondeni area).

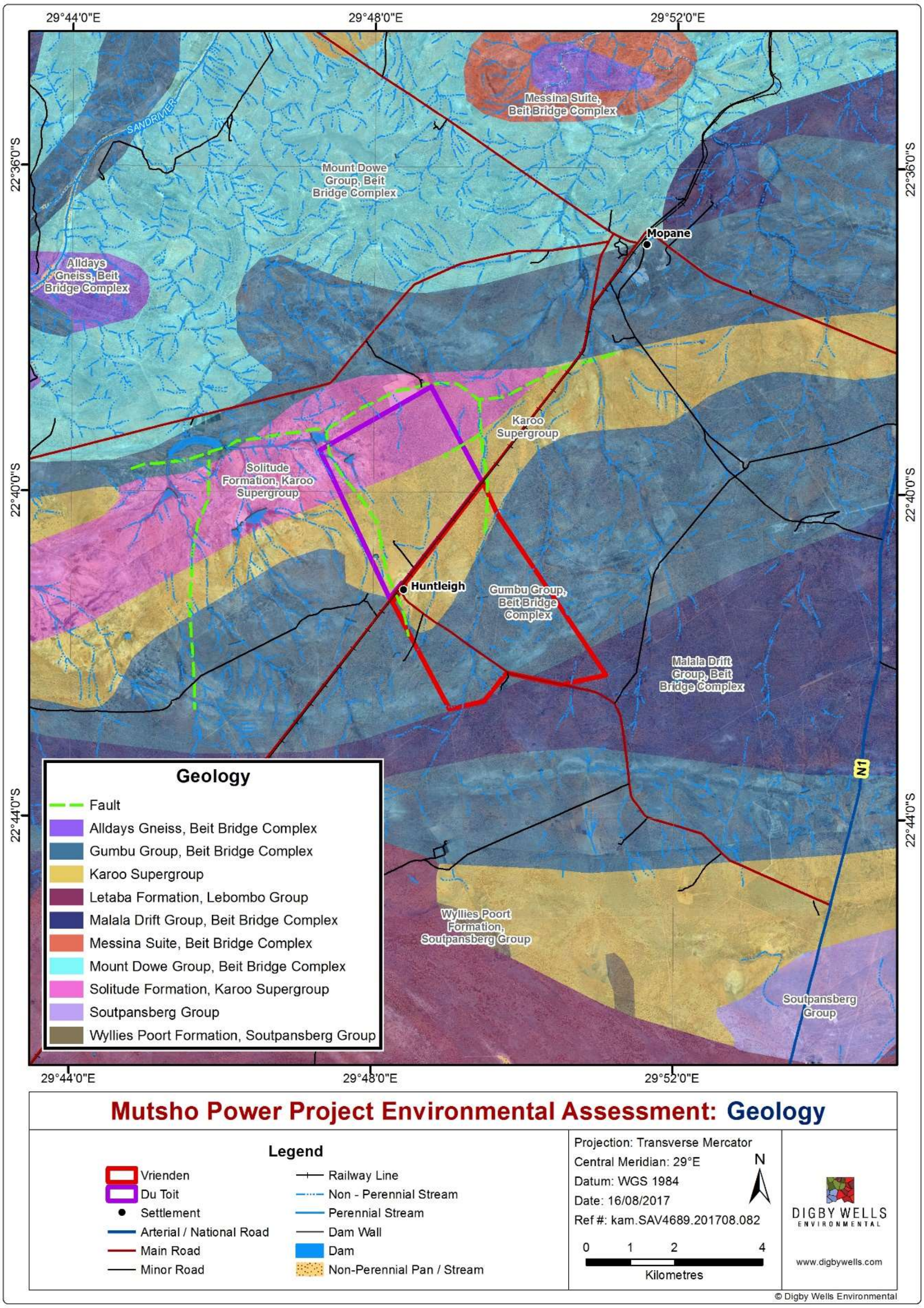


Figure 8: Regional Geology

4.3 Regional Vegetation

The project area falls within the Musina Mopane Bushveld vegetation type (Mucina and Rutherford, 2012), which is characterised by undulating plains ranging from open savanna to open woodland to moderately closed shrubveld, dominated by *Colophospermum mopane*. In areas with dense cover of *Colophospermum mopane* shrubs, the herbaceous layer is poorly developed. Musina Mopane Bushveld is considered 'Least threatened' but only 2% of it is statutorily conserved. Large areas have been converted tor cultivation. Erosion is considered to be high to moderate.

Table 16 list the species characteristic of the Musina Mopane Bushveld

Table 16: Plant Species Characteristic of the Musina Mopane Bushveld

Plant Form	Species
Tall trees	*Senegalia (Acacia) nigrescens, Adansonia digitata, Sclerocarya birrea subsp. caffra*
Small Trees	*Colophospermum mopane (d), Combretum apiculatum (d), Senegalia (Acacia) senegal var. leiorhachis, Vachallia (Acacia) tortilis subsp. heteracantha, Boscia albitrunca, B. foetida subsp. rehmanniana, Commiphora glandulosa, C. tenuipetiolata, C. viminea, Sterculia rogersii, Terminalia prunioides, T. sericea, Ximenia americana.*
Tall Shrubs	*Grewia flava (d), Sesamothamnus lugardii (d), Commiphora pyracanthoides, Gardenia volkensii, Grewia bicolor, Maerua parvifolia, Rhigozum zambesiacum, Tephrosia polystachya.*
Low Shrubs	*Acalypha indica, Aptosimum lineare, Barleria senensis, Dicoma tomentosa, Felicia clavipilosa subsp. transvaalensis, Gossypium herbaceum subsp. africanum, Hermannia glanduligera, Neuracanthus africanus, Pechuel-Loeschea leubnitziae, Ptycholobium contortum, Seddera suffruticosa.*
Succulent shrubs	*Hoodia currorii subsp. lugardii*
Herbaceous Climber	*Momordica balsamina*
Graminoids	*Schmidtia pappophoroides (d), Aristida adscensionis, A. congesta, Bothriochloa insculpta, Brachiaria deflexa, Cenchrus ciliaris, Digitaria eriantha subsp. eriantha, Enneapogon cenchroides, Eragrostis lehmanniana, E. pallens, Fingerhuthia africana, Heteropogon contortus, Sporobolus nitens, Stipagrostis hirtigluma subsp. patula, S. uniplumis, Tetrapogon tenellus, Urochloa mosambicensis.*
Herbs	*Acrotome inflata, Becium filamentosum, Harpagophytum procumbens subsp. transvaalense, Heliotropium steudneri, Hermbstaedtia odorata, Oxygonum delagoense*

Plant Form	Species
Succulent Herbs	*Stapelia gettliffei, S. kwebensis*

4.4 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) provide strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable use of water resources (Nel *et al.,* 2011). Demarcation of these areas is firmly rooted in the National Water Act (No. 36 of 1998) and the National Environmental Management Biodiversity Act (No. 10 of 2004). Conservation importance of the wetlands was based on their designated status as NFEPA wetlands (Nel *et al.,* 2011). Table 17 below indicates the criteria that were considered for the ranking of wetland areas.

The project area and its surrounds are characterised by a number of NFEPA wetlands as shown in Figure 9. Based on the NFEPA data the landscape is dominated by hillslope seep wetlands, followed by bench wetlands and to a very smaller extent channel valley bottom.

All the identified wetlands in the study area are rank 6. Rank 6 wetlands are all other wetlands that are identified as NFEPA wetland but do not fall within rank 1 to 5

Table 17: NFEPA Wetland Classification Ranking criteria

NFEPA Wetland Criteria	NFEPA Rank
Wetlands that intersect with a RAMSAR site.	1
Wetlands within 500 m of an IUCN threatened frog point locality; Wetlands within 500 m of a threatened water bird point locality; Wetlands (excluding dams) with the majority of their area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes; Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of exceptional Biodiversity importance, with valid reasons documented; and Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands that are good, intact examples from which to choose.	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of biodiversity importance, but with no valid reasons documented.	3

NFEPA Wetland Criteria	NFEPA Rank
Wetlands (excluding dams) in A or B condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion); and Wetlands in C condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion).	4
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing Impacted Working for Wetland sites.	5
Any other wetland (excluding dams).	6

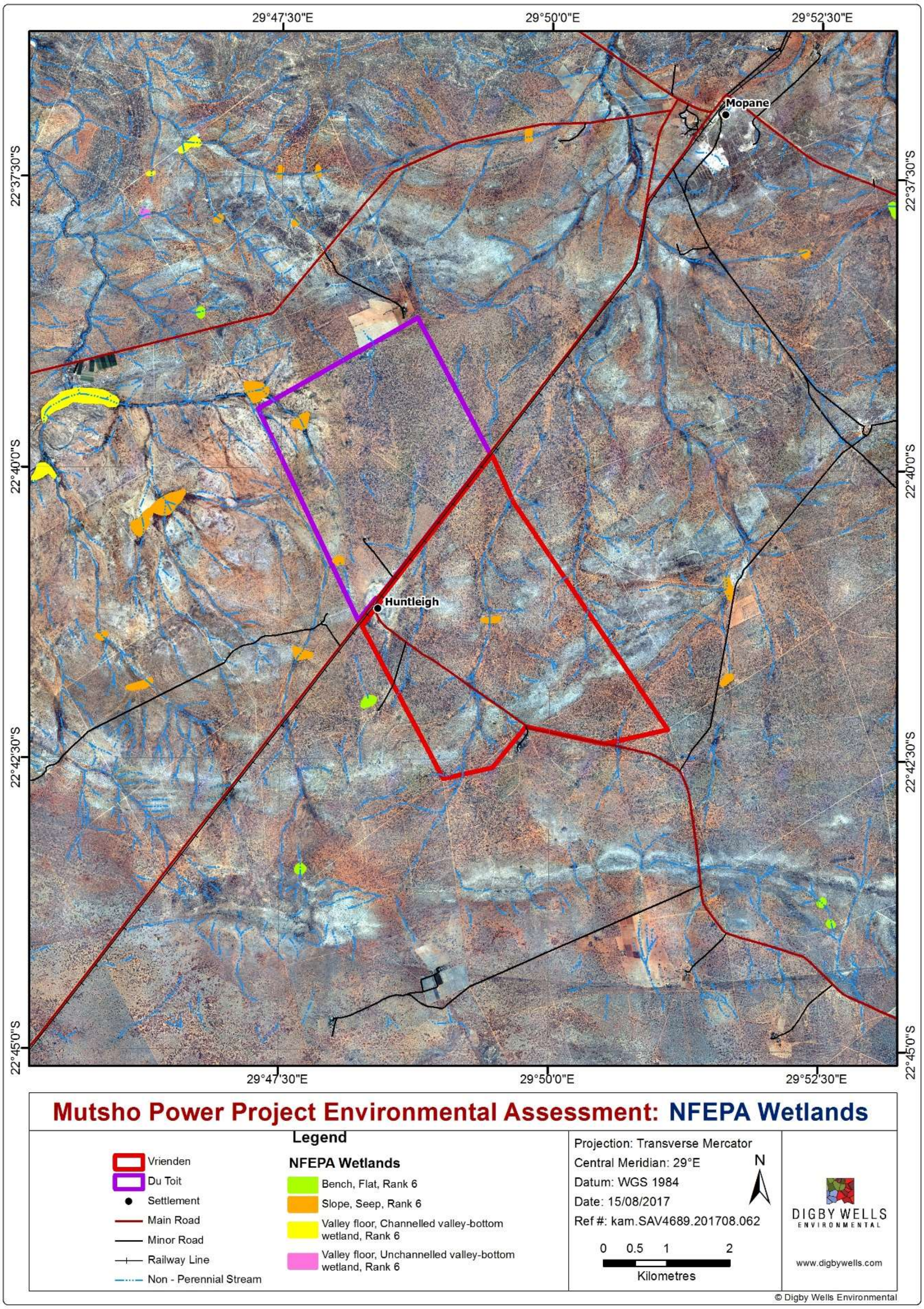


Figure 9: NFEPA Wetlands within Project Area

4.5 The Limpopo C-Plan

To facilitate and assist with managing and monitoring biodiversity the Limpopo Department of Economic Development, Environment & Tourism (LEDET) developed the Limpopo Conservation Plan Version 2 (2013), updated in 2012, and made available in 2013. This initiative was undertaken with the primary objectives of producing a revised conservation plan for Limpopo Province that conformed to the Bioregional Planning guidelines published by SANBI (South African National Biodiversity Institute) in 2009 (Limpopo CPlan V2, 2013).

The purpose of a conservation plan is to inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. Accompanying the map of the CBAs are land-use guidelines that are compatible or not with the biodiversity management objective of the CBA category. The CBAs are summarised below:

- Protected Areas: Formal Protected Areas and Protected Areas pending declaration under National Environmental Management; Protected Areas Act, 2003 (Act No. 57 of 2003) (NEMPA).
- Critical Biodiversity Area 1: Irreplaceable sites. Areas required to meet biodiversity pattern and/or ecological process targets. No alternative sites are available to meet targets.
- Critical Biodiversity Area 2: Best Design Selected sites. Areas selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets.
- Ecological Support Areas 1: Natural, near natural and degraded areas supporting CBAs by maintaining ecological processes.
- Ecological Support Areas 2: Areas with no natural habitat that are important for supporting ecological processes.
- Other Natural Areas: Natural and intact but not required to meet targets, or identified as CBA or ESA.

Table 18 lists the definitions of important biodiversity areas identified within the study site.

Table 18: Definitions of Important Biodiversity Areas for the Limpopo Conservation Plan

Category	Definition
Critical Biodiversity Areas (CBAs)	CBAs are the parts of the landscape we went to keep natural and are required for meeting the biodiversity targets for ecosystems, species or ecological processes as identified in a systematic biodiversity plan.
Ecological Support Areas (ESAs)	These area support the ecological functioning of the CBAs and/ or provide ecosystem services. ESAs need to stay functional to maintain the integrity of CBAs; however this doesn't necessarily mean that they need to maintained as natural. As a consequence, land use and management differs between CBAs and ESAs.

The project area is characterised by CBA 1 as shown in Figure 10. Both sites under investigation are located entirely in the sub-category CBA 1 which can be classified as intact natural areas supporting CBAs, however the southern boundary of the farm Vrienden is on sub-category CBA 2, which is classified as best design selected sites required to meet biodiversity targets.

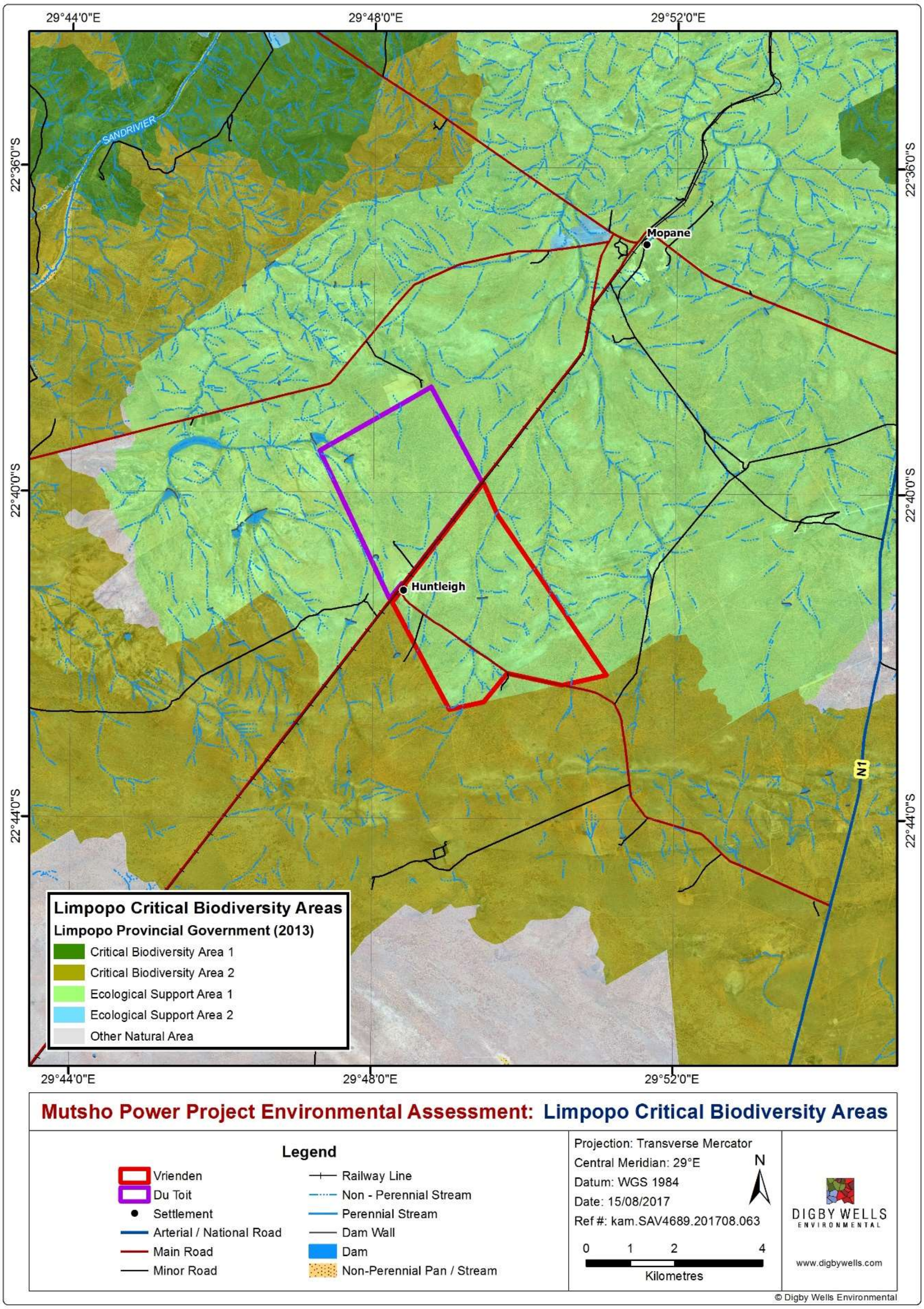


Figure 10: Important Biodiversity Areas within Project Areas

4.6 Surface Water Hydrology

South Africa is divided into 9 Water Management Areas (WMA) (Revised National Water Resource Strategy, 2012), managed by their own water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A to X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment; A2 for example will represent the secondary catchment; A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the Water Resources of South Africa, 2012 manual. Each of the quaternary catchments has associated hydrological parameters.

The project area is located in the A71K quaternary catchments of the Limpopo WMA as revised in the 2012 water management area boundary descriptions (government gazette No. 35517), this is shown in **Figure 11**. The surface water attributes of the affected quaternary catchment; namely Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) were obtained from the Water Resources of South Africa 2012 Study (WR2012) and are summarised in Table 19.

Table 19: Summary of the surface water attributes of the A71K quaternary catchment

Catchment	Area (km^2)	MAP (mm)	MAR $m^3 * 10^6$	MAE (mm)
A71K	1668	305	7.28	2000

The A71K quaternary catchments has a net area of 1 668 km^2 which receives an average of 305 mm of rainfall per annum with an average potential S-pan evaporation rate of 2 000 mm per annum.

Sand River is the only major river (ephemeral) within this quaternary catchment (approximately 8 km from the western side of the project area). The Sand River flows from the South-west side of the project area towards the north-east side where it eventually joins the Limpopo River approximately 50 km north from the project area.

Few drainage lines exist within the demarcated project area and runoff from this site drains from the southern side in a north western direction via these drainage line and finally reports to the Sand River approximately 8 km west of the project site.

The flow in the lower Sand River, its tributaries and minor streams is highly ephemeral. Run-off occurs after rainfall events, with flow in the main stem of longer duration after major, wide-spread rainfall in its catchment area (WSM Leshika, 2013).

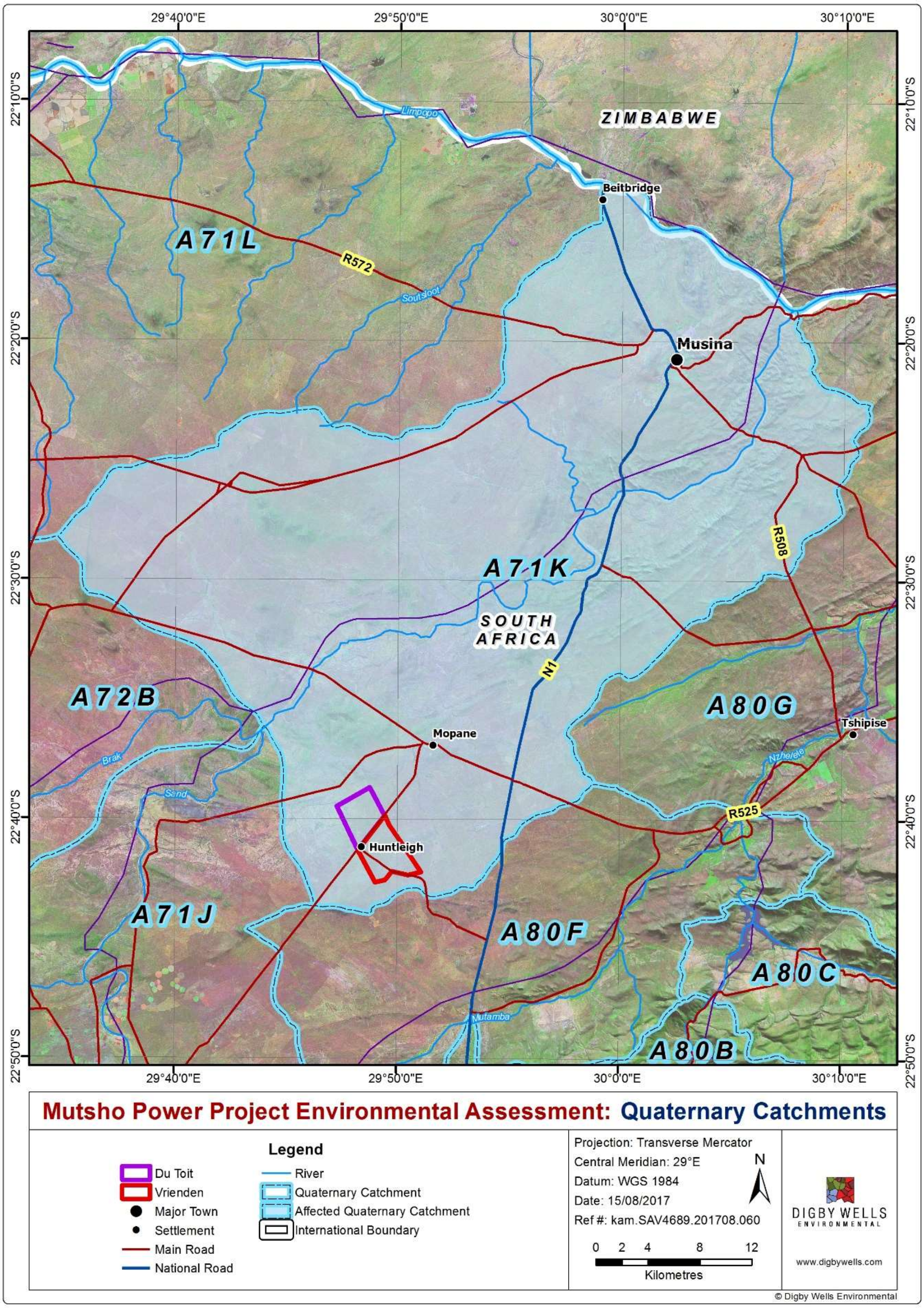


Figure 11: Hydrological Setting

4.7 State of the Sand River Catchment

The Sand (Polokwane River) River Catchment (SRC) is a major tributary of the Sabie River located in the north-eastern part of South Africa, spanning Limpopo and Mpumalanga Provinces (Pollard, 2008). The major tributaries of this river catchment are Brak, Hout, Dwars and Dorp rivers. This catchment spans an area of 1910 km² and is subdivided into 9 quaternary catchments (Smits et al., 2004). The source of the Sands River is located in the hills at the edge of Yserberg. It must be noted, however, that the majority of this catchment lies in the dry Lowveld, where the mean annual rainfall is only 500 mm/yr (Pollard and Walker, 2000).

This catchment is the driest catchment in the Limpopo WMA North with limited surface water resources. Despite this there is a high demand for water in this catchment compared to the rest of the WMA with agriculture (irrigation) being the largest user. Water requirements of this area include activities such as power generation; irrigated agriculture, forestry; mining, domestic use and industrial and residential developments. The major land-uses of this catchment include commercial forestry, dryland and irrigated agriculture, dense rural settlements, state and privately owned conservation areas and mineral resource extraction. The surface water resources in this catchment are heavily utilized and severely limited. Conversely to this, groundwater resources are being fully extracted and possibly over-exploited (DWA 2016).

4.8 Bioregional Context

The study area is located within the Zambezian Lowveld freshwater ecoregion, which represents an overlap region of tropical Zambezian and southern temperate faunas (Darwall et al., 2009). Although not necessarily within the study area, approximately 120 freshwater fish species are known to inhabit the waters of the Zambezian Lowveld ecoregion, of which 22 are endemic.

Dominant fish within the Zambezian Lowveld ecoregion include cichlids, cyprinids, gobies and mochokid catfishes, with many species found in fresh, brackish and saline waters, while several catadromous species also found in the ecoregion spend part of their life cycle in the freshwater coastal rivers and streams (e.g. several members of the Anguillidae family; Dallas, 2013). In addition, interesting endemics of the ecoregion include several rock catlets (Chiloglanis spp.) that live in rocky riffles and rapids, the Sibayi goby (Silhouettea sibayi) whose largest known population occurs in Lake Sibaya, and the brightly-coloured turquoise killifish (Nothobranchius furzeri) that is limited in distribution to the ephemeral pans of the Gonarezhou National Park in Zimbabwe (Skelton, 1994; cited in Dallas, 2013).

However, in light of the semi-arid nature of the area, it is suspected that many of these fish species are expected to be absent from the associated study area.

Table 20 provides a summary of the relevant location-specific environmental attributes associated with the study area, whilst a locality map and a map showing the surrounding water resources is shown in Figure 1 and Figure 2, respectively.

Table 20: Summary of site characteristics and attributes of the associated study area

Map Reference	2229DB
Political Region	Limpopo
Level 1 Ecoregion	1. Limpopo Plain
Level 2 Ecoregion	1.01
Freshwater Ecoregion	Southern Temperate Highveld
Geomorphic Province	Limpopo Flats
Vegetation Type	Musina Mopane Bushveld Limpopo Ridge Bushveld
Water Management Area	1. Limpopo
Secondary Catchment	A7

Quaternary Catchment	A71K
Watercourse	Sand River and adjoining tributaries
Slope Class	E – Lower Foothills Z - Unclassified
Seasonality	Perennial Ephemeral

4.9 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

1. Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
2. Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity within the context of equitable social and economic development. The second aim is comprised of two separate components: the *(i)* national component aimed to align DWA (or currently the DWS) and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems, while the *(ii)* sub-national component is aimed to use three case studies to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes. The project further aimed to maximize synergies and alignment with other national level initiatives, including the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation(Driver et al., 2011).

Based on current outputs of the NFEPA project (Nel et al., 2011; Figure 3), the sub-quaternary catchment associated with the proposed Mutsho Power Project was defined as a FEPA catchment, as a result of river ecosystem type. These catchments help to achieve national biodiversity targets, as the ecological condition of the associated systems are currently regarded as being in a good condition (A or B ecological category) and as such, these catchments and adjacent areas should be managed in a way that maintains their ecological condition, so as to conserve freshwater ecosystems and protect water resources for sustainable human use (Nel et al., 2011).

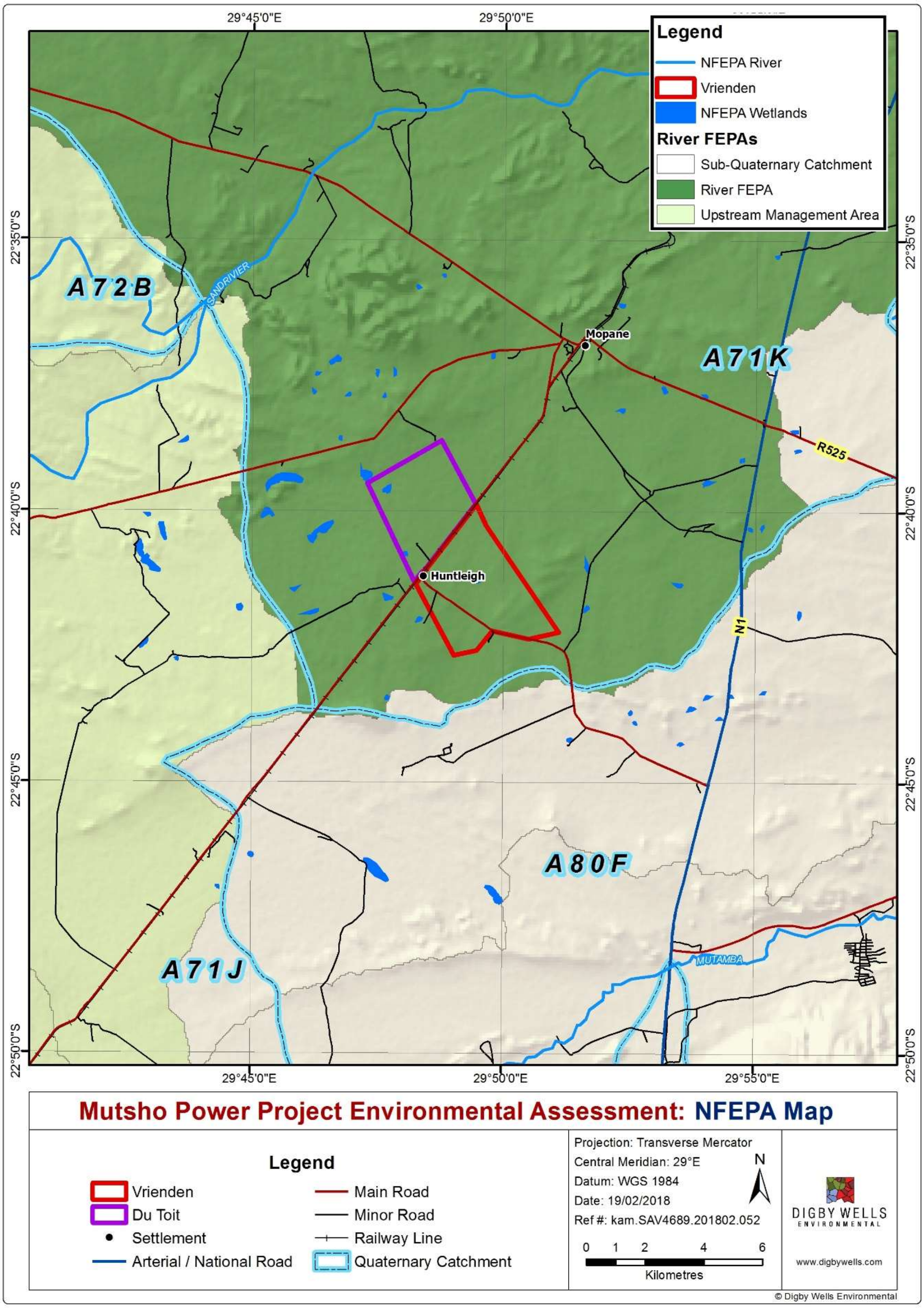


Figure 12: NFEPA classification of the associated catchment areas

4.10 Land and Water Uses

The predominant present land use in the wider area is agriculture with potential for mining, whilst the main use of surface water in the area is agricultural (irrigation) and possibly limited abstraction for mining activity.

The water requirements within the Sand catchment are large compared to the rest of the WMA, with irrigation comprising the largest water user. The majority of the irrigation sector's water requirements are met by the extraction of groundwater reserves via boreholes in the Sand / Limpopo Rivers which have been over-exploited. Although the urban requirements are high, a large portion of water is supplied through transfers from other WMAs (Savannah Environmental, March 2017).

5 SPECIALIST FINDINGS

5.1 Aquatics

5.1.1 Selection of Sampling Sites

In an effort to identify trends regarding the occurrence of species present within the watercourses associated with the study area, as well as provide a comparative basis for which future impacts can be evaluated, a number of sampling sites were strategically selected based on accessibility, availability of sampling habitat and relative proximity to associated potential impacts originating from the study area.

Co-ordinates of the sampling sites utilised during this investigation (Table 21) were determined using a Garmin global positioning device (GPS) and presented graphically in Figure 4. Photographs of the sites sampled are provided in Appendix A.

It should be noted that assessment of sampling sites identified on a national and provincial level for the River EcoStatus Monitoring Programme (REMP; previously the River Health Programme, or RHP) is a preferred approach, as suitable biotopes for application of standard biomonitoring approaches are available and the results obtained are most often directly comparable to previous studies. However, the upstream REMP (or RHP) Site A7SAND-JAGTK was observed to be dry at the time of the survey and as relatively far distance from the study area to add value, especially from a future monitoring perspective.

Table 21: Location and description of the selected sampling sites assessed

Site	Co-Ordinates	Description
Farm Vrienden 589		
VR1	22°41'53.55"S 29°49'18.32"E	Located along a southern unnamed ephemeral drainage line along a road dividing Farm Vrienden 589, which is on the southern boundary of the study area.
VR2	22°41'31.63"S 29°48'42.44"E	Located along a western unnamed ephemeral drainage line along a road dividing Farm Vrienden 589, which is on the southern boundary of the study area.
VR3	22°40'18.94"S 29°49'38.58"E	Located along a southern unnamed ephemeral drainage line along the northern boundary of the study area.
Farm Du Toit 563		
DU1	22°41'00.51"S 29°48'25.44"E	Small isolated impoundment located along the southern boundary of Farm Du Toit 563, which was

		likely to drain any excess road runoff.
Du2	22°40'53.36"S 29°48'32.48"E	Small impoundment along the southern boundary of Farm Du Toit 563, which collected upstream runoff conveyed by the ephemeral drainage line.
DU3	22°39'35.90"S 29°47'40.54"	Moderate impoundment in the north-western portion of the study area, which is expect to collect the majority of the rainfall runoff on the farm.
DU4	22°39'07.93"S 29°45'29.62"E	Located directly downstream of a large impoundment along the unnamed tributary of the Sand River, directly downstream of the farm road crossing.
Mainstem Sand River		
SR1	22°46'54.30"S 29°36'15.87"E	Located upstream of the study area along the mainstem Sand River, directly downstream of the bridge coming from the town of Mopane.
SR2	22°33'47.21"S 29°46'09.24"E	Located downstream of the study area along the mainstem Sand River, downstream of the town of Waterpoort and a historical REMP (or RHP) site.

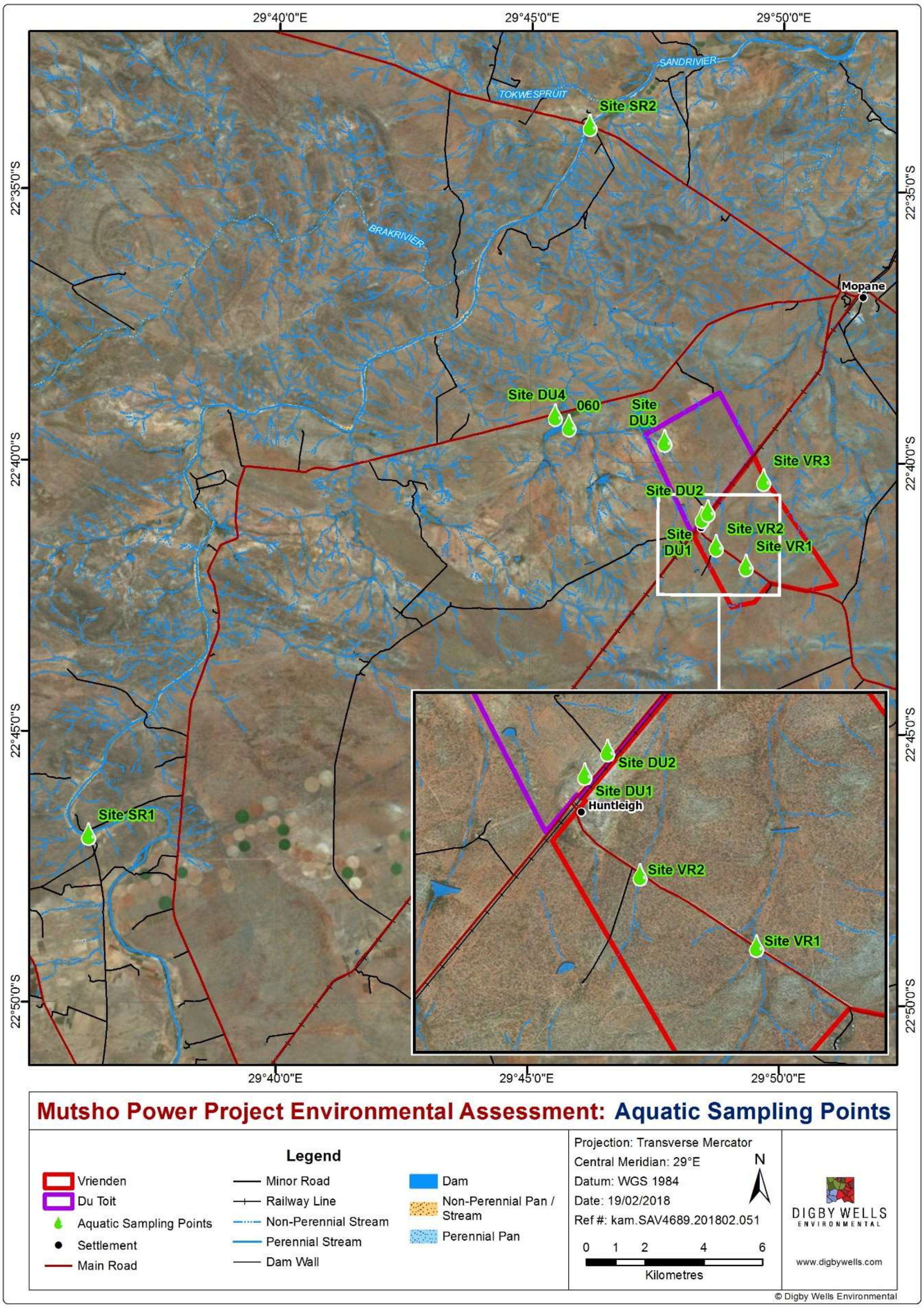


Figure 13: Selected aquatic sampling points assessed at the time of the survey

5.1.2 In Situ Water Quality

Due to the highly dynamic nature of lotic (or flowing) systems, water quality conditions have been known to vary substantially on a temporal scale (e.g. seasonality) and along the longitudinal profile of the watercourse (Dallas and Day, 2004). Despite these variations, the assessment of *in situ* water quality variables is important for the interpretation of results obtained during biological investigations, as aquatic organisms are influenced by the environment in which they live. Table 22 provides the *in situ* water quality data obtained at each site assessed during the February 2018 field survey.

Table 22: *In situ* water quality variables recorded at each of the sites assessed during the February 2018 field survey

Site	Time	Temp. (°C)	pH	Electrical Conductivity (µS/cm)	Dissolved oxygen	
					(mg/ℓ)	(% sat)
Farm Vriendin 589						
VR1	Site Dry					
VR2	Site Dry					
VR3	Site Dry					
Farm Du Toit 563						
DU1	Site Dry					
Du2	Site Dry					
DU3	14h15	31.0	7.24	24.8	4.64	83.3
DU4	Site Dry					
Mainstem Sand River						
SR1	Site Dry					
SR2	Site Dry					

With the exception of Site DU3, each of the selected sampling sites were observed to be dry at the time of the survey despite the rainfall expected throughout the summer months leading up to the survey. This was to be attributed to the semi-arid nature of the study area and further amplified by the drought experienced across much of the country during the previous two years. Consequently, only selected *in situ* parameters could be measured at the time of the survey.

Based on the *in situ* water quality variables recorded, each of the respective variables were deemed to be within expected ranges and as a result, these conditions were not expected to deter the colonisation and/or inhabitation of these watercourses by indigenous aquatic biota. However, in light of the low water levels within the impoundment at the time of the survey, it was suspected that the conditions observed were largely as a result of an improved 'dilution capacity,' which was attributed to the recent rainfall received approximately three days prior to the survey (i.e. 14 mm recorded within the catchment area).

It should also be noted that some water had also recently accumulated within the larger impoundment further upstream (i.e. directly upstream of Site DU4), which is shown in Figure 4 as GPS 060. However, this site was not assessed at the time of the survey, as it was suspected that the conditions would be largely comparable to Site DU3, as well as its location outside of the proposed development area and its lentic (or standing) nature.

5.1.3 Aquatic and Riparian Habitat

Assessment of aquatic habitat within the study area was based largely on the application of recognised assessment indices at each of the selected sampling points, as well as associated reach) within the assessed watercourses, namely the Index for Habitat Integrity (or IHI) and the Invertebrate Habitat Assessment System (or IHAS). While the IHI is a rapid, field-based, visual assessment of modifications to a number of pre-selected biophysical drivers (i.e. semi-quantitative) used to determine the Present Ecological State (PES, or Ecological Category) of associated instream and riparian habitats, the use of the IHAS presents an indication of the representativeness of "ideal" habitat availability for supporting diverse aquatic macroinvertebrates at each of the assessed sites.

5.1.3.1 Index for Habitat Integrity

In light of the predominant presence of highly dynamic, ill-defined, temporary (or ephemeral) drainage lines through the proposed development area and small-to-moderate earthen impoundments, these systems were not deemed to be suitable for the application of the IHI at the time of the current survey. Nonetheless, a low confidence assessment was undertaken along the associated portion of the mainstem Sand River, as access to the river was very limited by extensive fence lines within the study area and difficulty in contacting the relevant stakeholders at the time of the survey.

For the purposes of the present study, the habitat assessment unit was referred to as the portion of the mainstem Sand River between the town of Waterpoort and the downstream site SR2. The perceived ecological condition of the instream and riparian habitat is described in Table 23.

Table 23: Index for Habitat Integrity (IHI) values obtained for associated reach

<table>
<tr><th>Reach</th><th>Component</th><th>IHI (%)</th><th>Ecological Category</th><th>Major Impacts</th></tr>
<tr><td rowspan="2">Sand River</td><td>Instream Habitat</td><td colspan="2">Site Dry</td><td rowspan="2">- Water abstraction was flagged as a large impact due to weirs and/or irrigation schemes (i.e. pivot arms) in close proximity to the river.
- Moderate overgrazing and/or trampling by livestock and wild game within isolated areas was believed to facilitate erosive processes within these soils.</td></tr>
<tr><td>Riparian Habitat</td><td>73.1</td><td>C</td></tr>
</table>

Typical habitat of the Sand River within the A71K-00031 SQR was confirmed to be dominated by sandy substrates within a wide seasonal channel (mostly alluvial) with anastomosing sections, pools and shallow areas. While the instream habitat conditions along the main-stem Sand River was not determined due to its dry state at the time of the survey, the riparian component was determined to represent moderately modified conditions (Ecological Category C; Table 12). Only the water abstraction metric was tentatively scored at a largely modified component due to the notable concentration of agricultural croplands within the upper reaches of the associated portion of the watercourse, which was only expected to amplify the highly dynamic nature of this alluvial system. Also, the presence of livestock and wild game was believed to have facilitated the erosive processes along the banks of the river due to overgrazing and trampling during periods of flow, as these animals are expected to use the river as a watering point wherever possible.

5.1.3.2 <u>Invertebrate Habitat Assessment System</u>

The Invertebrate Habitat Assessment System (IHAS, Version 2.2), developed by McMillan (1998), has routinely been used in conjunction with the SASS approach as a measure of variability in the quantity and quality of representative aquatic macroinvertebrate biotopes available during sampling. However, according to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores at assessed sampling sites, as its performance appears to vary between geomorphologic zones and biotope groups (Ollis et al., 2006). While no final conclusion can be made regarding the accuracy of the index until further testing has been conducted, these potential limitations and/or shortfalls should be noted.

Unfortunately, the IHAS could not be applied at the time of the current survey, as it is restricted for application within flowing systems and therefore, it was not deemed to be appropriate at Site DU3, which was classified as a lentic (or standing) system.

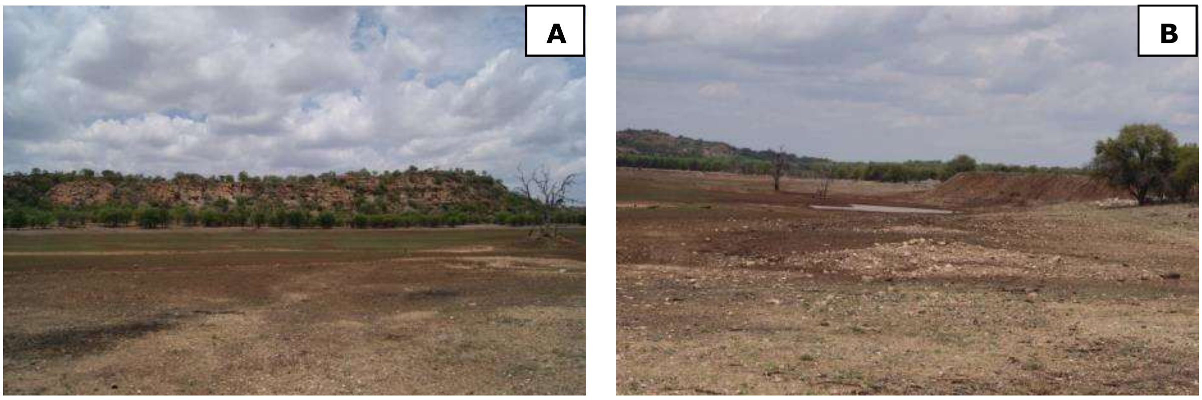


Figure 14: Unnamed tributary of the Sand River observed to be dry at the inlet **(A)** and the dam wall **(B)** of the large impoundment situated directly upstream of Site DU4 following recent rainfall received three days earlier

In light of the semi-arid nature of the associated catchment area, as well as the limited surrounding basal vegetation cover, any rainfall received within the study area was expected to quickly drain the surrounding area and rapidly re-inundate (or 'flush') the adjoining drainage lines and/or tributaries of the Sand River (Figure 6). However, given the alluvial nature of these systems, the smaller systems would quickly infiltrate into the water table below the surface of these systems. These highly dynamic conditions were likely to limit the continued establishment of sensitive aquatic biota within the study area. Consequently, it can be concluded that the representativeness of the biological composition along these systems would be directly related to the inundation period and the re-colonisation strategy of established taxa, which in principle is believed to take approximately 4-6 weeks within permanent systems (Rossouw et al., 2005).

5.1.4 Aquatic Macroinvertebrates

Due to the differential sensitivities of aquatic macroinvertebrates, the composition of the aquatic macroinvertebrate community can provide an indication of changes in water quality and other ecological conditions within a watercourse. The use of the SASS has undergone numerous advances, culminating in Version 5 presently being utilised in river health studies along with the application of the MIRAI. However, it should be noted that the application of the SASS5 and MIRAI indices within non-perennial/intermittent rivers and/or impoundments should be interpreted with caution, as these assessment indices were primarily designed to be used exclusively within lotic (or flowing) systems. Nevertheless, for the purpose of standardising the monitoring approach, the SASS method was deemed to be sufficient for assessing changes to the number of aquatic macroinvertebrates families inhabiting the associated impoundments only.

Non-perennial rivers are ecosystems that place extreme stress on the organisms inhabiting them by exhibiting highly variable physical and chemical attributes, of which the most obvious is the unpredictable and highly variable flow patterns of the watercourses themselves (Rossouw et al., 2005). Consequently, only biota with specific coping mechanisms and/or a wide tolerance of water quality impairment can survive in these systems, particularly when critical phases of their lifecycles occur at a time when spates and droughts are probable. The ability to rapidly recolonise a dry system once re-inundation has occurred is one such mechanism that many macroinvertebrate taxa have developed to help to ensure survival. These specialised strategies vary widely between families, but the three main sources of re-colonisation originate from previously laid resting eggs, invertebrate forms capable of aestivation, and eggs laid by flying adults immediately after re-inundation (Harrison, 1966). However, in systems with constructed dams or weirs, sections of this system remain inundated for extended periods (i.e. Site DU3) and as a result, these systems often serve as refugia for previously established aquatic biota during the dry season and facilitate a more efficient re-colonisation process.

Studies on the re-colonisation of non-perennial watercourses by aquatic macroinvertebrates families are few, but it appears that Chironomidae (Midges), Oligochaeta (Earthworms) and Simulidae (Black Flies; only in true-running streams) are some of the early colonizers (Rossouw *et al.*, 2005). This was supported by observation in a study by Harrison (1966), as other early-colonisers (i.e. within the first ten days) were also noted to be oligochaetes, small crustaceans and small insect larvae. However, it should be noted that species typical of permanent streams only returned within one month of re-inundation in lentic (or standing) pools and within 4-6 weeks in lotic (or flowing) streams (Rossouw *et al.*, 2005).

5.1.4.1 Benthic Community

Of the 34 different macroinvertebrate taxa highly likely to occur within the study area (Department of Water and Sanitation, 2014), only a total of seven families were collected at Site DU3, which were further noted to be dominated by six air-breathing taxa (shown in **Bold** in Table 24). This was largely typical of lentic (or standing) systems, which was a direct result of a lack of hydraulic diversity and varied surface substrates for colonisation (e.g. cobbles, bedrock, etc.)

Table 24: Expected aquatic macroinvertebrate taxa in the Sand River

Family Names		
Turbellaria	**Corixidae**	**Hydrophilidae**
Oligochaeta	Gerridae	Ceratopogonidae
Hirudinea	Hydrometridae	Chironomidae
Potamonautidae	Naucoridae	Culicidae
Atyidae	Nepidae	Muscidae
Baetidae	**Notonectidae**	Tabanidae
Caenidae	Pleidae	Tipulidae
Ceonagrionidae	Veliidae	Ancylidae
Aeshnidae	Hydropsychidae	Lymnaeidae

Family Names		
Gomphidae	Leptoceridae	**Physidae**
Libellulidae	**Dytiscidae**	
Belostomatidae	**Gyrinidae**	

In addition to these tolerant, air-breathing, early-colonising macroinvertebrates families observed at the time of the survey, various branchiopod crustacean families were also observed to be present at the time of the survey. These organisms have developed life strategies and unique adaptations that allow them to cope with harsh environments (i.e. regular desiccation) and as a result, their opportunistic life cycle allows them to use the short inundation periods to their maximum benefit, as these groups hatch, grow to sexual maturity and reproduce within an extremely short period of time (Ferreira et al., 2011). Consequently, it was an opportune occasion to collect and observe these groups, of which included large numbers of Anostraca (Fairy Shrimps) and Conchostraca (Clam Shrimps) and as a result, a greater level of biodiversity was shown to be supported within the egg banks contained within the sediment of the assessed impoundment.

5.1.4.2 Present Ecological State

Due to the dry conditions observed at the time of the survey and the inappropriate application of SASS within the assessed impoundment, no Present Ecological State could be determined, as the MIRAI is exclusively for application within flowing systems.

5.1.5 Ichthyofauna

Of the 18 different macroinvertebrate taxa are expected to occur within the study area (Department of Water and Sanitation, 2014). No fish were collected at the time of the field survey (Table 25).

Table 25: Expected fish species in the Sand River

Fish Species	Common Name	Conservation Status (Darwall et al., 2009)
Enteromius mattozi	Papermouth	Least Concern
Enteromius paludinosus	Straightfin Barb	Least Concern
Enteromius toppini	East Coast Barb	Least Concern
Enteromius trimaculatus	Threespot barb	Least Concern
Enteromius unitaeniatus	Longbeard Barb	Least Concern
Enteromius viviparus	Bowstripe Barb	Least Concern
Clarias gariepinus	African Catfish	Least Concern
Chiloglanis paratus	Sawfin Suckermouth	Least Concern

Fish Species	Common Name	Conservation Status (Darwall et al., 2009)
Labeo cylindricus	Redeye Labeo	Least Concern
Labeo molybdinus	Leaden Labeo	Least Concern
Labeo rosae	Rednose Labeo	Least Concern
Labeo ruddi	Silver Labeo	Least Concern
Labeobarbus marequensis	Lowveld largescale Yellowfish	Least Concern
Micralestes acutidens	Sharptooth Tetra	Least Concern
Mesobola brevianalis	River Sardine	Least Concern
Oreochromis mossambicus	Mozambique Tilapia	Near Threatened
Pseudocrenilabrus philander	Southern Mouthbrooder	N/A
Schilbe intermedius	Butter Catfish	Least Concern

While it is envisaged the a notable number of the aforementioned fish species will be present during periods of elevated flows and sufficient habitat cover, it is suspected that all remaining fish species present within the system have most likely migrated further downstream (where possible) to find refuge within isolated pools and/or inundated impoundments, or alternatively have died due to a lack of available habitat. Following cursory discussions with the residents within the area, this was supported by the fact that the only other rainfall received within the area within the past 6-9 months occurred in November 2017 (approx. 82 mm within the catchment area).

5.1.5.1 Present Ecological State

In light of the dry conditions of the associated watercourses, the application of the FRAI was not deemed to be necessary and as such, no Present Ecological State could be determined.

5.1.6 Integrated EcoStatus Determination

The EcoStatus is defined as: *The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services"* (Iversen et al., 2000). In essence, the EcoStatus represents an integrated ecological state representing the drivers (hydrology, geomorphology, physico-chemical) and responses (fish, aquatic invertebrates and riparian vegetation; Kleynhans & Louw, 2008).

Since no PES was determined for each of the biological components at the time of the survey, no Instream Biological Integrity could be determined within the EcoStatus Model and no integrated EcoStatus could be determined. Nonetheless, it should be noted that the conditions observed at the time of the survey were deemed to be normal for the region and as such, the biological communities are expected to quickly re-inhabit the associated watercourses following the establishment of favourable conditions.

For the purpose of determining a PES at the time of the survey, the only available desktop data indicates that the mainstem Sand River is representative of a moderately modified condition (i.e. Ecological Category C). This was largely attributed to the small- to large- impacts originating from surrounding land-use activities, including the most notable agricultural activities (i.e. crop cultivation and livestock watering).

5.1.7 Ecological Importance and Ecological Sensitivity

Essentially, the ecological importance of a particular riverine reach is assessed to obtain an indication of its representativeness (or rarity) of any inherent biophysical attributes (e.g. unique systems, rare species, etc.) in relation to a larger framework, while an assessment of the corresponding ecological sensitivity provides an indication of the vulnerability of a system to environmental modification (e.g. flow, physico-chemical and geomorphic modifications) within the context of the Present Ecological State (PES, or Ecological Category). In terms of a regional scale, this would relate to the ability of the sub-quaternary reach to endure, resist and recover from various forms of anthropogenic utilisation (Department of Water and Sanitation, 2014).

Although conducted at a desktop level, the assessment of ecological importance and sensitivity by Department of Water and Sanitation (2014) for the associated reach of the Sand River (Sub-Quaternary Reach A71K-00031) provided a catchment level perspective and context for professional judgement (or expert opinion). Only limited site-based information collected during the present study (i.e. riparian condition) was used to supplement the desktop approach to provide a more accurate depiction of the specified watercourse under study (Table 26).

Table 26: Ecological Importance and Sensitivity for the Sand River and adjoining tributaries

Site	Ecological Importance	Ecological Sensitivity
Sand River	**High** ▪ *Oreochromis mossambicus* (listed as Near Threatened) exhibited a moderate -to-high likelihood of occurrence during periods of improved flow. ▪ Representivity and rarity within the secondary catchment was defined to be *moderate-to-high* for each of the expected biota. ▪ Sub-quaternary catchment was identified as *Freshwater Ecosystem Priority Area* and classified as a provincially determined *Ecological Support Area 1* and/or *Critical Biodiversity Area 2*.	**Moderate-to-High** ▪ A number of *highly* sensitive flow-dependent species were expected to occur within the associated reach during periods of elevated flows. ▪ A number of species that were regarded as *moderate-to-highly* sensitive to water quality impairment were expected to occur during periods of elevated flows. ▪ Riparian vegetation are well adapted to the fluctuating water levels within the river, which implied that riparian component is regarded to exhibit a *low* sensitivity.

Consequently, the Ecological Importance was defined to be high and the Ecological Sensitivity determined to be moderate-to-high during periods of elevated flow. This emphasizes the biodiversity values of the associated watercourses within the study area, especially during periods outside of drought conditions.

5.2 Wetlands

5.2.1 Wetland delineation and classification

The background information available from national and provincial databases indicates that the wetland and other freshwater features of the local area are relatively sensitive and ecologically important. Based on the findings of the field assessment it is evident that the wetlands and freshwater features within project area consist mostly of ephemeral drainage lines that cannot be defined as wetland or riparian resources. Fewer larger linear features that convey sufficient water to be defined as true watercourses with an associated riparian zone are located to the north of the proposed project area. Two pans and a number of earth dams were also identified within the project area.

These fresh water features cover an approximate 147.5 ha.

The breakdown of the wetland types per area is detailed in Table 27 and illustrated in Figure 15.

Table 27: Wetland HGM Units

HGM Unit	HGM Unit Type	Area (ha)
1	Pan	0.68
2	Pan	0.41
3	Ephemeral drainage lines	146.41

The buffer zones relating to the wetlands are illustrated in Figure 16. Zones of Regulation of 32m around each wetland have been assigned according to NEMA (Act No. 107 of 1998).

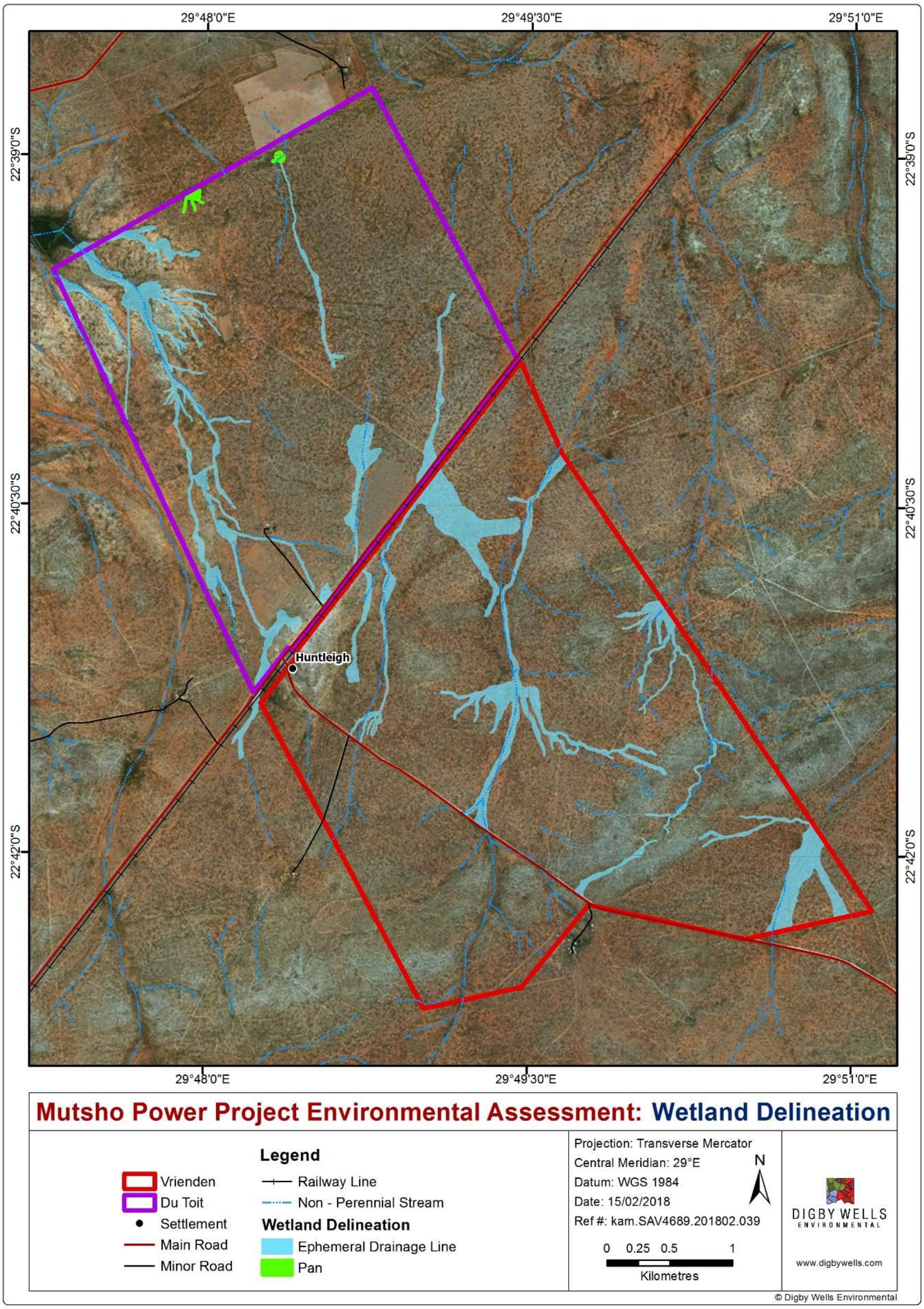


Figure 15: Wetland Delineation

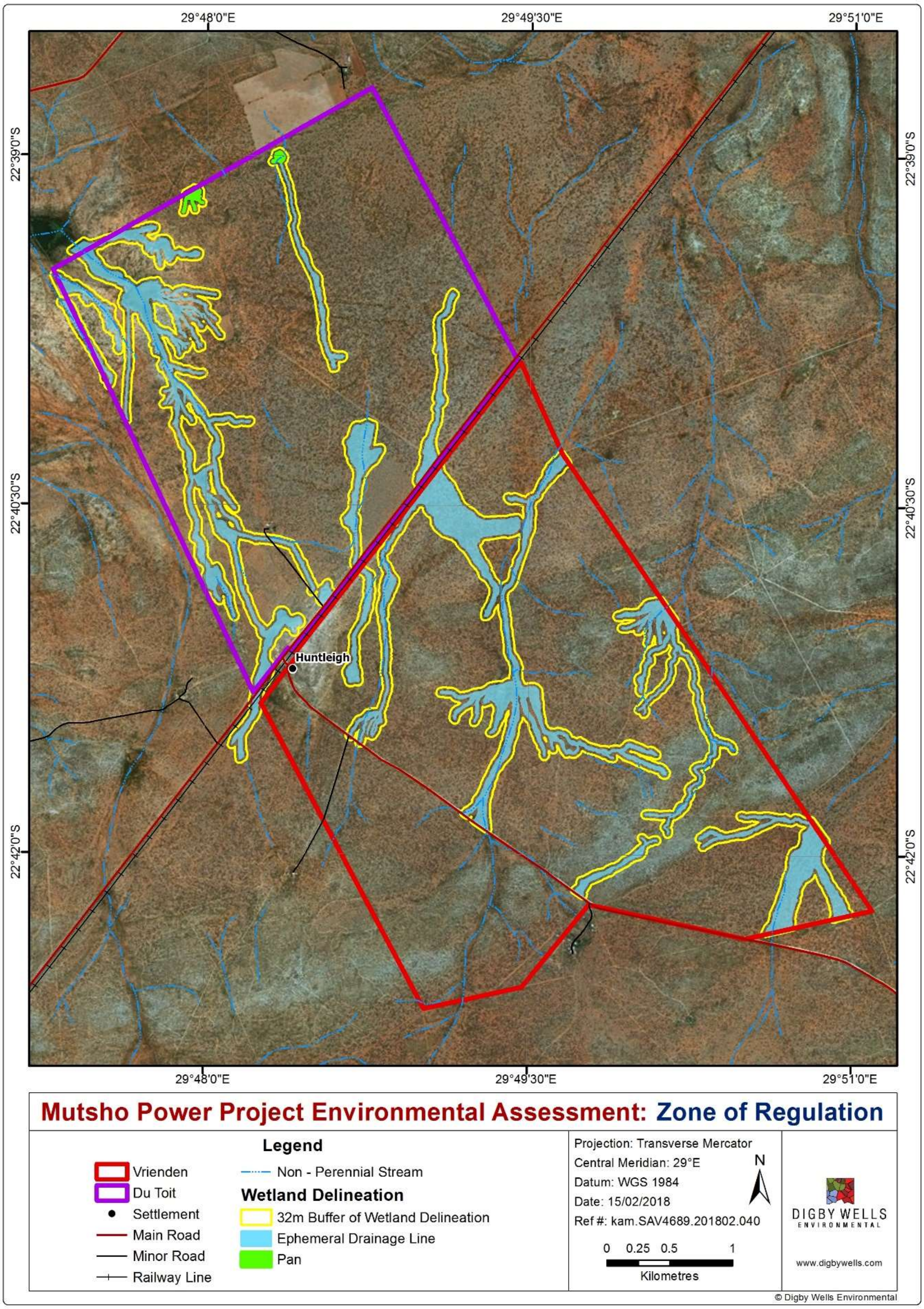


Figure 16: Zones of Regulation

5.2.1.1 HGM Unit 1 (Pan)

This pan is situated on the North West border of the farm Du Toit 563. The pan covers an area of 0.68 ha and is characterised by a large expanse of bare patches of sandy soil. *Panicum maximum* colonises the edges with trees such as *Colophospermum mopane* and *Combretum imberbe* (protected) on the edges. Various drainage lines supply the pan with water and sandy alluvial deposits can be seen where the drainage lines enter the pan. See Figure 17 for a visual representation of the wetland habitat of HGM unit 1. Very few impacts were identified at this pan, and overgrazing by herbivores was not observed. Additionally, no alien and invasive plants (AIPs) were noted.

Figure 17: HGM Unit 1

5.2.1.2 HGM Unit 2 (Pan)

This wetland is situated on the North West border of the farm Du Toit 563, to the East of HGM unit 1. The pan covers an area of 0.41 ha and is also characterised by an expanse of bare patches of sandy soil. *Panicum maximum* colonises the edges with trees such as *Acacia erubescens*, *Combretum imberbe* (protected) and *Colophospermum mopane*. See Figure 18 for a visual representation of the wetland habitat of HGM unit 2.

Figure 18: HGM Unit 2

5.2.1.3 Ephemeral Drainage Lines

The ephemeral drainage lines (146.41 ha) are characterised by sandy beds and thicker and taller vegetation on the edges than in the surrounds with *Colophospermum mopane* being the dominant species. Impacts to these drainage lines include:

- Preferential flowpaths have been created where vegetation has been cleared for roads;
- Some erosion and fragmentation is observable due to the creation of roads across and along the drainage lines;
- The damming of the drainage lines for water storage purposes has impacted on the wetland integrity of the site (many earthen dams were observed).

See Figure 19 for a visual representation of the drainage lines observed.

Figure 19: HGM Unit 3 (Drainage Lines)

5.2.2 Present Ecological State (PES)

Table 28 indicates the PES scores for the various HGM Units observed.

The wetlands within the Project area exhibit Category B (*Largely Natural*) and Category C (*Moderately Modified*) PES values (Table 28).

The pans have not been impacted on to a great extent aside from grazing which alters the vegetation structure and composition. The geomorphological and Hydrological health has been altered minimally. The pans therefore both exhibit Category B values.

The ephemeral drainage lines are considered to be Category C. They are mostly impacted on hydrologically due to the presence of earthen dams, which restrict the flow of water downstream. The geomorphological score was not impacted on greatly as the only impact was sediment deposition in the dams. Vegetation scores were not altered to a great extent.

Table 28: Present Ecological Health Scores

HGM Unit	Hydrological Health Score	Geomorphological Health Score	Vegetation Health Score	Final Ecological Health Score	PES Score
1	0	0.2	4	1.2	B
2	0	0	6.5	1.9	B
*3	6.5	0.2	3.3	3.8	C

*method is not intended for drainage lines, however it was applied as an indicator of functionality

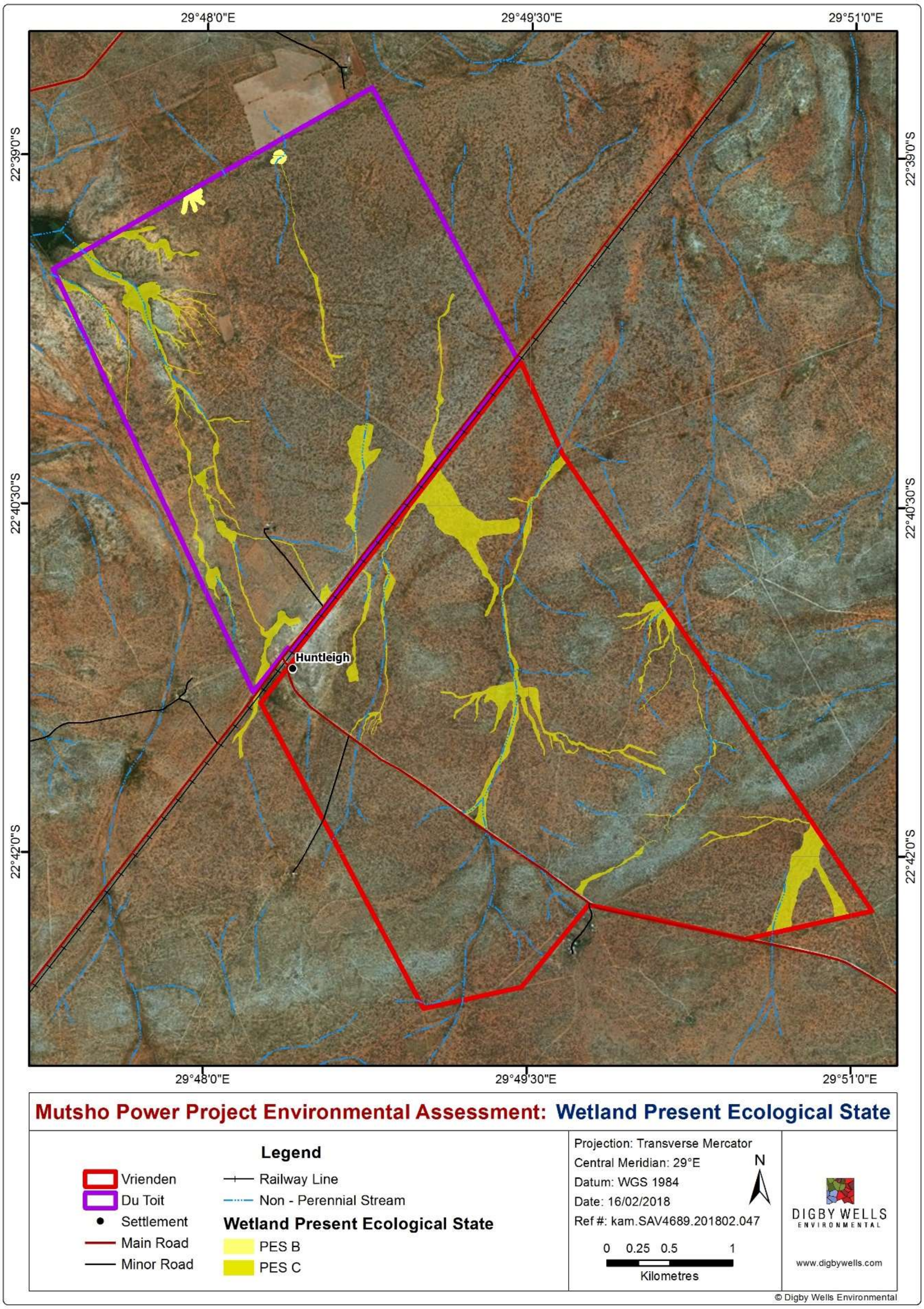


Figure 20: Present Ecological State

5.2.3 Ecological Importance and Sensitivity

Table 29 indicates the EIS scores for the various HGM Units with the final EIS scores ranging from Very High (3.7) to High (2.5).

Hydrological/Functional Importance' values were low as the pans don't perform well for streamflow regulation, erosion control, sediment trapping or phosphate assimilation. The drainage lines also have limited hydrological function in terms of true wetland systems. However, in terms of catchment yield and surface water recharge to the systems further downstream, as well is in the maintenance of healthy stormwater regulation, these systems are considered invaluable.

'Ecological Importance & Sensitivity' for the HGM unit 2 and 3 is *Very High* as various protected species are present within them or in close proximity.

'Direct Human Benefits' were not high in general. These features are not used culturally or recreationally. The HGM units are utilised for grazing and for watering of cattle and game. The score is higher for the drainage lines as some are dammed and the water is utilised by the farm owners.

Table 29: EIS Scores

HGM Unit	Ecological Importance & Sensitivity	Hydrological/Functional Importance	Direct Human Benefits	Final EIS Score	Final EIS Category
1	2.3	0.5	1	2.3	B
2	3.3	0.6	1	3.3	A
3*	3.7	0.4	1.3	3.7	A

*method is not intended for drainage lines, however it was applied as an indicator of functionality

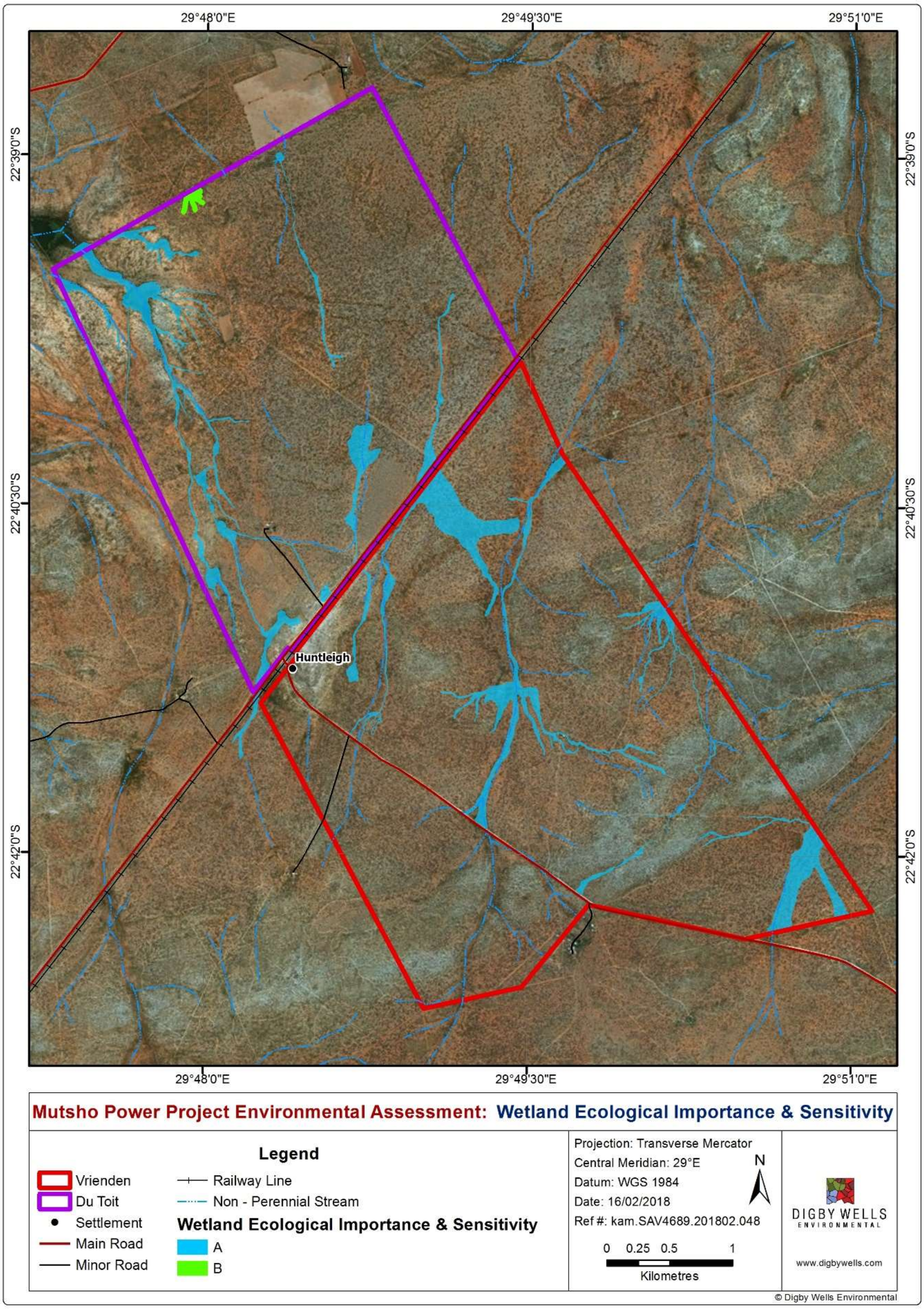


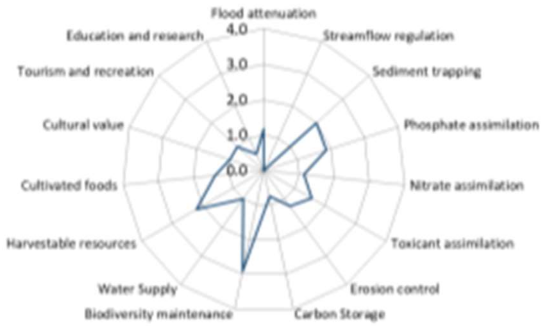
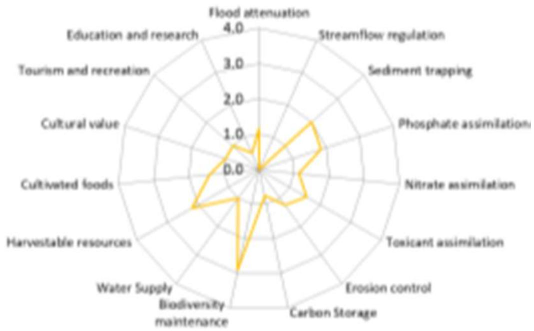
Figure 21: Ecological Importance and Sensitivity

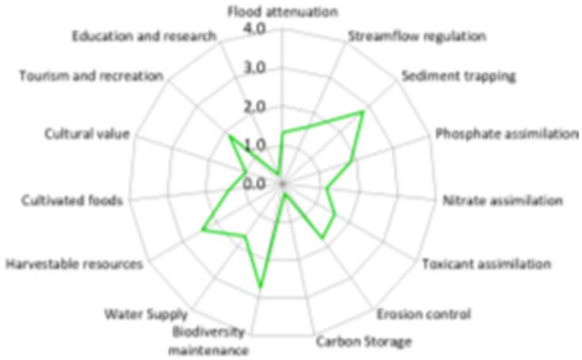
5.2.4 EcoServices

Table 30 indicates the EcoServices scores for the various HGM Units with the final scores ranging from 1.3 to 1.6 (Intermediate).

The HGM units provide similar EcoServices. Biodiversity maintenance through the harbouring of protected species, the provision of water sources and the provision of grazing land are important EcoServices. The drainage lines provide surface water recharge and trap sediment. The farms are not accessible for tourism, educational and cultural purposes and as such are not used for these purposes. Historical hunting activities were evident, however, through communication with ground staff, this is no longer common. Due to the nature of the systems, flood attenuation and streamflow regulation is low.

Table 30: EcoServices Scores

HGM Unit	Final EcoServices Score	Final EcoServices Category
1	1.3	
2	1.3	

HGM Unit	Final EcoServices Score	Final EcoServices Category
*3	1.6	

*method is not intended for drainage lines, however it was applied as an indicator of functionality

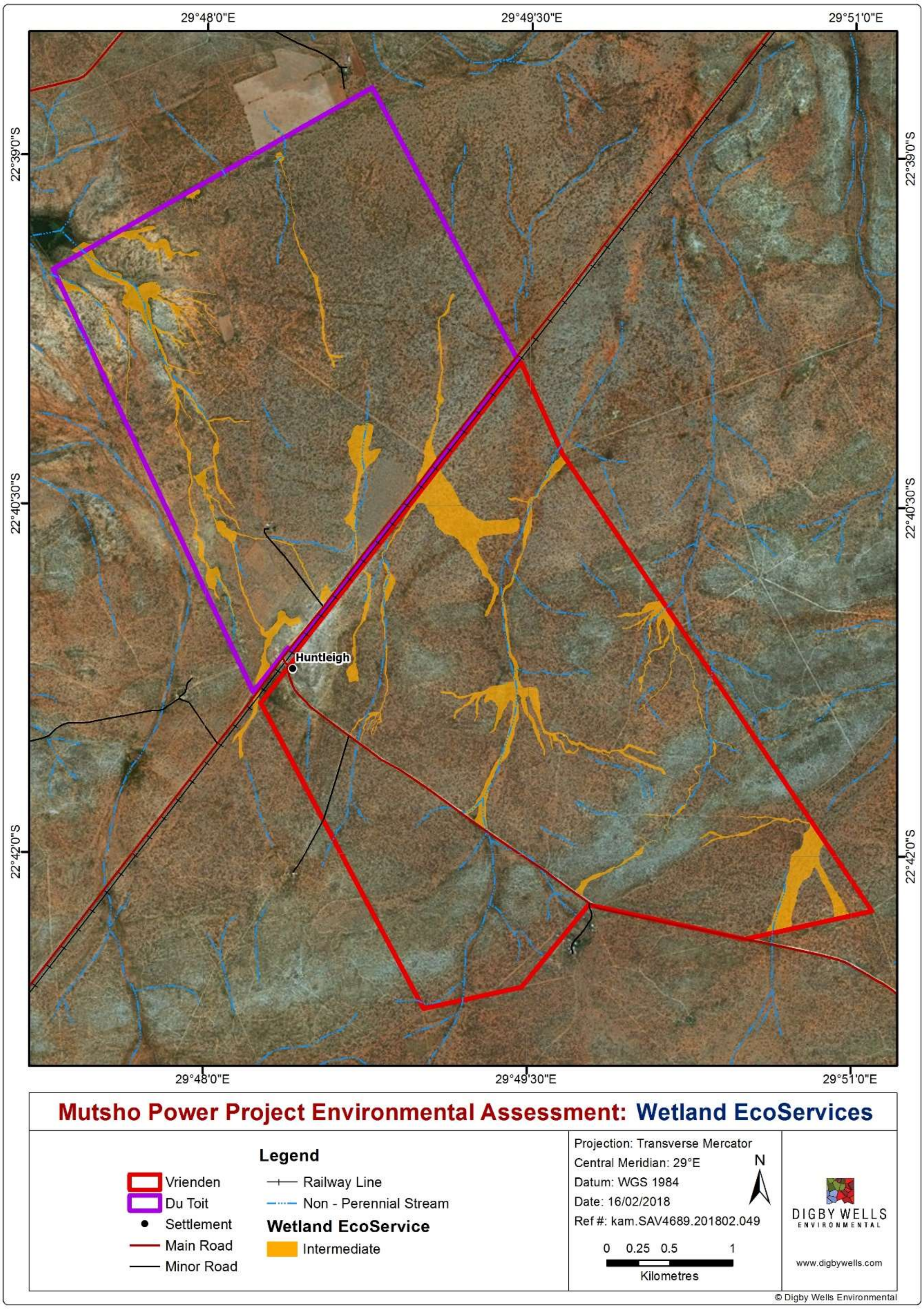


Figure 22: EcoServices

5.3 Groundwater

5.3.1 Regional Hydrogeology

Regional groundwater flow is oriented northwest towards the Sand River. Flow volumes are extremely low due to the low permeability and low recharge, especially in the northern half of the catchment underlain by the Limpopo Mobile Belt and overlain by alluvium (Figure 23).

In the south, where the catchment is underlain by Karoo and Soutpansberg rocks, a local northward hydraulic gradient is present due to high recharge in the Soutpansberg Mountains with the groundwater following the topography down towards the Limpopo River in the north.

A significant cone of depression exists around the Sand River directly north of the Soutpansberg Mountains due to the large scale irrigation from groundwater.

Under natural conditions, groundwater drains via localised springs, as baseflow to the perennial tributaries flowing from the Soutpansberg, and by evapotranspiration by riverine vegetation along the main river channels.

Groundwater is of good quality in the Soutpansberg rocks, which is the main recharge zone; however, increased salinity occurs northwards as groundwater flows through saline Karoo sediments, accumulating salts which mostly characterises the water facies as Na/Cl/Mg-Bicarbonate water. Low recharge rates in the drier terrain north of the Soutpansberg also results in low recharge rates to dilute these salts. The movement of groundwater passing through saline deposits of the Karoo rocks, and subsequent evapotranspiration by riverine vegetation, causes a rapid salt accumulation northward, with a peak salt load along the fringes of the channels lying over Karoo rocks, like the Mutamba, the Brak and Sand Rivers, resulting in poor natural water quality.

Groundwater is abstracted for irrigation on the farms Windhoek, Grootgeluk and Overwinning along the Kandanama, and irrigation boreholes along the Sand River on Sterkstroom, Sitapo, Sutherland and Waterpoort, or utilized by riparian vegetation. Very little surface runoff is believed to recharge the regional aquifers north of the Soutpansberg, since high salinity levels in the Karoo aquifers suggest it is not recharged by fresh water from the river. In comparison, groundwater is of good quality in the Karoo aquifer along the southern tributaries such as the Kandanama River, where river losses take place.

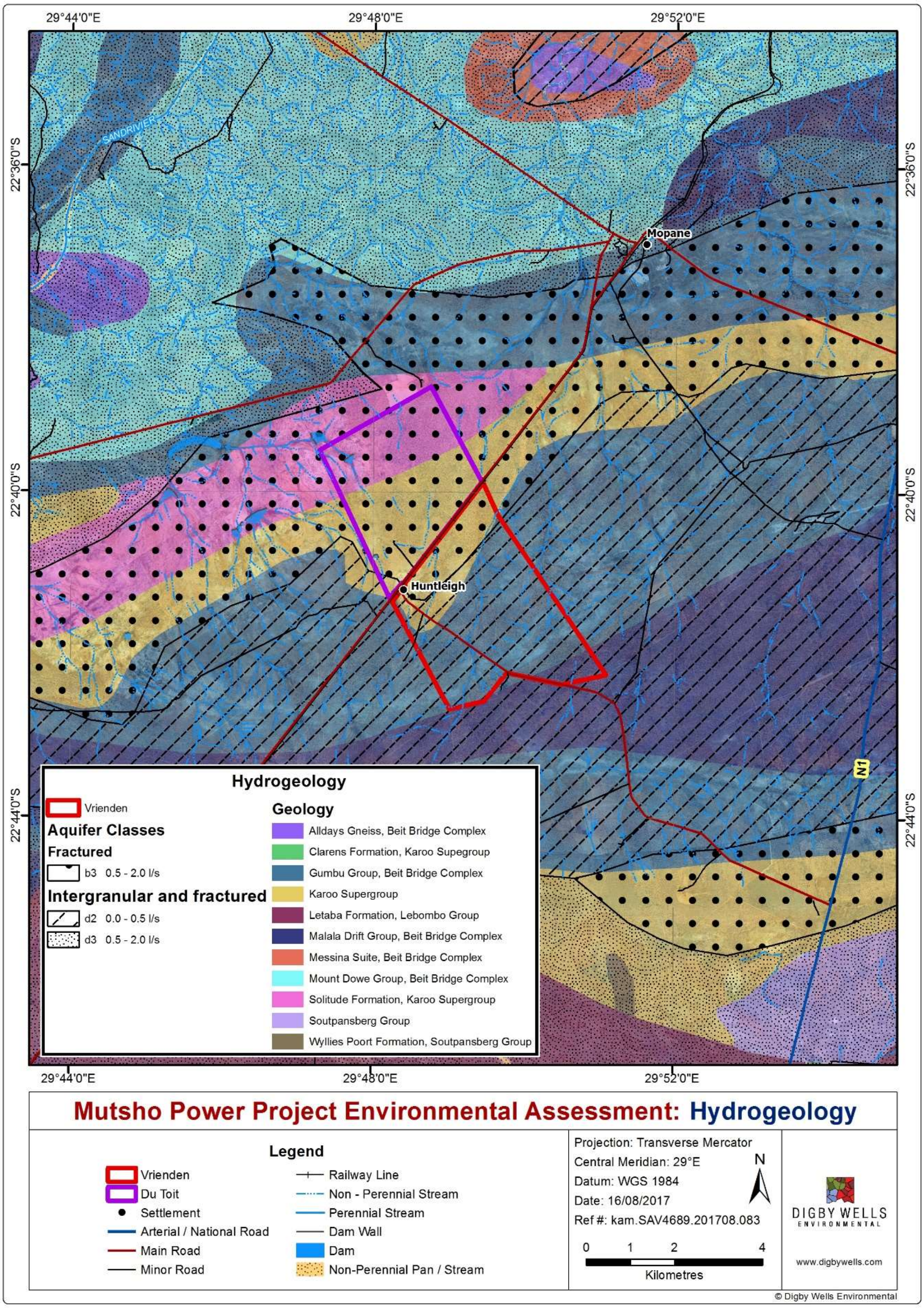


Figure 23: Site Hydrogeological Map

5.3.2 Local Hydrogeology and Conceptual Model

To acquire site specific groundwater conditions and to develop a conceptual model of the project area; a hydrocensus was conducted and reference to literature was made to acquire information that was not attained during the field investigation.

5.3.2.1 Groundwater Quality and Characterisation

During the hydrocensus conducted by Digby Wells (January 2018) a total of 6 boreholes were identified. Water levels were measured and water samples collected from 5 of those boreholes; the outstanding borehole was dry (DUTBH4). All boreholes were equipped and operational with the exception of DUTBH4. Borehole ID, co-ordinates, water levels and borehole usage are presented in Table 31. Photos of the boreholes are presented in Table 32 and their distribution is presented in Figure 24.

The groundwater quality results from the samples have been compared to the South African Water Quality Guidelines (SAWQG) (1996) for livestock and domestic use (Table 33).

All boreholes exceed the SAWQG for domestic use. Evaluations indicate the following:

- VRIBH1 has fluoride concentrations of 1.55 mg/L, which exceed standards for domestic use (1.5 mg/L). The consumption of water with elevated fluoride concentrations may cause discolouration of dental enamel and mottling, and gives rise to the possibility of the development of skeletal fluorosis. High fluoride concentrations are likely due to the local geology; the local geology is associated with the LMB gneisses which are made up of some volcanics and volcanic rocks are often enriched with fluoride;
- VRIBH2, DUTBH1, DUTBH2 and DUTBH3 have sulphate concentration of 280, 275, 463 and 319 mg/L, which exceed standards for domestic use (200 mg/L).The consumption of water with elevated sulphate concentrations may cause diarrhoea. The elevated concentrations of sulphate can be attributed to mining related impacts; and
- VRIBH1, VRIBH2, DUTBH1 and DUTBH2 have magnesium concentrations of 98.8, 313, 109 and 125 mg/L respectively, which exceed standards for domestic use (70 mg/L). The consumption of water with elevated magnesium concentrations may cause diarrhoea. The elevated concentrations of magnesium can be attributed to the presence of igneous.

The current water quality conditions at the project area are not pristine; this is consistent with the description of the regional hydrogeology. The region is expected to have poor water quality naturally because groundwater passes through saline deposits of the Karoo rocks. Salt accumulation is intensified by high evaporation and evapotranspiration by riverine vegetation, which is evident from the elevated chloride found in the groundwater. Additionally excessive sulphate is indicative of mining related impacts to the local groundwater quality.

Groundwater characterisation was conducted according to the Piper Diagram (Figure 25) and the groundwater quality at VRIBH1 and DUTBH3 are identified to be calcium-magnesium-bicarbonate type which is typically found at freshly recharged aquifers. VRIBH2, DUTBH1 and DUTBH2 are characteristic of calcium/sodium sulphate waters which are associated with mining activities, mining activities are present within 25 km of the project area and are likely to be the source of impact observed from the groundwater chemistry at the project area.

Table 31: Summary of hydrocensus results

BH ID	Latitude	Longitude	Elevation (mamsl)	Water level (mgbl)	Water level (mamsl)	BH Usage	Comment
VRIBH1	-22.6877	29.82324	710.3587	26.55	683.81	Livestock	-
VRIBH2	-22.702	29.82695	725.7149	-		Livestock	Dry until 57 mbgl, pipes prevented dip meter from going deeper
DUTBH1	-22.6769	29.80434	702.5429	23.25	679.3	Drinking water	-
DUTBH2	-22.6631	29.80217	687.7416	-		Livestock	Dry until 76 mbgl, pipes prevented dip meter from going deeper
DUTBH3	-22.6601	29.80192	685.0015	35.68	649.32	Livestock	-
DUTBH4	-22.6469	29.81346	674.4396	Dry		Not used	-

Table 32: Photos of boreholes

VRIBH1	VRIBH2	DUTBH1
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DUTBH2	**DUTBH3**	**DUTBH4**
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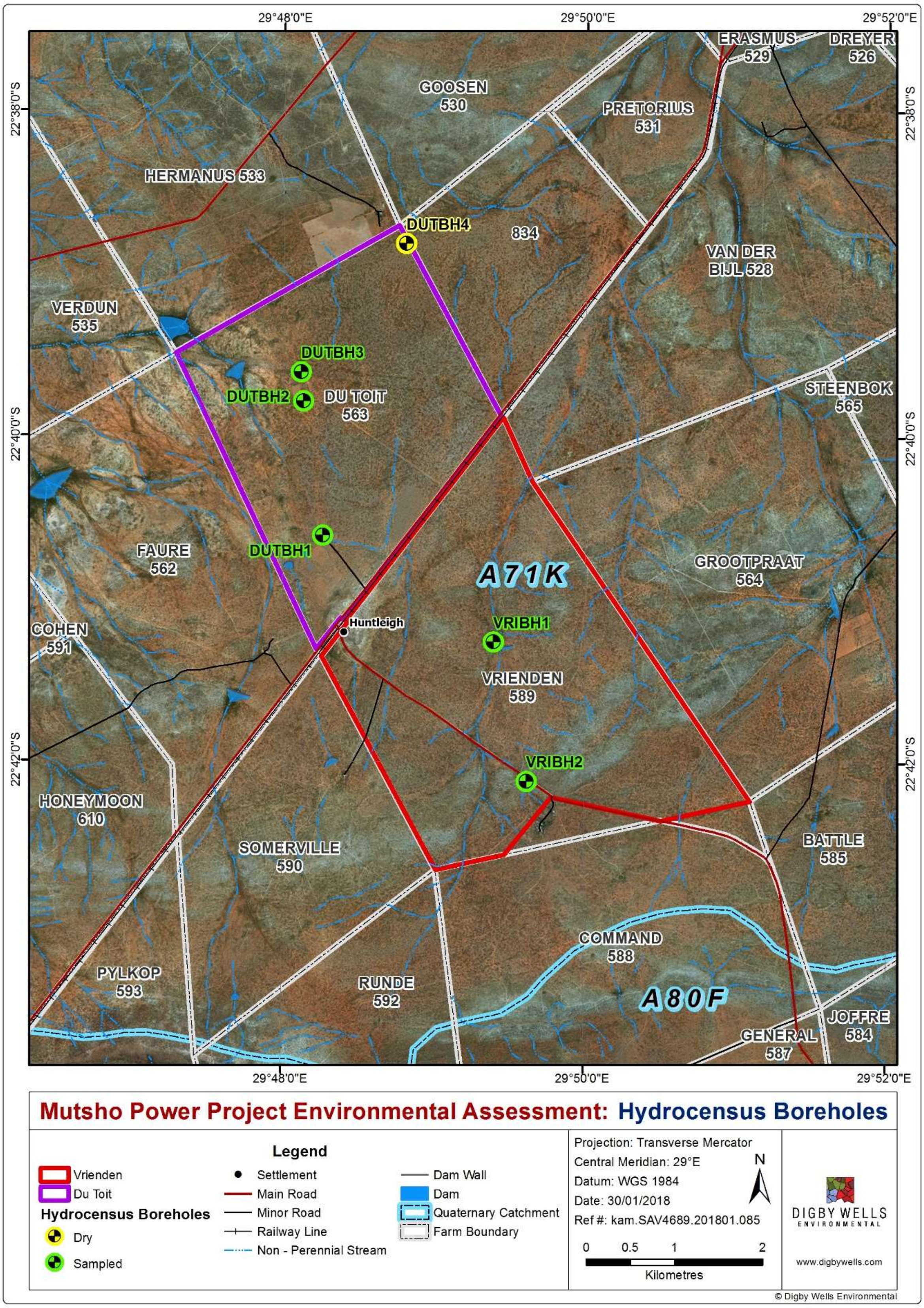

Figure 24: Hydrocensus Boreholes

Table 33: Baseline water quality compared against South African Water Quality Guidelines (SAWQG) (1996) for Livestock and Domestic Use

Constituent	Unit	SA WQ Guidelines		Borehole ID				
		Livestock	Domestic					
		Unacceptable		DUTBH1	DUTBH2	DUTBH3	VRIBH1	VRIBH2
pH			9	7.46	7.18	7.57	7.47	7.25
Electrical conductivity	mS/m		450	198	238	160	146	311
Nitrate as N	mg/l	100	6	2.54	0.76	<0.2	8.18	7.66
Sulphate	mg/l	1000	200	275	463	319	78.2	280
Calcium	mg/l	1000		123	159	43.9	64.4	141
Chloride	mg/l	1500	1200	403	467	87.4	221	861
Fluoride	mg/l	2	1.5	0.92	1.17	1.25	1.55	0.83
Magnesium	mg/l	500	70	109	125	41.1	98.8	313
Manganese	mg/l	10	5	0.16	<0.001	0.12	0.09	0.001
Sodium	mg/l	2000	400	289	358	330	217	332
Potassium	mg/l		50	21.3	22.6	8.4	11.6	16.4
Aluminium	mg/l	5	0.5	0.015	0.004	-0.002	0.005	0.008
Copper	mg/l	0.5	30	0.14	<0.002	<0.002	0.01	<0.002
Zinc	mg/l	20	10	0.25	0.03	0.07	0.05	0.02
Ammonium	mg/		2	0.11	0.03	0.24	0.05	0.02
Lead	mg/	0.1	10	<0.004	<0.004	<0.004	<0.004	<0.004
Nickel	mg/	2		<0.002	<0.002	<0.002	<0.002	<0.002
Chromium	mg/	1	0.05	<0.003	<0.003	<0.003	<0.003	<0.003
Arsenic	mg/	1	10	<0.006	<0.006	<0.006	<0.006	<0.006

Iron	mg/	10	1	<0.004	<0.004	<0.004	<0.004	<0.004

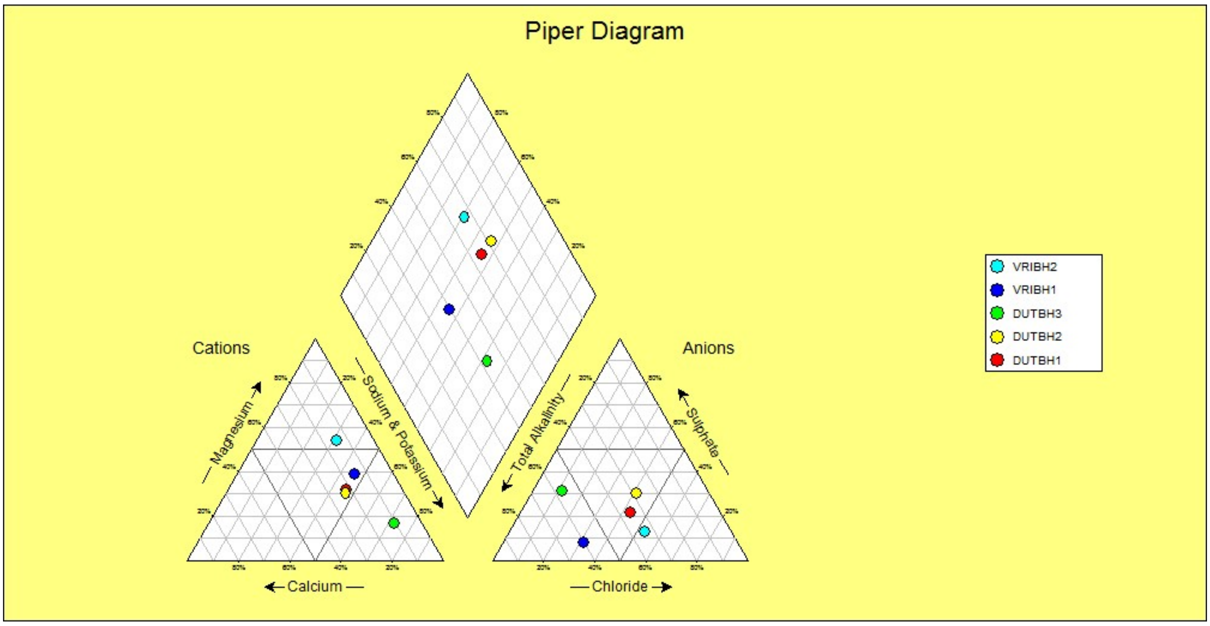

Figure 25: Piper Diagram

5.3.2.2 <u>Potential Groundwater Pathway</u>

5.3.2.2.1 Aquifer Classification

The aquifers of South Africa are defined according to their water supply potential, water quality and local importance for strategic purposes within an aquifer classification scheme and map. The aquifer classification map (DWA, 2012) identifies aquifers in the project area as minor aquifer systems which are moderately-yielding with variable water quality.

Aquifer vulnerability is defined as the tendency or likelihood for contamination to reach a specified position in the aquifer system after introduction at some location above the uppermost aquifer. The aquifer vulnerability map (DWA, 2013) identifies the local aquifers as possessing the least vulnerability.

5.3.2.2.2 Local Aquifers

The groundwater systems at the project area are defined by the local geology. The Karoo sediments were deposited onto basement granite gneisses. The lowermost sediments of the Karoo include Dykwa tillites, superimposed by the Ecca Group. The Ecca Group sediments comprises of sandstones and shales. It is observed that there is a distribution of igneous and sedimentary rocks.

Weathering occurs within the shallow aquifer, extending approximately 38 m. Below that, relatively consolidated material is expected to be fractured. The shallow aquifer is of interest, as no underground activities will be taking place, whatever impact occurs will be mostly to the shallow aquifer and the nature of water to migrate horizontally under natural conditions will retain any impact to the shallow aquifer. Additionally no drilling and aquifer testing was conducted at the project area therefore the description is kept as simple as possible.

5.3.2.2.3 The Weathered Aquifer

This aquifer is recharged by rainfall; at a recharge percentage in the order of 1% to 3% of the annual rainfall (Hodgson and Krantz, 1998).

It should, however, be emphasised that in a weathered system, such as the Ecca sediments, highly variable recharge values can be found from one area to the next. This is attributed to the composition of the weathered sediments, which range from coarse-grained sand to fine clay.

The sandstone contained in Ecca formation is generally of very low permeability and therefore contains low-yielding aquifers (Botha et al., 1998).

5.3.2.2.4 Dwyka Group

The formation consists predominantly of diamictite in a matrix of clay and silt, and to a lesser extent there are shale, sandstone, and conglomerate. Diamictite and shale are of very low hydraulic conductivity, ranging between 0.075 and 0.0075 m/d.

The few sandstone bodies are of minimal extent and are bounded by diamictite. The water quality of the few aquifers present is saline due to the depositional environment which was on beaches or areas of high significant fracturing (Botha et al., 1998).

5.3.2.2.5 Water Level and Flow Direction

The groundwater levels at the project area were acquired from the hydrocensus. Water level acquisition data such as procedure, locations and outcomes are found in Section 3.3.2 and 5.3.2.1. The groundwater hydraulic heads ranged between 23.25 and 35.68 mbgl, showing a strong correlation (97% according Pearson correlation coefficient) to the surface topography, presented in Figure 26. All boreholes identified on site were operational; the groundwater uses are presented in Figure 27. The local groundwater flow direction may be influenced by the gradient created by abstraction; however observing the correlation between the topography and water levels it can be assumed that the natural groundwater flow patterns follow a similar trend to the topography.

The groundwater flow direction is towards the north-west, shown in Figure 27.

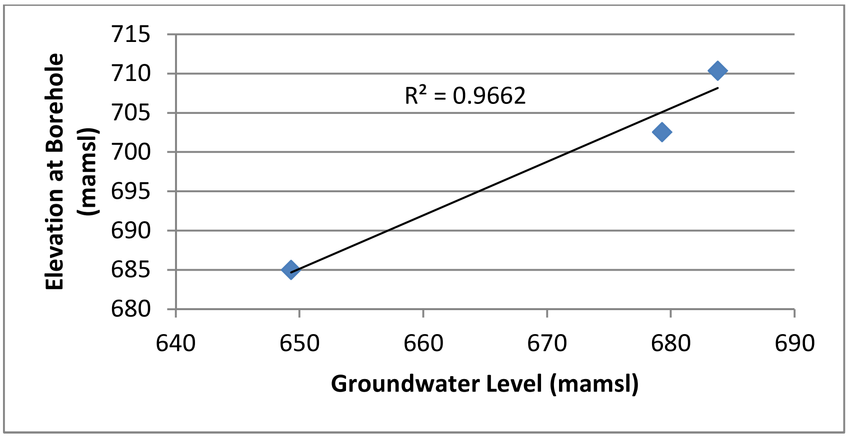

Figure 26: Topography and groundwater elevation correlation

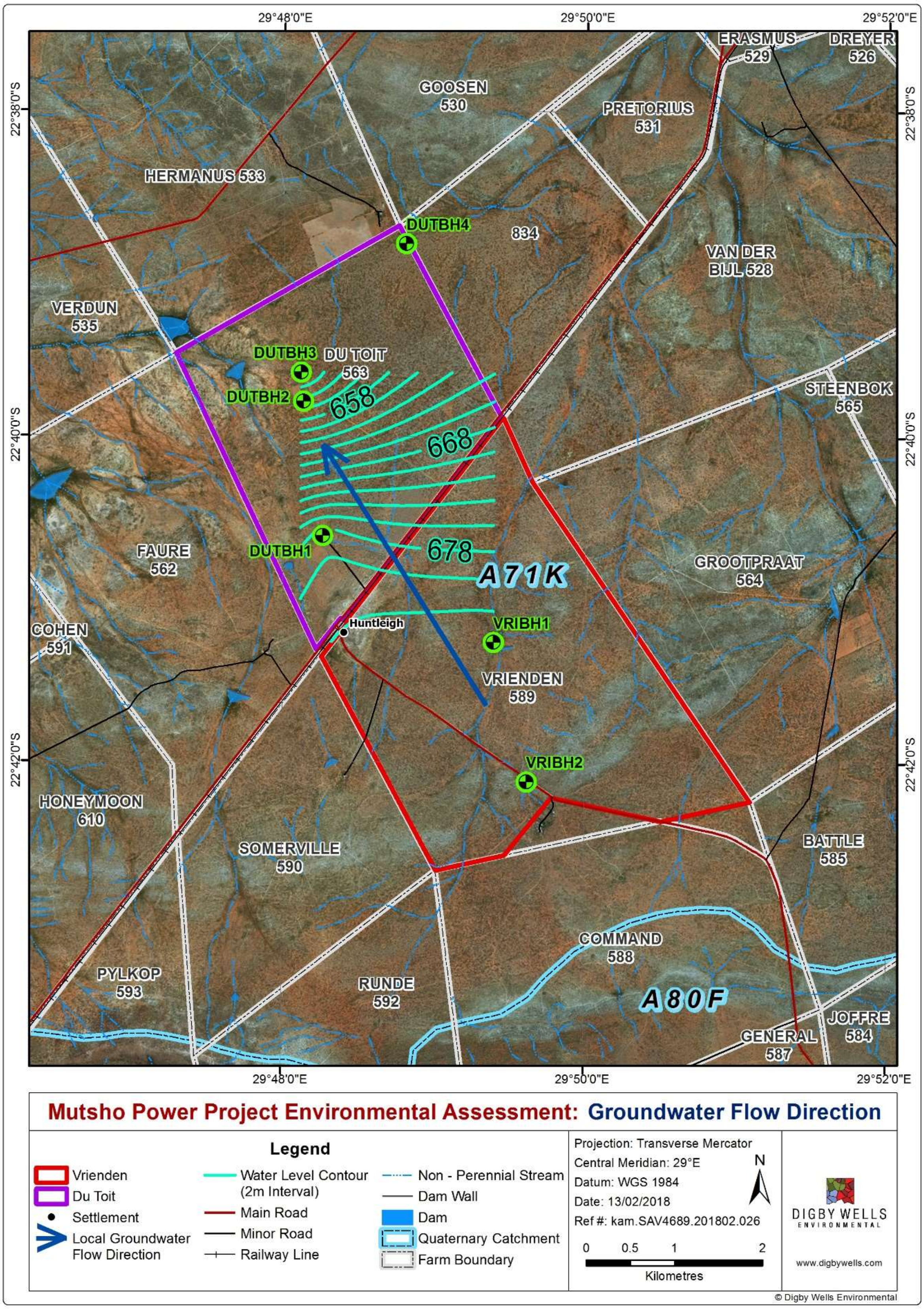

Figure 27: Groundwater flow direction

5.3.2.3 Potential Contaminant sources

The main potential impact to the groundwater environment identified at the power station site is groundwater contamination from the ash dump and coal stockpile.

Typical ash water chemistries within ash disposal sites include:

- A drop in pH (from > 12 to approximately 8) and precipitation of calcium carbonate, in the presence of air;
- High base potential under neutral and basic conditions; and
- High leachability of heavy metals under acid conditions.

Coal stockpiles are expected to be operational only during operation and demolished thereafter. Additionally the coal product will be compacted prior to deposition therefore limiting leachate formation. These factors contribute to the fact that the coal stockpile will be a lesser concern to the groundwater quality compared to the ash dump.

Contamination potential to the groundwater occurs in the following manner; as rainwater infiltrates through the disposed ash and stockpiled coal, leachate is formed. The leachate then seeps to the groundwater and migrates by advection in the groundwater environment in the form of a contamination plume. Impact to the groundwater may be negligible if the ash and coal product are compacted and lined. Additionally, seepage rates at ash dumps reduce over time naturally.

5.3.2.4 Potential Receptors

Potential receptors are all the entities that are part of the system that may be impacted negatively if the groundwater quality is depleted as a result of the proposed power plant and associated infrastructure. The potential receptors are identified as humans and livestock (consuming groundwater from private boreholes), surface water bodies that are fed by groundwater (baseflow) and natural ecosystems that depend on the groundwater.

High priority potential receptors are those located downstream of the potential contamination source, namely; VRIBH1, DUTBH, DUTBH2, DUTBH3 and non- perennial streams. This is due to the nature of the contamination plume to migrate by advection as opposed to dispersion.

The non-perennial streams at the project are expected to be losing streams due to the water levels at the project area ranging between the depths of 23.25 (DUTBH1) and 35.68 mbgl (DUTBH3). Losing streams are streams that lose water to the groundwater, basically a portion of their flow infiltrates into the subsurface, as opposed to gaining streams which are fed water by groundwater through base flow.

5.3.3 Analytical Model

An analytical groundwater model was used to predict the potential impact of the proposed ash dump associated with layout option 1 only (as the preferred option from a groundwater perspective).

The analytical model is based on Darcy's Law which is:

$q=Ki$ (1)

K=T/b (2)

i= dh/dl (3)

Where:

q = seepage rate, also referred to as the outflow rate (m/d);

K = hydraulic conductivity (m/d), (assumed to be 0.01 m/d from literature review);

T = aquifer transmissivity (m2/d);

i = hydraulic gradient;

b = aquifer thickness (m);

dh =change in head (the change in head between VRIBH1 and DUTBH3 is 34.5 m); and

dl = change in length (distance between VRIBH1 and DUTBH3 is 3481 m).

Leachate is expected to seep from the ash dump, migrate through the unsaturated zone. When it reaches the aquifer (saturated zone) it then migrates horizontally. This assumes that no liner is installed.

5.3.3.1 Seepage into the Groundwater Environment

The Karoo sediments occur predominantly throughout the project area and are weathered. An average hydraulic conductivity of 0.01 m/d has been assumed; taking into consideration that the aquifer is expected to be of low permeability and based on the expected hydraulic conductivity of unconsolidated sedimentary according to Thomas (2013). The applied hydraulic conductivity is solely based on estimation (taking into consideration literature review of the available background information of the region). Aquifer tests are recommended in order to understand the local aquifer(s). Aquifer tests are conducted by stressing the aquifer and observing aquifer responses, the test results serve to quantify hydraulic parameters. For model update; aquifer hydraulic parameters at the project area need to be investigated in order to acquire site specific aquifer properties which will serve as input to improve modelling predictions.

The water level of the closest borehole to the ash dump (300 m) has been assumed to be the water level at the ash dump area; therefore the watertable is expected to be at 26 mgbl (VRIBH1).

The hydraulic gradient from the ash dump is assumed to be one since the flow will mainly be vertical. Therefore the magnitude of the seepage rate would be equal to the hydraulic conductivity (q = 0.01 m/d x 1) =0.01 m/d.

The equation of time, distance and speed (time = distance/speed) becomes relevant with regards to estimating the time it will take seepage to reach the watertable. Based on the assumptions mentioned above seepage is expected to reach the watertable after approximately 7 years of operation. An additional assumption of the study is that the estimated hydraulic conductivity is consistent throughout the project area as a homogeneous aquifer is assumed within the project area. Therefore, seepage rate is expected to be the same from both the ash dump area and the coal stockpile; with the exception of area where the fault is located. Structures such as faults and fractures potentially act as preferential pathways and are expected to have high hydraulic conductivity, site specific investigations ae required to acquire hydraulic properties of such structure as they vary vastly from site to site.

Based on the current lack of geochemical data it is recommended that a liner is installed prior to ash placement unless tests are done on the ash resulting in a relaxation of the liner requirements. From experience, typical ash material requires a class C liner as defined in Regulation 634 of August 2013; however this is subject to change based on the outcomes of the recommended geochemical studies that should be done before any ash placement/dumping takes place on surface. It is stipulated that seepage from a Class C liner does not exceed 8.64 x 10^{-4} m/d (DWAF, 1998). A conceptual design for a Class C liner as given by the NEM: WA guidelines (GNR634 of August 2013) is shown in Figure 28.

For the analytical model:

- A liner thickness of 700 mm is applied as seen in Figure 28 ;and
- For conservative prediction the maximum seepage rate for a Class C liner (8.64 x 10-4 m/d) is applied.

Analytical calculations conducted for a liner with these specifications conclude that seepage is expected to migrate through the liner over approximately 800 years. The liner can therefore be regarded as impermeable and it can be concluded that the installation of the liner will restrict seepage. As long as the watertable does not rise, any seepage that may pass through will be minimal and is not expected to reach the groundwater environment.

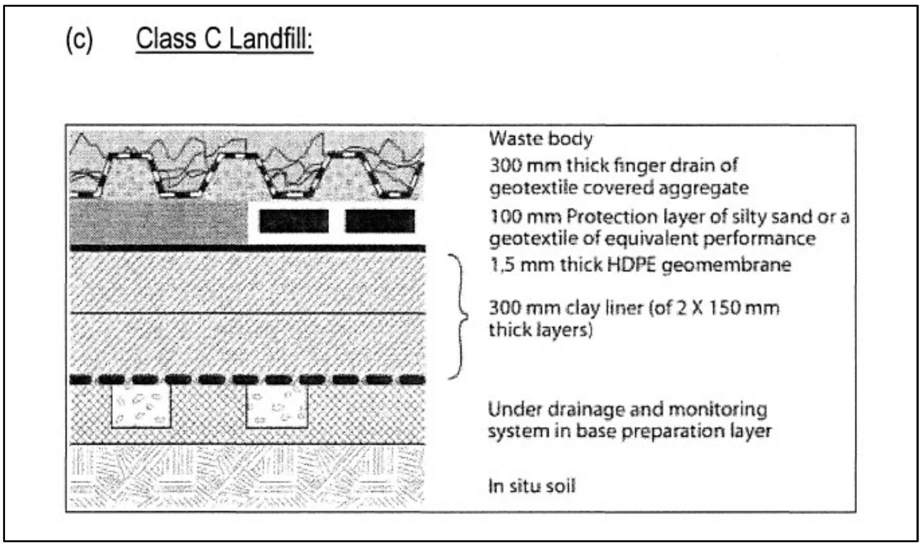

Figure 28: Minimum design requirement for a Class C liner (GNR634, 2013)

5.4 Surface Water

5.4.1 Water quality Baseline

The collected sample was sent to an accredited laboratory (Aquatico Laboratories) for analysis of physical and chemical parameters. The surface water quality results are presented in Table 35 and the original certificate from the laboratory is attached in Appendix B.

The predominant water use around the project area was for agriculture (irrigation) and Livestock watering, for that reason, the results were benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation and Livestock (DWAF, 1996) which describes the "fitness for use" of a water resource. The fitness for use of water defines how suitable the quality of water is for its intended use. Table 34 presents the coordinates for the surface water sampling point and these are also shown Figure 29.

Table 34: Surface Water Monitoring Points

Point Name	Sample	Latitude	Longitude
Dam1	Dry	22° 41' 00.145" S	29° 48' 26.278" E
Dam2	Dry	22° 40' 48.733" S	29° 48' 00.258" E
Dam3	Dry	22° 40' 35.485" S	29° 48' 05.200" E
Dam 4	Sampled	22° 39.579'S	29° 47.690'E
SW01	Proposed	22° 40' 15.861" S	29° 49' 37.512" E
SW03	Proposed	22° 42' 36.569" S	29° 49' 12.157" E
SW02	Proposed	22° 41' 17.543" S	29° 49' 26.615" E

Geographic Coordinate System WGS84 Datum

5.4.2 Water Quality Analysis Results

In Table 35 below, water quality results from a sampled point can be summarised as follows:

- Elevated level of pH (8.6) that exceeds the South African Water Quality Guidelines for Agricultural Use (Irrigation) has been observed. No specific target water quality range has been set for livestock watering;
- All the other parameters were within both the SAWQG Irrigation and livestock standards.

5.4.3 Historical water quality (regional)

According to the Water Resource Situation Assessment (DWA, 2002), the upper and central Sand River receive "large quantities" of industrial and domestic effluent from large towns and high density rural towns along its banks. The mineralogical water quality of the whole of the catchment was thus classified as "marginal".

In contrast to this assessment, the Internal Strategic Perspective (ISP) study (DWA, 2004) states that apart from problems with groundwater quality in the Vivo and Dendron areas there are no major water quality problems in the Sand River Key Area (the Key area includes the Sand River Basin and other smaller rivers draining to the Limpopo River).

A Baseline Study of the water chemistry of the Limpopo Basin (Univ. of Zimbabwe, 2009) found that in the Vhembe District, which includes the Sand River, nitrate levels increased with groundwater flow towards the Sand River and high levels of nitrate were recorded in both the river and alluvial groundwater during the raining season. It was suggested that the nitrate is from dry land cropping, overgrazed pastures and, in some areas, pit latrines. High fluoride was noted in the area north of the Soutpansberg and has been attributed to high evaporation.

From the historical monitoring along the Sand River, elevated levels of pH, Electrical Conductivity (EC), chloride, magnesium and sodium were observed. This could be attributed to the upstream irrigation activities.

The same elevated levels were observed after the extreme flood of 2000 and also in the following year and this could have resulted in higher wash-off from contaminated and/or agricultural areas.

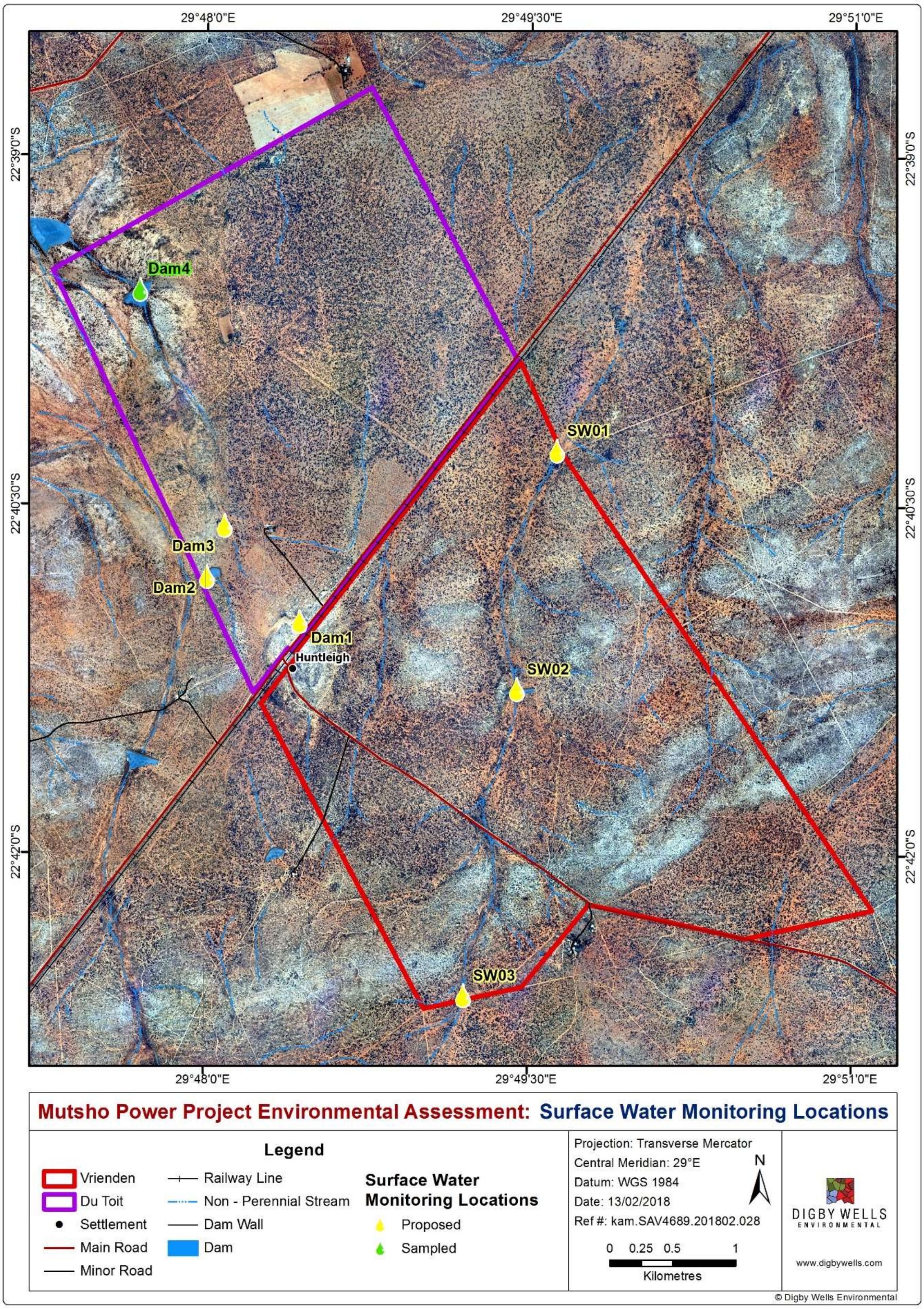

Figure 29: Monitoring Locations

Table 35: Water Quality Results benchmarked against the South African Water Quality Guidelines

Sample ID		pH	EC (mS/m)	Cl (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	NH_4 (mg/l)	Mn (mg/l)	F (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	Pb (mg/l)	Fe (mg/l)	Al (mg/l)	As (mg/l)
SWQG: Agriculture Use: livestock Watering (Target Water Qauality Range)				**6000**	**1000**	**100**		**10**	**2**	**1000**	**500**	**2000**	**0.1**	**10**	**5**	**1**
SWQG: Agriculture Use: Irrigation (Target Water Qauality Range)		**<6.5 - >8.4**	**40**	**100**	**N/A**	**N/A**	**N/A**	**0.02**	**2**	**N/A**	**N/A**	**70**	**0.2**	**5**	**5**	**0.1**
SW1-Dam 4	18/01/2018	8.6	23.0	3.0	13.7	0.21	0.04	0.02	<0.263	44.1	7.0	2.8	0.014	<0.004	0.014	<0.006

6 SENSITIVITY

In this section a preferred infrastructure layout is selected based on the environmental sensitivity identified within the project area based on the specialist assessments undertaken.

Based on the Groundwater Assessment, sensitivities associated with the projects were based on preferential flow paths for groundwater movement, which could result in larger impacts occurring. The sensitivity analysis was based on the findings of the analytical model. The analytical model considered Option 1 as the preferred option based on the location of fault lines within the area and also proximity to potential receptors. The location of boreholes based on Option 1 is listed in Table 36 and the distance from the ash dump is provided.

Table 36: Distance of potential receptor (borehole) from potential contamination source

Borehole ID	Comment	Distance from ash dump
VRIBH1	Located downstream from the ash dump. Water is used for livestock	300 m
VRIBH2	Located upstream from the ash dump. Water is used for livestock	900 m
DUTBH1	Located downstream from the ash dump. Water is used for drinking water	2.6 km
DUTBH2	Located downstream from the ash dump. Water is used for livestock	3.3 km
DUTBH3	Located downstream from the ash dump. Water is used for livestock	3 km
DUTBH4	Dry borehole not used	3.8 km
Sandrivier	Perennial river	8 km
Non-perennial streams	Because they flow seasonally, this reduces the intensity of the impact from the ash dump	Closest is located 100 m from ash dump

From a water resource perspective a desktop sensitivity analysis on the affected farms indicates that there are few well-defined drainage lines and several runoff pathways or washes.

Washes can be defined as those areas which show visible signs of occasional water movement and sediment transport, but which do not receive sufficient runoff to develop characteristic soils or vegetation associated with wetlands or drainage lines. These are a characteristic feature of arid and semi-arid environments and are related to the occurrence of occasional intense rainfall events within areas of low total rainfall.

A defined drainage line on the north-western part of Farm Du Toit 563 comprise of a significant floodplain in which an artificial impoundment has also been constructed. This drainage line flows northwards towards the Sand River, and exhibits typical vegetation attributes. The presence and ecological contribution of these attributes increases the habitat diversity of the Farms and, ultimately, the perceived sensitivity (Savannah Environmental, March 2017).

A portion of the Vrienden 589 farm is mainly comprised of the washes. The identified drainage line in this study area has been classified as highly sensitive whilst all the washes are considered moderate or less sensitive.

All the identified washes, drainage lines and the main Sand River were found to be dry during the site assessment.

As mentioned above, the flow in the lower Sand River, its tributaries and minor streams or washes is highly ephemeral. Run-off occurs after rainfall events, with flow in the main stem of longer duration after major, wide-spread rainfall within the catchment. The sensitivity map is shown in Figure 30. From a infrastructure layout point of view, avoiding highly sensitive areas should be considered, such as the drainage paths located on Farm Du Toit 563. This system has been defined as highly sensitive and should be avoided. Also avoidance of other less sensitive drainage lines also needs to be considered and were possible avoiding these areas should also be considered.

Two pan systems have been identified on the Farm Du Toit 563 and are located on the northern boundary of the farm. In addition to this the extent of the ephemeral drainage lines has been determined and was undertaken as part of the Wetland Assessment. Based on the findings of the wetland assessment the system located on the Farm Du Toit 563, is considered to be more sensitive and water that flows through the ephemeral drainage lines flow towards the Sand River. The ephemeral drainage lines located on the Farm Vrienden are more isolated. In saying this, every effort should be taken to avoid drainage lines were possible.

From an Aquatic perspective, with regards to the mainstem Sand River, the Ecological Importance was defined to be high due to a moderate-to-high likelihood of occurrence for *Oreochromis mossambicus* (listed as Near Threatened) during periods of flow, a moderate-to-high representivity and rarity within the secondary catchment, as well as the occurrence of the study area within a Fresh Water Ecosystem Priority Area and provincially determined Ecological Support Area 1. Also, the Ecological Sensitivity was defined to be moderate-to-high, which was attributed to an elevated number of highly sensitive flow-dependent species, a number of species that were regarded as moderate-to-highly sensitive to water quality impairment, and a riparian vegetation component is well adapted to the fluctuating water levels within the associated alluvial system.

Refer to Figure 30, which overlays all the sensitives associated with the assessments undertaken.

The above information was then utilised to determine the most suitable location based on the three options provided and is discussed in further detail in the next section of this report, regarding the consideration of infrastructure layout and alternatives.

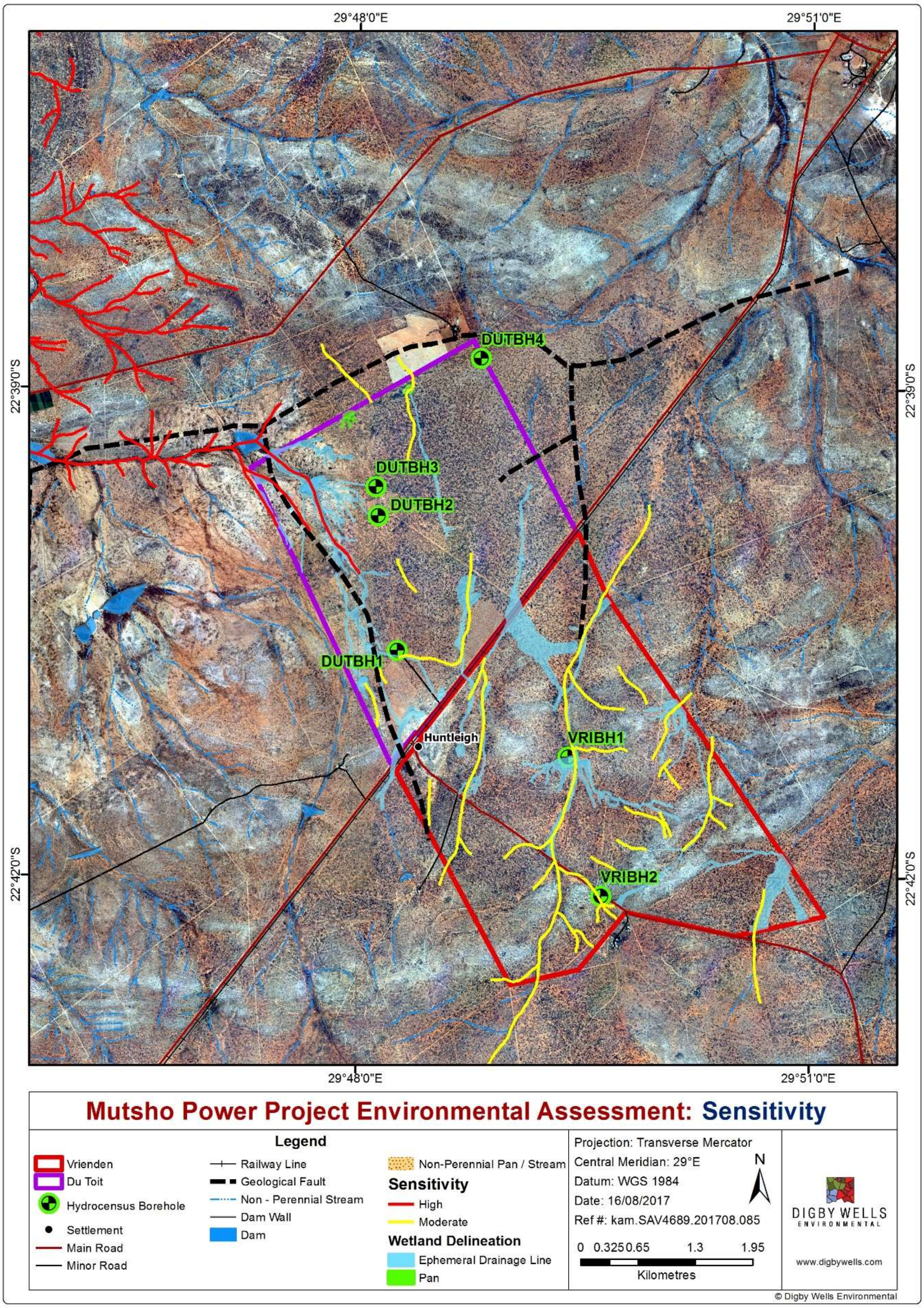

Figure 30: Sensitive and No-Go Areas

7 SUITABILITY OF THE PROPOSED INFRASTRUCTURE AREAS AND ALTERNATIVES

The Mutsho Power Project has three proposed infrastructure locations which are all within the demarcated project area. Considering the nature and activities of this project, the main impacts could be contamination of the natural streams as a result of runoff from the Ash Dump and Coal Stockyard, reporting into these natural streams, which could have implications on biota and cause determination of these systems. In addition to this the potential contamination to groundwater needs to be considered as an impact of concern and when placing infrastructure needs to be taken into consideration.

Therefore, to assess the most suitable location of infrastructure, the suitability of the proposed infrastructure location was completed based on the following criterion:

- **Criteria 1:** Presence of natural water features on the proposed site;
- **Criteria 2:** Proximity/Distance of the water resources to the ash dump and coal stockyard – a shorter distance to the river/stream will result in a higher risk of impacting to the water resource;
- **Criteria 3:** Dirty water runoff likely to report in to the natural water resources;
- **Criteria 4:** Sensitivity of natural water features within the proposed site**.**
- **Criteria 5**: Location of fault lines within the proposed site

These criteria were rated on a scale from 1 (unsuitable), 2 (Less suitable), 3 (Negligible / Insignificant), 4 (Suitable) to 5 (most suitable) to quantifiably compare the suitability of the various infrastructure sitings, based on the various specialist assessments. Once the ratings were determined based on the criteria above, these were caluculated to determine the overall suitability ranking of the proposed ash dump and coal stockyard areas. The results of this assessment are presented in Table 37 and described in the narrative below.

Table 37: Rating of criteria for the consideration of infrastructure alternatives

Options	C1	C2	C3	C4	C5	Total %	Rating	
							Score	Definition
Option 1	2	3	2	3	5	60%	3	Negligible
Option 2	2	2	1	1	1	20%	1	Unsuitable
Option 3	2	2	3	2	2	40%	2	Less suitable

*Rating = Rounded average (Criteria 1 value + Criteria 2 value + Criteria 3 value + Criteria 4 value + Criterial 5 value)/5

If each specialist study is rated in isolation, without considering the other specialist studies the following was determined.

From a surface water perspective, option 2 and 3 are the most suitable infrastructure areas with negligible or insignificant impacts on the natural surface water resources whilst option 1 is the least suitable since the ash dump is located on top of the drainage lines, please note these the drainage lines that may be affected by Option 1 have been classified as moderate sensitive on the analysis above, and thus the potential impacts on these would not have great or significant impact.

From a wetlands perspective the following was concluded:

- Based on the utilisation of areas of existing anthropogenic disturbance, such as an existing road, fence-lines and powerline servitude, preference is given to Option 2;
- In terms of the extent of the freshwater resources likely to be impacted both in terms of direct loss of surface water drainage areas, as well as due to potential loss of ecological integrity in the downstream aquatic resources, preference is given to layout Option 1, followed by layout Option 2;
- In addition, layout Option 2 is considered the least invasive in terms of hard surface crossings as the access road is constructed from the existing gravel road between Farm Du Toit and Farm Vrienden; and
- Both layout Option 2 and 3, involve a more compact infrastructure footprint, which is likely to result in fewer impacts to the freshwater resources present and will aid in the management and mitigation of impacts during the life of the proposed project.

It is concluded that layout Option 2 is the most suitable in terms of wetland and freshwater ecological integrity.

Looking at aquatics the driving factor would be to place infrastructure as far as possible from the Sand River system, thus Option 1 was considered as the most feasible option.

Lastly for groundwater sensitive receptors, such as boreholes and fault lines were taken into consideration. Private boreholes are located downstream from the proposed ash dump and coal stockpile (with the exception of VRIBH2, for all layout options), the nearest perennial river is located 8 km north west of the project area (Sand River); local streams within the project area are non-perennial, they flow seasonally.

Considering environmental sensitivity a fault located in the northern part of the farm Du Toit was identified. Based on that observation, Option 1 is recommended as the most suitable layout as the location of the ash dump for this option is located furthest from the fault. The ash dump and coal stockpile location is most critical as these facilities are the main concern regarding impacts to groundwater. Structures that could potentially act as preferential pathways should be avoided with regards to the placement of the facilities. No groundwater sensitive areas were identified for the proposed locations of the coal stockpile for all layout options.

Once each specialist assessment considered the respective sensitivities in isolation, all the findings were integrated into one scoring system as noted above. Based on the scoring system, the best option to consider would be Option 1. None of the options avoid impacts completely, however based on the sensitivities and recuing impacts, Option 1 should considered as the preferred option.

8 IMPACT ASSESSMENT

8.1 Methodology

The methodology used to determine the environmental impact significance rating is provided below. The rating is based on the Nature, Significance, Consequence, Extent, Duration and Probability of potential direct, indirect and cumulative surface water impacts. This is explained as follows:

- 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 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 are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- > 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

8.2 Proposed Site Layout

At the time of writing, three proposed alternative layouts were presented for the proposed design of the power plant and associated infrastructure and as such, each aspect was assessed in terms of the potential impacts upon the receiving watercourses (Figure 7-9).

The major infrastructure was comprised of the following:

- Power plant;
- Ash dump;
- Ash dump run-off dam;
- Coal conveyor;
- Transmission substation;
- Transmission line; and
- Rail road siding, which is to be excluded from the current assessment, as it forms part of a separate authorisation process for the associated Makhado Colliery development.

It is assumed that the following activities associated with the development and operation of the plant are likely to elicit a potential impact upon the receiving watercourses:

Table 38: Activity associated with the proposed development

Phase of Project	Activities
Construction	▪ Site clearing, including the removal of topsoil and vegetation; ▪ Engineering and construction activities; and ▪ Temporary storage of hazardous products, including fuel, as well as waste and sewage.
Operational	▪ Operation and maintenance of power plant and associated processes; ▪ Operational activities associated with the ash dump and coal stockyard; ▪ Water use and storage on-site; and ▪ Storage, treatment and disposal of hazardous products and waste products.
Decommissioning & Closure	▪ Demolition and removal of all infrastructure; ▪ Rehabilitation, including spreading of soil, re-vegetation and profiling or contouring; and ▪ Post-closure monitoring and rehabilitation.

8.3 Impacts Identified

8.3.1 Construction Phase

8.3.1.1 Aquatics

The expected potential aquatic-related impacts were assessed considering the construction, operation and decommissioning phases of the life of the project, for all proposed options. The following tables outline the potential aquatic related impacts for the three above listed phases of the project.

Table 39: Identified potential impacts during the construction phase

Nature: Site clearing and associated construction activities within the proposed development areas is likely to facilitate erosive potential of the vulnerable soils observed at the time of the survey and as such, increase sedimentation within the receiving watercourses is to be expected. In addition, the direct loss of vegetation and the replacement of less permeable surfaces (e.g. compacted soils) is likely to result in an elevated surface runoff velocity from these areas into the surrounding watercourses, which further expected to amplify the erosive potential of the area. Accidental spillage of hydro-carbon based fuels and associated habits from construction vehicles (e.g. oil leaks), materials (e.g. corrosive chemicals) and personnel (e.g. litter)

are likely to contaminate the surface runoff and in turn the receiving watercourses. This will have a direct implication of the sensitive aquatic biota occurring within the study area.		
	Without mitigation	**With mitigation**
Extent	Surrounding farms (2)	Site only (1)
Duration	Short-term (2)	Short-term (2)
Magnitude	Large (8)	Low (4)
Probability	High (4)	Low (2)
Significance	**Medium (48)**	**Low (14)**
Status (positive or negative)	Negative	Neutral
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:

- Develop soil management measures for the construction area/s that will prevent an increased runoff into the associated watercourses, such as the construction of trenches and/or the use of silt curtains;
- Erosion control structures and mechanisms, such as surface stormwater drainage systems, should be implemented so as to reduce the potential occurrence of erosion and sedimentation within and adjacent to the associated watercourses;
- The disturbance of instream channels and riparian zones must be minimized, where possible;
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils;
- Portable septic toilets are to be provided and maintained (including their removal without sewage spillage) for construction crews outside of the 1-100 year floodline; and
- Store all litter and waste carefully and dispose of correctly, so it cannot be

washed or blown into any of the watercourses within the study area; ▪ No-go areas (or options) applicable where watercourses are to be avoided (see Wetland Assessment Report for delineated areas).
Residual Risks: No residual risks identified during the construction phase

8.3.1.2 Wetlands

The main activities during the construction phase that could result in impacts to the freshwater ecology of the area are associated with the site clearing and construction of the various parts of the power station infrastructure. Both the drainage features ,as well as the two pans identified on the Farm Du Toit, are considered relatively sensitive and ecologically important based on the findings of both the desktop and field assessments. Any site clearing or construction activities are likely to have a potential impact on the freshwater ecology in terms of the ephemeral drainage lines and wetland systems in the vicinity of the Project area as well as further downstream. Based on the assessment conducted, the two pans may not be impacted upon, however there will be impacts to the ephemeral drainage lines.

Impacts include erosion and sedimentation, the potential loss of biodiversity and habitat, fragmentation of the systems present and potential loss of catchment yields and surface water recharge to the systems further downstream. Among the impacts associated with the proposed construction phase are minor potential impacts to soil and water quality as a result of the ingress of hydrocarbons. Larger impacts include compaction of soils, potential loss of natural vegetation and the increased potential for erosion and sedimentation in the vicinity of any cleared areas and resulting in impacts further downstream. Removal of vegetation and disturbance of soils in the vicinity of the construction footprint is likely to give rise to an increased potential for encroachment by robust pioneer species and AIPs, further altering the natural vegetation profiles of the freshwater resources encountered in the vicinity of the project footprint.

Table 40 summarises potential impacts to the freshwater ecology identified during the construction phase.

Table 40: Identified potential impacts during the construction phase

Nature: Site clearing and increased vehicular movement within the Project area resulting in: ▪ Potential contamination of soils as a result of the ingress of hydrocarbons; ▪ Compaction of soils; ▪ Loss of biodiversity and natural vegetation; ▪ Fragmentation of the systems present; ▪ Loss of catchment yield;

- Increased sedimentation; and
- Increased potential for onset of erosion.

	Without mitigation	**With mitigation**
Extent	Regional (4)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Moderate (6)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (48)**	**Medium (33)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:

The following mitigation and management measures have been prescribed for the construction phase:

- Ensure soil management programme is implemented and maintained to minimise erosion and sedimentation;
- Active rehabilitation, re-sloping, and re-vegetation of disturbed areas immediately after construction;
- Implement and maintain an alien vegetation management programme. This must be put in place so as to prevent further encroachment as a result of disturbance to the surrounding terrestrial zones;
- Limit the footprint area of the construction activities to what is absolutely essential in order to minimise impacts as a result of vegetation clearing and compaction of soils (all areas but critically so in freshwater areas);
- If it is absolutely unavoidable that any of the freshwater areas present will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the ephemeral drainage lines present

takes place; ▪ All erosion noted within the construction footprint should be remedied immediately and included as part of an ongoing rehabilitation plan; ▪ Permit only essential personnel within the 32 m zone of regulation for all freshwater features identified; ▪ All areas of increased ecological sensitivity should be designated as "No-Go" areas and be off limits to all unauthorised vehicles and personnel; ▪ No unnecessary crossing of the freshwater features and their associated buffers should take place and the substrate conditions of the ephemeral drainage lines and downstream stream connectivity must be maintained; ▪ No material may be dumped or stockpiled within any freshwater features; ▪ No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must remain on demarcated roads and within the construction footprint; ▪ All vehicles must be regularly inspected for leaks; ▪ Re-fuelling must take place on a sealed surface area away from freshwater features to prevent ingress of hydrocarbons into topsoil; ▪ All spills should be immediately cleaned up and treated accordingly; and ▪ Appropriate sanitary facilities must be provided for the duration of the construction activities and all waste must be removed to an appropriate waste facility.
Residual Risks: No residual risks identified during the construction phase

8.3.1.3 Groundwater

The main activities during the construction phase that could result in groundwater impacts are associated with the site clearing and construction of the various parts of the power station infrastructure, including the ash dump and coal stockyard and associated infrastructure.

The watertable at the project area ranges between 23.25 (DUTBH1) and 35.68 mbgl (DUTBH3). Any site clearing or construction activities that would involve excavation below the watertable depth may have a potential impact on the groundwater quantity and quality. Table 41 summarises potential groundwater impacts identified during the construction phase.

Table 41: Identified Potential Impacts during the construction phase

Nature: Potential lowering of the water table associated with foundations that are going to be constructed.

	Without mitigation	**With mitigation**
Extent	Low (1)	Low (1)
Duration	Short-term (1)	Short-term (1)
Magnitude	Minor (2)	Low (1)
Probability	Improbable (2)	Very improbable (1)
Significance	**Low (8)**	**Low (3)**
Status (positive or negative)	Negative	Neutral
Reversibility	Medium	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes

Mitigation:

There will be no impact to the groundwater if excavation does not exceed the depth of the watertable at the location of excavation. Local water levels range from 23.25 to 35.68 mbgl. If it does exceed the depth of the watertable, the impact significance will depend on the depth of excavation below the watertable. In areas where the foundation of structures is to be installed below the water level, dewatering of the aquifer to locally lower the watertable can be considered. The abstracted water can be utilised for dust suppression, vegetation or discharged to the storm water dams.

Residual Risks:

No residual risks identified during the construction phase

8.3.1.4 Surface Water

During the construction phase, there are activities that could potentially have an impact on the natural water resources. These include but are not limited to site clearing, stripping of topsoil, establishment of runoff dams, storage of hazardous material (fuel), generation and removal of domestic & hazardous waste, vehicular movement etc.

The section below describes the identified impacts in detail and provides the appropriate management/mitigation measures.

Table 42: Identified Impact Description during Construction Phase

Nature: Clearing or removal of vegetation leaves the soils prone to erosion during rainfall events, and as a result runoff from these areas which will be high in suspended solids will cause an increase in turbidity in the natural water resources. This could also result from the stockpiled topsoil if not vegetated.

Dust generated during the construction activities and increased vehicular movements can also be deposited into the nearby natural streams during rainfall events thereby contributing to the accumulation of suspended solids in these water resources leading to the siltation of the water bodies.

	Without mitigation	**With mitigation**
Extent	Local (3)	Local (3)
Duration	Short term (1)	Short term (1)
Magnitude	Moderate (6)	Low (4)
Probability	Highly probable (4)	Improbable (2)
Significance	Medium (40)	Low (16)
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes

Mitigation:
▪ Clearing of vegetation must be limited to the development footprint area and the use of existing access roads must be prioritized so as to minimise construction of new access roads in these areas; ▪ If possible, construction should be undertaken during the low rainfall season (April to September) to minimise erosion and sedimentation/siltation of the water course; ▪ Any construction work that involves site clearance, digging, excavation or trenching during construction services should be suspended during heavy rains to avoid erosion and sedimentation of the water course; ▪ When wet season construction cannot be avoided, sedimentation control measures, such as hay bales, sedimentation basins or any silt trap method should be in place during construction activities; ▪ Dust suppression measures must be undertaken on the cleared areas during construction; and ▪ Dirt roads must be well compacted to avoid erosion of the soil into the natural water course.
Residual Risks: Risk of erosion on the developed area that may lead to siltation of the nearby streams.

Table 43: Identified Impact Description during Construction Phase

Nature: Dirty water runoff from the contaminated areas (general & hazardous waste storage facilities, disposal sites) has the potential to contaminate the natural water resources if the storm water management plan is not implemented.

These impacts will lead to the deterioration of the water quality and hence impact the downstream water users, as well as the aquatic life. However, these impacts can greatly be prevented and/or reduced if the recommended measures in the following section are implemented.

	Without mitigation	**With mitigation**
Extent	Local (3)	High (3)
Duration	Short term (1)	Short term (1)
Magnitude	High (8)	High (8)
Probability	Highly probable (4)	Improbable (2)
Significance	Medium (48)	Low (24)
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes

Mitigation:

- All runoff emanating from the dirty water areas which include hazardous storage facilities will need to be diverted to the containment facility e.g. a sump prior to construction of the runoff/storm water dams;
- All spillages must be contained to the smallest possible area and must be cleaned immediately; and
- All construction equipment shall be put onto a maintenance program, including daily inspection of the equipment.

Residual Risks:
There is a risk of hydrocarbon spills, general and hazardous material spillages during construction. This may lead to contamination of the water course when runoff from such areas reports into the streams.

8.3.2 Operational Phase

8.3.2.1 Aquatics

Table 44: Identified potential impacts during the operation phase

Nature: Potential contamination of the surrounding watercourses can potentially originate either from the mismanagement of the ash originating from the operational activities at the power plant (e.g. improper disposal of ash, inadequate compaction of the ash dump, etc.), and/or the inappropriate storage and separation of coal received or 'dirty' water situated within the proposed development area. In the event that pollutant levels become elevated within the receiving watercourses, inhabiting aquatic biota become physiologically stressed and migrate away from the affected area, if possible.		
	Without mitigation	**With mitigation**
Extent	Local (3)	Surrounding farms (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	High (4)	Low (2)
Significance	**Medium (60)**	**Low (28)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Medium
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	Yes

Mitigation: ▪ A dirty water system (including the proposed PCD) should be engineered and maintained on a regular basis to ensure efficacy;   ▪ Management of any accumulated water within the operational area should be regularly monitored and pumped to the PCD, so as to prevent the accumulation of dirty water within the operational area;   ▪ The proposed design of the PCD should be over-engineered to include lining the facility with an impermeable membrane to prevent any potential seepage;   ▪ Water within the PCD should be utilized within the operational area to facilitate the evaporation of the accumulated dirty water (e.g. dust suppression activities).
Residual Risks: Following decommissioning of the plant, it is envisaged that only the ash dump will remain and as such, it is recommended that other methods to safely dispose of excess ash be explored and implemented (e.g. additive to cement production). Also, sound and proper management practices are encouraged to maintain the shape of the dump and to engineer the subsequent rehabilitation (if possible) in a way that complements and emulates the baseline topography.

8.3.2.2 Wetlands

During operation, the ash dump is identified as the main facility that may potentially impact the freshwater resources present.

Additional impacts associated with the proposed project are potential impacts to soil and water quality as a result of the ingress of hydrocarbons and mechanical spills associated with moving machinery required for transport of coal and ash, compaction of soils, the potential loss of natural vegetation and the increased potential for erosion and sedimentation in the operational footprint.

Any potential dumping or stockpiling within freshwater areas, and more significantly, any spills from the ash dump, has the potential to result in loss of stream connectivity, loss of refuge areas, alterations to the terrain profiles of the areas and the creation of preferential flow paths, which may result in sedimentation, alterations to the vegetation structure of the area, encourage alien vegetation encroachment and result in increased erosion and sedimentation potentials.

Table 45 summarises potential impacts to the freshwater ecology identified during the operational phase.

Table 45: Identified potential impacts during the operational phase

Nature: Sedimentation and loss of flow connectivity; Potential ingress of hydrocarbons and other pollutants to the freshwater resources present; Altered hydrology, loss of biodiversity and fragmentation of freshwater systems; Loss of catchment yield;

Increased vehicular movement along river crossings and within wetland/riparian zones resulting in:

- Potential contamination of soils as a result of the ingress of hydrocarbons;
- Compaction of soils;
- Loss of natural vegetation;
- Loss of surface water recharge to the systems further downstream;
- Fragmentation of the systems present;
- Increased sedimentation; and
- Increased potential for onset of erosion.

	Without mitigation	**With mitigation**
Extent	Regional (4)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Very High (10)	High (8)
Probability	Highly Probable (4)	Probable (3)
Significance	**High (72)**	**Medium (39)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:

The following mitigation and management measures have been prescribed for the operational phase:

- Clean and dirty water separation systems to be implemented prior to the commencement of activities and to be maintained throughout the life of the proposed project;
- Ensure that as far as possible all operational infrastructures are placed outside of freshwater areas and their associated 32 m zone of regulation;

- Limit the footprint area of the operational activities to what is absolutely essential in order to minimise impacts as a result of any potential vegetation clearing and compaction of soils (all areas but critically so in freshwater areas);
- If it is absolutely unavoidable that any of the freshwater areas present will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the freshwater features present takes place as a result of the proposed operational activities;
- All erosion noted within the operational footprint as a result of any potential surface activities should be remedied immediately and included as part of the ongoing rehabilitation plan;
- During the operational phase, erosion berms should be installed on roadways and downstream of stockpiles to prevent gully formation and siltation of the freshwater resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed;
  - Where the track slopes between 2% and 10%, berms every 25m should be installed;
  - Where the track slopes between 10%-15%, berms every 20m should be installed; and
  - Where the track has slope greater than 15%, berms every 10m should be installed.
- A suitable AIP control programme must be put in place so as to prevent further encroachment as a result of disturbance to the surrounding terrestrial zones;
- Permit only essential personnel within the 32 m zone of regulation for all freshwater features identified;
- All areas of increased ecological sensitivity should be designated as "No-Go" areas and be off limits to all unauthorised vehicles and personnel;
- No unnecessary crossing of the wetland features and their associated buffers should take place and the substrate conditions of the wetlands and downstream stream connectivity must be maintained;
- No material may be dumped or stockpiled within any of the ephemeral drainage lines in the vicinity of the proposed operational footprint;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must remain on demarcated roads;
- All vehicles must be regularly inspected for leaks;
- Re-fuelling must take place on a sealed surface area away from freshwater

features to prevent ingress of hydrocarbons into topsoil;

- All spills should be immediately cleaned up and treated accordingly;
- Appropriate sanitary facilities must be provided for the duration of the operational activities and all waste must be removed to an appropriate waste facility;
- Monitor all systems for erosion and incision.

Residual Risks:

The ash dump is not expected to have a significant impact on the freshwater ecology further north of the Project area; however, if suitable mitigation measures are not implemented, impacts associated with the ash dump may result in sedimentation of the aquatic resources downstream.

8.3.2.3 Groundwater

During operation, the ash dump and coal stockpile are identified as the main facilities that may potentially impact the groundwater environment.

In order to provide site specific detail on the chemistry expected from the contamination which could emanate from the ash dump and coal stockpile, and recommend a suitable liner, it is recommended that geochemistry and waste classification studies be conducted prior to any activities taking place. Based on experience it is highly likely that the ash dump will need to be lined in addition to this this will be required for the Water Use Licence Application, thus would be legally required to be undertaken. Applying a liner is expected to significantly reduce seepage of contaminants (leachate) from the ash dump into the receiving environment. Dry ash disposal has been proposed for the project site, whereby the ash is partially wetted to contain approximately 15% moisture. Dry ashing has an advantage over wet ashing as it minimises the quantity of leachate that will be generated.

Table 46 and Table 47 summarises potential groundwater impacts identified during the operation phase.

Table 46: Identified potential impacts during the operation phase

Nature: Groundwater contamination from ash dump		
	Without mitigation	**With mitigation**
Extent	Low (1)	Low (1)
Duration	Long-term (4)	Short-term (1)
Magnitude	Moderate (6)	Small (2)
Probability	Probable (3)	Improbable (1)
Significance	**Medium (33)**	**Low (4)**
Status (positive or negative)	Negative	Neutral
Reversibility	Low	Medium
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	Yes
Mitigation: If the groundwater is contaminated, the plume from the ash dump may reach the identified potential receptors (such as groundwater users using surrounding boreholes for drinking and livestock, and local streams). The local streams may receive the groundwater as baseflow; however the likelihood of this is low due to the relatively deep water levels currently observed on site (28 mbgl on average). Groundwater-surface water interaction is expected to be of losing-streams and base flow feeding the local streams with groundwater is not expected. With the implementation of an appropriately designed ash dam liner and dry ash deposition, seepage into the groundwater environment is not expected and impacts are regarded as negligible. Should an impact be detected through monitoring, affected receptors should be compensated.		

Residual Risks:

The potential contamination plume is not expected to migrate into the groundwater environment with the installation of a liner; however if not installed there may be an impact to the potential receptors and the local groundwater quality may deteriorate.

Table 47: Identified potential impacts during the operation phase

Nature: Groundwater contamination from coal stockpile		
	Without mitigation	**With mitigation**
Extent	Low (1)	Low (1)
Duration	Long-term (4)	Short-term (1)
Magnitude	Moderate (6)	Small (2)
Probability	Probable (3)	Improbable (1)
Significance	**Medium (33)**	**Low (4)**
Status (positive or negative)	Negative	Neutral
Reversibility	Low	Medium
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	Yes

Mitigation:

If a potentially contaminated plume from the coal stockpile reaches the groundwater, local receptors may be affected. Due to the relatively deep water levels (28 m on average) currently observed on site the likelihood of this impact to the local streams is minimal. Groundwater-surface water interaction is expected to be of losing-streams and base flow feeding the local streams with groundwater is not expected locally.

With the implementation of an appropriately designed ash dam liner and compaction, seepage into the groundwater environment is not expected and impacts are regarded as negligible.

Should an impact be detected through monitoring, affected receptors should be compensated.

Residual Risks:
The coal stockpile is not expected to release leachate into the groundwater environment with the installation of a liner. However if not installed there may be an impact to the private boreholes located downstream (used for drinking and livestock) as the local groundwater quality may deteriorate.

8.3.2.4 Surface Water

Activities that may have surface water impacts during the operational phase include plant operations, maintenance, storage of fuel, storage of coal, operation of runoff/storm water dams and storm water management systems, operational use of ash dump. The potential surface water impacts during this phase are described in the Table 48 and Table 49 below.

Table 48: Identified Impact Description during Operational Phase

Nature: Dirty water runoff from the contaminated surfaces and the infrastructure within the project area (power plant area, coal stockyards, hazardous storage facilities, ash dump) has the potential to contaminate and silt up the existing pans if the storm water management plan is not in place/implemented.

These impacts will lead to deterioration of the water quality and hence impact the downstream water users, as well as the aquatic life. However, these impacts can greatly be prevented and/or reduced if the recommended measures are implemented.

	Without mitigation	**With mitigation**
Extent	Regional (4)	Regional (4)
Duration	Long term (4)	Long term (4)
Magnitude	High (8)	Moderate (6)
Probability	Highly probable (4)	Improbable (2)
Significance	High (64)	Medium (28)
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	No	No

Can impacts be mitigated?	Yes	No

Mitigation:

- All the dirty water runoff emanating from dirty areas (ash dump, plant and coal stockpile areas) should be contained within the dirty water dams. This water should be stored for re-use within the power plant so as to prevent unnecessary discharge into the environment;
- Should the contained water be more than the water use requirement, the Best Practice Guideline advise that the water be recycled or as the last resort be treated to acceptable levels and discharged to the natural environment or be supplied to other industries as a lower grade water;
- Development of a storm water management infrastructure should be in line with Regulation 704 of the NWA, 1998 (GN 704);
- Clean water emanating from upstream of the project area must be diverted away and discharged to the nearby watercourse or environment;
- All spillages must be contained to the smallest possible area and must be cleaned immediately.

Residual Risks:

There is a risk of dam overflows, risk of hydrocarbons spills, general and hazardous material spillages. This may lead to contamination of the water course when runoff from such areas reports into the streams.

Table 49: Identified Impact Description during Operational Phase

Nature/description: Containment of dirty water runoff within the dams prevents contamination of the natural stream. However, this runoff had been contributing to the natural catchment and streams prior to commencement of the project as clean water.

Containment of this water (now as dirty water) reduces the amount of runoff reporting to the natural environment. A decrease in the catchment yield may have an impact on the downstream water users as they may not have sufficient water for their needs, while also decreasing the flows required for the ecological reserve.

However, the project boundary layout where all the three alternative infrastructure locations are located amounts to approximately 12 km^2 which makes up less than 1% of total quaternary catchment area of 1668 km^2 (A71K).

The percentage decrease in MAR amounts to 0.7% of the total mean annual runoff within this quaternary catchment and this is considered to be insignificant.

	Without mitigation	**With mitigation**

Extent	Local (2)	Local (2)
Duration	Long term (4)	Long term (4)
Magnitude	Low (2)	Low (2)
Probability	Definite (5)	Definite (5)
Significance	Medium (40)	Medium (40)
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	No	No
Mitigation: • Although there is no mitigation for this loss of catchment yield, the extent or overall potential loss (less than 1%) will be insignificant • Clean water from upstream catchment will be diverted around site and report to natural environment or streams.		
Residual Risks: There is a risk of dam overflows and dirty water finds its way into the natural streams, thereby contaminating the natural watercourse.		

8.3.3 Decommissioning and Post Closure Phase

8.3.3.1 Aquatics

Table 50: Identified potential impacts during the decommissioning and post--closure phase

Nature: Demolition and removal of the power plant infrastructure is intended to restore the baseline conditions to some extent (e.g. original topography, restored catchment yield, re-establish connectivity between fragmented watercourses). However, the increased movement of heavy machinery and vehicles during the particular phase is expected to increase the risk of potential water quality impairment (i.e. hydrocarbon leaks) and/or loss riparian habitat through increased operational footprint.

	Without mitigation	**With mitigation**
Extent	Surrounding farms (2)	Surrounding farms (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Small (2)
Probability	Probable (3)	Very improbable (1)
Significance	**Medium (30)**	**Low (8)**
Status (positive or negative)	Negative	Neutral
Reversibility	Medium	Medium
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	Yes
Mitigation: ▪ Care should be taken not to impact areas that have remained un-affected throughout the life of the power plant and associated infrastructure. ▪ On-going rehabilitation should be conducted throughout the Operational phase. Only the removal of remaining infrastructure and reshaping the final topography should occur during the closure phase.		
Residual Risks: No residual risks associated with decommissioning, closure and rehabilitation.		

8.3.3.2 Wetlands

This phase is characterised by the decommissioning and closure of the power plant and associated infrastructure, the ash dump however is planned to remain on surface, which is likely to result in ongoing impacts to the freshwater ecology over time. Among the impacts associated with the proposed decommissioning phase are minor potential impacts to soil and water quality as a result of the ingress of hydrocarbons and mechanical spills associated with moving machinery required for the decommissioning activities.

Larger impacts include compaction of soils, potential loss of natural vegetation and the increased potential for erosion and sedimentation in the decommissioned areas and resulting in impacts further downstream.

Any temporary storage or dumping of decommissioned infrastructure within freshwater areas or any of the ephemeral drainage lines, has the potential to result in loss of stream connectivity, loss of refuge areas, alterations to the terrain profiles of the areas and the creation of preferential flow paths, which may result in sedimentation, alterations to the vegetation structure of the area, encourage alien vegetation encroachment and result in increased erosion and sedimentation potentials.

Removal of vegetation and disturbance of soils in the vicinity of the decommissioning footprint is likely to give rise to an increased potential for encroachment by robust pioneer species and AIPs, further altering the natural vegetation profiles of the freshwater resources encountered in the vicinity of the decommissioning footprint.

The largest impact during the decommissioning and closure phases of this proposed project is related to the ash dump which will remain once the project is completed. There is a high potential for ongoing impacts to the freshwater ecology of the area as a result of ash spills, poor maintenance of erosion berms and poor dust control, resulting in erosion and sedimentation of the freshwater resources present. Some measures may be implemented to gradually reclaim ash for the production of cement, thereby reducing ash volume over time. The ash dam may also be sealed by the placement of soil over it and the planting of vegetation in order to reduce ash runoff and to prevent erosion and sedimentation and the generation of dust.

Table 51 summarises potential freshwater impacts identified during the decommissioning phase

Table 51: Identified potential impacts during the decommissioning phase

Nature: Potential dumping of decommissioned infrastructure in freshwater areas; Potential incomplete removal of infrastructure; Disturbance of natural vegetation structures; Erosion and sedimentation related to inadequate maintenance of erosion berms and clean and dirty water separation systems; Spread of AIPs; Increased vehicular movement along within freshwater zones, resulting in:

- Potential contamination of soils as a result of the ingress of hydrocarbons;
- Compaction of soils;
- Loss of natural vegetation;
- Increased sedimentation; and
- Increased potential for onset of erosion

	Without mitigation	**With mitigation**
Extent	Regional (4)	Local (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Slight (2)

Probability	Probable (3)	Improbable (2)
Significance	**Medium (48)**	**Low (14)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:

The following mitigation and management measures have been prescribed for the decommissioning and closure phase:

- Ensure that sound environmental management is in place during the proposed decommissioning phase;
- Ensure that as far as possible all decommissioned infrastructures are placed outside of freshwater areas and their associated 32 m zone regulation;
- Limit the footprint area of the decommissioning activities to what is absolutely essential in order to minimise impacts as a result of disturbances to soils, compaction of soils and loss of natural vegetation;
- If it is absolutely unavoidable that any of the freshwater areas present will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the freshwater resources present takes place as a result of the proposed decommissioning activities;
- All erosion noted within the decommissioning area footprint should be remedied immediately and included as part of the ongoing rehabilitation plan;
- A suitable AIP control programme must be put in place for both the decommissioning and closure phases so as to prevent further encroachment as a result of disturbance to the surrounding terrestrial zones;
- Permit only essential personnel within the zones of regulation for all freshwater features identified;
- All areas of increased ecological sensitivity should be designated as "No-Go" areas and be off limits to all unauthorised vehicles and personnel;
- No unnecessary crossing of the freshwater features and their associated buffers should take place and the substrate conditions of the ephemeral drainage lines

and downstream stream connectivity must be maintained;

- Wherever possible, restrict decommissioning activities to the drier winter months to avoid sedimentation of the freshwater resources further downstream;
- No material may be dumped or stockpiled within any freshwater areas (or the buffers) in the vicinity of the proposed decommissioning footprint;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must remain on demarcated roads and within the decommissioning area footprint;
- All vehicles must be regularly inspected for leaks;
- Re-fuelling must take place on a sealed surface area away from freshwater systems to prevent ingress of hydrocarbons into topsoil;
- All spills should be immediately cleaned up and treated accordingly;
- Appropriate sanitary facilities must be provided for the duration of the decommissioning activities and all waste must be removed to an appropriate waste facility; and
- Monitor all systems for erosion and incision.

Residual Risks:

The remaining ash dump is not expected to have a significant impact on the freshwater ecology further north of the Project area, however, if suitable mitigation measures are not implemented, impacts associated with the ash dump may result in sedimentation of the aquatic resources downstream.

8.3.3.3 Groundwater

The closure phase is characterised by the decommissioning of the power plant and associated infrastructure. The ash dump however is planned to remain on surface even after closure. Infiltration of rainwater and leachate formation will continue from the operational phase through to the post-closure phase. However, this is unlikely to pollute the groundwater with the application of the proposed liner and post-closure dump rehabilitation. Ash dump rehabilitation is recommended to include reshaping, compacting, capping and revegetating.

At dry ash dams, carbon dioxide moves into the ash with the rain water. The carbon dioxide reacts with the calcium oxide in the ash and lime ($CaCO_3$) precipitates forming a hard layer known as pozzolanic layer. Hodgson et al. (1998) reported that pozzolanic layer at a dry ash dump is typically up to 500 mm thick. As the crystallisation of lime continues, the top portion of the ash becomes less and less permeable. A stage should therefore be reached where the hydraulic conductivity of the pozzolanic layer has been reduced to such an extent, that rainwater can no longer effectively penetrate into the ash. The ability of pozzolanic ash to successfully act as a sealant, has also been demonstrated by Edil et al. (1992) in the US, in which they state that ash permeabilities are reduced to less than 10^{-7} m/s with time. The ash dump may also be sealed by the placement of soil over it and the planting of vegetation in order to reduce water ingression and to prevent erosion and the generation of dust.

It is possible that uses for the ash such as cement filler may be found and the dump can then be gradually removed. The feasibility of this option would however need to be confirmed based on demand for such materials. Table 52 summarises potential groundwater impacts identified during the post-closure phase.

Table 52: Identified potential impacts during the post-closure phase

Nature: Groundwater contamination from the ash dump		
	Without mitigation	**With mitigation**
Extent	Low (1)	Low (1)
Duration	Permanent (5)	Short-term (1)
Magnitude	Moderate (6)	Small (2)
Probability	Probable (3)	Very improbable (1)
Significance	**Medium (36)**	**Low (4)**
Status (positive or negative)	Negative	Neutral
Reversibility	Low	Medium
Irreplaceable loss of resources?	Yes	No
Can impacts be mitigated?	Yes	Yes
Mitigation: Depending on the integrity of the liner and rehabilitation maintenance in the post-closure phase, the impact could be moderate. Formation of the pozzolanic layer is also additional mitigation that occurs naturally over time, and therefore leachate formation is expected to cease at a certain point therefore reducing the risk to the groundwater over time post-closure. Continuous post-closure monitoring is required so that deterioration in groundwater quality is detected as soon as it occurs, allowing for mitigation measures to be implemented early. Monitoring is recommended to be conducted until satisfactory		

groundwater quality is reached (through the implementation of monitoring and comparing this to standards and objectives set in the Water Use Licence) and thereafter signed off by the relevant authorities. Should an impact be detected through monitoring, affected receptors should be compensated.
Residual Risks: The contamination plume is not expected to migrate into the groundwater environment with the installation of a liner; however if not installed or if the integrity thereof is compromised, there may be an impact to the private boreholes located downstream used for drinking and livestock) and the local groundwater quality will deteriorate.

8.3.3.4 Surface Water

Activities during this phase include disassembly of production units and ancillary infrastructure, the demolishing of buildings, the removal of hazardous waste, and the rehabilitation of the ash dump and project site.

Although decommissioning activities have the potential to impact on the streams, the outcome of the rehabilitation will ensure that the site is rehabilitated to a state that is reflective of anticipated future use.

Table 53: Identified Impact Description during Decommissioning Phase

Nature/description: Dismantling of infrastructure will again expose the surface and leave the soils prone to erosion during high rainfall events. As a result, runoff from these areas (which will be high in suspended solids) can lead to an increase in turbidity in the natural water course.		
	Without mitigation	**With mitigation**
Extent	Local (3)	Local (3)
Duration	Short term (1)	Short term (1)
Magnitude	Moderate (6)	Low (4)
Probability	Highly probable (4)	Improbable (2)
Significance	Medium (40)	Low (16)
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium

Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes

Mitigation:

- The constructed storm water infrastructure will have to remain until post closure. This will ensure that dirty water is captured and contained during removal of infrastructure and thereby prevent siltation and contamination of the river;
- All rehabilitated areas must be vegetated. Until vegetation has successfully been established, sedimentation should be mitigated by installing silt traps at areas where the surface runoff enters the surface water resources;
- The surface profile of the rehabilitated area should resemble the natural conditions prior to the project. This should ensure that the surface profile encourages natural drainage, such that no ponding or standing water occurs after a rainfall event.
- Dust suppression measures must be undertaken during this phase to prevent deposition of dust particle into the stream; and
- Use of accredited contractors for removal or demolition of infrastructures.

Residual Risks:

Risk of erosion on the exposed areas during decommissioning, this may lead into siltation of the nearby streams.

8.3.4 Cumulative Impacts

Cumulative impacts have been considered for the proposed project, taking into account existing mine related projects within the area. Refer to Figure 31 for other mines that are found within the area.

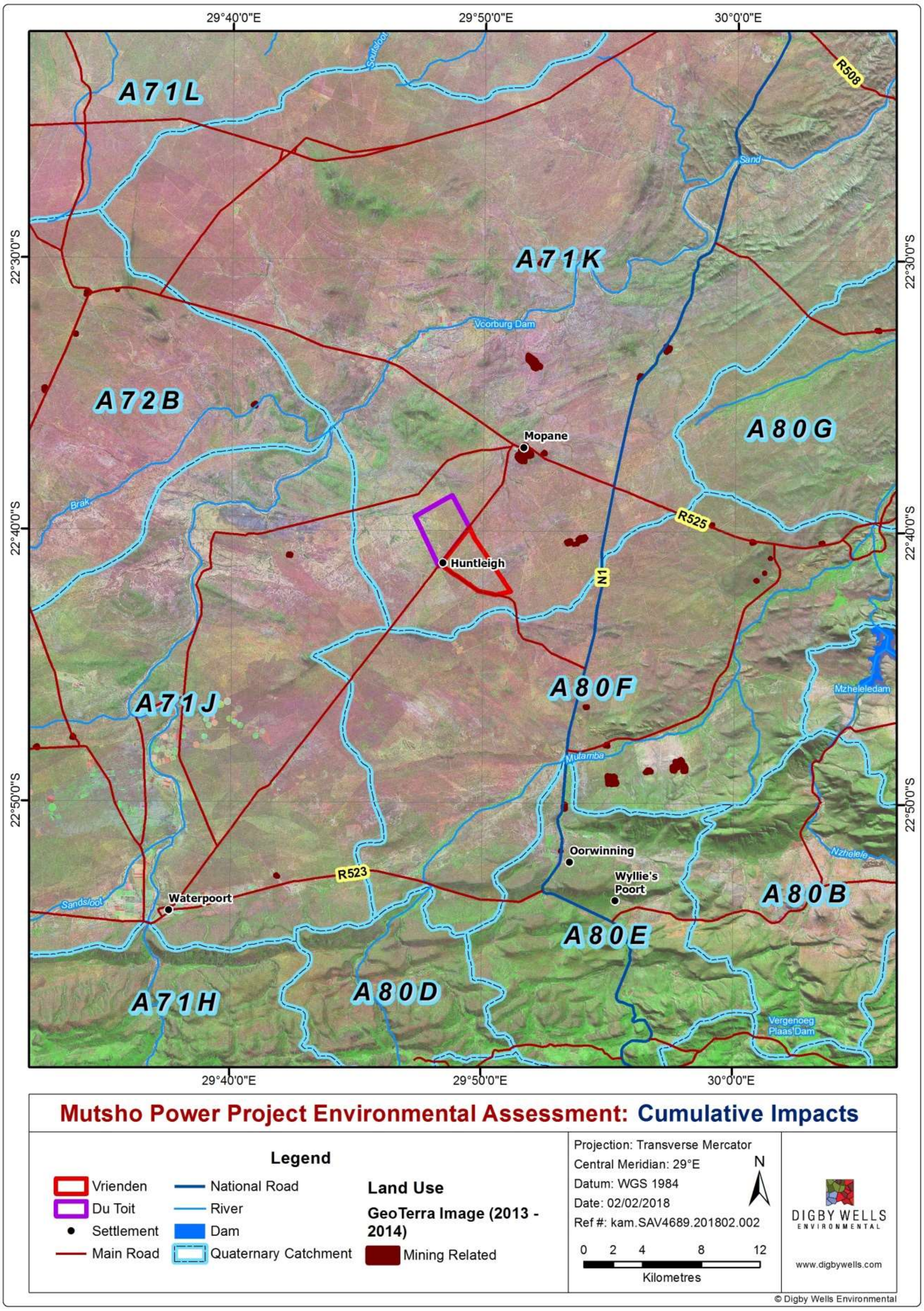

Figure 31: Mines in the vicinity of the project site

8.3.4.1 Aquatics

The cumulative impacts are assessed in consideration of the greater study area and any surrounding activities within a 25 km radius. While there is a notable number of existing mining-related areas within the associated quaternary catchment (including Mopane operations situated approximately 7km due north-east), it is believed that there are also a few proposed mining areas currently being evaluated and reviewed for Environmental Authorisation due to the high number of coal deposits within the area (e.g. the Duel Colliery along the Mutamba River 20 km east).

On the other hand, the greater study area appears to be predominantly operated as private game reserves, provincial nature reserves (e.g. Nzehelele Nature Reserve) and/or agricultural holdings for either livestock rearing or crop cultivation, especially further upstream in the catchment area (near Waterpoort).

Table 54: Identified cumulative impacts within the study area

Nature: The numerous impacts associated with the power generation industry (including mining operations), especially toward contamination of surrounding watercourses is a well-documented phenomenon and this is expected to be amplified should a number of complexes be operating in close proximity. In addition, the potential impacts of surrounding agricultural activities upon the receiving watercourses are known to alter the characteristics of the system and the biological composition is subsequently affected. While the effects of game farming and trophy hunting lodges are not likely to present severe impacts upon the associated systems, the conventional farming practices, such as livestock rearing and crop cultivation concentrated closer to Waterpoort, are expected to affect water availability and quality (e.g. abstraction, nutrient runoff, etc.).		
	Without mitigation	**With mitigation**
Extent	Local (3)	No feasible mitigation measures proposed.
Duration	Long-term (4)	
Magnitude	Low (4)	
Probability	Probable (3)	
Significance	**Medium (33)**	
Status (positive or negative)	Negative	
Reversibility	Medium	
Irreplaceable loss of	Yes	

resources?		
Can impacts be mitigated?	Yes	No
Mitigation: ▪ Unless the overall density of mining and agricultural activities can be reduced (e.g. decommissioning of surrounding collieries), no feasible mitigation measures were proposed at the time of writing. It is envisaged the cumulative impacts will only be amplified within the near future should all pending authorisations be granted.		
Residual Risks: No residual risks associated with decommissioning, closure and rehabilitation.		

While the cumulative impact associated with the power generation industry following the commissioning of the proposed power plant is currently regarded as minimal to low, there is a potential for a number of imminent impacts that might be overlooked. Despite the temporary nature of many of the associated watercourses within the study area, there remains sufficient evidence of notable impacts upon the flow regulation within the Sand River (e.g. abstraction points, weirs, impoundments, etc.). In light of the semi-arid nature of the study area and the water scarcity within the catchment, hence the elevated impact score of Medium significance. This is a cause for potential concern and other available water-friendly technologies should be implemented wherever possible.

The proposed ash dump is an expected source of notable potential contamination, as any contamination is likely to accumulate within the downstream impoundments and potentially reach the main stem Sand River over time, especially if Option 2 is the preferred alternative. However the significance of this potential impact is reduced to negligible in the event that the ash dump is lined, compacted and rehabilitated post-closure, as well as an additional ash run-off dam is installed at all potential seepage points (e.g. north-west of northern portion of ash dump in Option 2).

8.3.4.2 Wetlands

The cumulative impacts are assessed considering the project area and its surroundings (within a 25 km radius). The freshwater resources in this quaternary catchment are currently under pressure as a result of mining related activities observed north east of the Project area, with the closest located approximately 6 km east. Approximately 12 km south east of the project area there are more mining activities. In addition, extensive farming and irrigation activities along the Limpopo and Sand Rivers are placing increasing strain on the aquatic resources present.

The ash dump at the project area is an expected source of contamination. The project footprint for all three infrastructure options is likely to reduce the catchment yield, which is likely to affect surface water recharge to the systems further downstream. In addition impacts such as sedimentation and impaired water quality as a result of surface water runoff, has the potential to reduce the biodiversity and loss of habitat of the freshwater and wetland systems present. Cumulative losses in biodiversity and habitat will result in a loss of sensitive systems as a whole within the greater catchment.

Table 55: Identified potential cumulative impacts identified

Nature: Cumulative catchment-wide impacts include the following: ▪ Loss of catchment yield; ▪ Contamination of water quality; ▪ Loss of habitat and biodiversity; and ▪ Loss of surface water recharge.		
	Without mitigation	**With mitigation**
Extent	Regional (4)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	Very High (10)	High (8)
Probability	Probable (3)	Probable (3)
Significance	**High (54)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes
Mitigation: The following mitigation and management measures have been prescribed to prevent and minimise cumulative impacts as a result of the loss of the ephemeral systems which occur in the vicinity of the three proposed infrastructure layout options: ▪ Optimise the placement of infrastructure to minimise impacts to the freshwater resources present; ▪ Clean and dirty water separation systems to be implemented prior to the commencement of activities and to be maintained throughout the life of the		

proposed project;

- Ensure that as far as possible all infrastructures are placed outside of freshwater areas and their associated 32 m zone of regulation;
- Limit the footprint area of any project related activities to what is absolutely essential in order to minimise impacts as a result of any potential vegetation clearing and compaction of soils (all areas but critically so in freshwater areas);
- If it is absolutely unavoidable that any of the freshwater areas present will be affected, disturbance must be minimised and suitably rehabilitated;
- Ensure that no incision and canalisation of the freshwater features present takes place as a result of the proposed project activities;
- All erosion noted within the project footprint as a result of any potential surface activities should be remedied immediately and included as part of the ongoing rehabilitation plan;
- Erosion berms should be installed on roadways and downstream of stockpiles to prevent gully formation and siltation of the freshwater resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed;
  - Where the track slopes between 2% and 10%, berms every 25m should be installed;
  - Where the track slopes between 10%-15%, berms every 20m should be installed; and
  - Where the track has slope greater than 15%, berms every 10m should be installed.
- A suitable AIP control programme must be put in place so as to prevent further encroachment as a result of disturbance to the surrounding terrestrial zones;
- Permit only essential personnel within the 32 m zone of regulation for all freshwater features identified;
- All areas of increased ecological sensitivity should be designated as "No-Go" areas and be off limits to all unauthorised vehicles and personnel;
- No unnecessary crossing of the wetland features and their associated buffers should take place and the substrate conditions of the wetlands and downstream stream connectivity must be maintained;
- No material may be dumped or stockpiled within any of the ephemeral drainage lines in the vicinity of the proposed project footprint;
- No vehicles or heavy machinery may be allowed to drive indiscriminately within any freshwater areas and their associated zones of regulation. All vehicles must

remain on demarcated roads; ▪ All vehicles must be regularly inspected for leaks; ▪ Re-fuelling must take place on a sealed surface area away from freshwater features to prevent ingress of hydrocarbons into topsoil; ▪ All spills should be immediately cleaned up and treated accordingly; ▪ Appropriate sanitary facilities must be provided for the duration of the proposed project and all waste must be removed to an appropriate waste facility;

8.3.4.3 Groundwater

The cumulative impacts are assessed considering the project area and its surroundings (within a 25 km radius, presented in Figure 31). The area falls within the Limpopo WMA within quaternary catchment A71K.

The groundwater quality of the broader study area currently indicates impact by mining related activities. Unspecified mining related activities are present predominantly in the north east quadrant in relation to the project area, with the closest located approximately 6 km east of the proposed project site. More mining activities are located approximately 12 km south east of the project area.

The ash dump at the project area is an expected source of contamination. Private borehole users and surface water bodies (through baseflow) are potential receptors. The intensity of the potential impact to the surface water bodies is reduced due to the surrounding rivers being non-perennial.

The ash dump and coal stockpile may contribute to the groundwater quality deterioration, however, the significance of this potential impact to the groundwater is reduced to negligible, if:

- The ash dump is lined, compacted and rehabilitated post-closure; and
- The coal stockpile is lined and compacted.

8.3.4.4 Surface Water

Water quality along the Sand River, which is the main river within the affected quaternary catchment, has shown elevated levels of pH, Electrical Conductivity (EC), chloride, magnesium and sodium resulting from irrigational runoff associated activities. Impacts from the proposed project may contribute to a further degradation of water quality in this WMA with the current and proposed project for the area.

Table 56: Identified potential cumulative impacts identified

Nature: Although the affected quaternary catchments have limited industrial and mining activities, water quality monitoring along the Sand River indicates elevated levels of various salts which were above the SAWQG limits. Impact from the proposed coal-fired power station may contribute to a further deterioration of water quality in the Limpopo WMA.

	Cumulative Contribution of Proposed Project	**Cumulative Impact without Proposed Project**
Extent	Regional (4)	Regional (4)
Duration	Short term (1)	Short term (1)
Magnitude	High (8)	Moderate (6)
Probability	Highly probable (4)	probable (3)
Significance	**Medium (52)**	**Medium (33)**
Status (positive/negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Low	Low
Can impacts be mitigated?	Yes	Unknown

Mitigation:

This cumulative impact can be prevented or minimised by implantation of the measures. These include but are not limited to:

- All runoff emanating from the dirty water areas which include hazardous storage facilities will need to be diverted to the containment facility e.g. a sump prior to construction of the runoff/storm water dams;
- All spillages must be contained to the smallest possible area and must be cleaned immediately; and
- All construction equipment shall be put onto a maintenance program, including daily inspection of the equipment.
- The constructed storm water infrastructure will have to remain until post closure. This will ensure that dirty water is captured and contained during removal of infrastructure and thereby prevent siltation and contamination of the river;
- All the dirty water runoff emanating from dirty areas (ash dump, plant and coal stockpile areas) should be contained within the dirty water dams. This water should be stored for re-use within the power plant so as to prevent unnecessary discharge into the environment;
- Clean water emanating from upstream of the project area must be diverted away

and discharged to the nearby watercourse or environment.

- All spillages must be contained to the smallest possible area and must be cleaned immediately. Although there is no mitigation for this loss of catchment yield, the extent or overall loss for the two catchments (less than 1%) will be insignificant; and
- Clean water from the upstream catchment will be diverted around site and report to natural environment or streams.
- All rehabilitated areas must be vegetated. Until vegetation has successfully been established, sedimentation should be mitigated by installing silt traps at areas where the surface runoff enters the surface water resources;
- The surface profile of the rehabilitated area should try and resemble the natural conditions prior to the project, this should ensure that the surface profile encourages natural drainage, such that no ponding or standing water occurs after a rainfall event.

9 UNPLANNED EVENTS AND LOW RISK

The unplanned events that may happen at the project site and the proposed mitigation plans are listed in Table 57.

Table 57: Unplanned events, low risks and their management measures

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Hydrocarbons and any hazardous material spillage	Contamination	Major vehicles maintenance must only be conducted within designated service bays. The management of hazardous waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites. The fuel, lubricants and hazardous waste storage facilities must be located on a hard standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilization of leaked hazardous substances. An emergency spillage response plan and spill kits should be in place and accessible to the responsible monitoring team. The Material Safety Data Sheets (MSDS) should be kept on site for the life of the project for reference to anytime in terms of handling, storage and disposal of materials.
Spillage or seepage from the ash dump or ash run-off dam	Deterioration of water quality and aquatic biodiversity	▪ In the case where a spill (or seepage) is detected, this water should be diverted away from natural watercourses and treated before being released into the environment. ▪ A liner to be installed beneath ash and wastewater storage areas to prevent seepage.
Overflowing of	Contamination	As required by the GN704, the constructed

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
dams if a rainfall of more than 1:50 year occurs		dams must maintain and operate to have a minimum freeboard of 0.8 metres above full supply level to reduce the chances of overflowing during a rainfall event of more than 1:50 year.

10 ENVIRONMENTAL MANAGEMENT PROGRAMME

The objective of an Environmental Management Programme (EMPr) is (a) to manage undue or unavoidable adverse impacts associated with the development of a project and (b) to enhance potential positives, if any.

This study has identified the groundwater impacts that may occur as a result of the proposed Mutsho Power Project and associated infrastructure development. These activities could negatively impact the local water resources by the deterioration of water quality. The risk of the potential impacts to the water quality will be significantly reduced by the installation of an appropriately designed liner at the ash dump. The Impacts, Objectives and Outcomes of the EMPr and Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law are presented in Table 58 and Table 59

Table 58: Impacts, Objectives and Outcomes of the EMPr

Project component/s	Potential Impact	Activities	Mitigation: Target/Objective	Responsibility & Timeframe	Performance Indicator	Monitoring
Coal-fired Power plant and Associated Infrastructure (construction phase)	Siltation of the water course leading to the deterioration in water quality	Site clearing, stripping of topsoil, conducting earthworks / terracing, and excavation for foundations etc.	Clearing of vegetation must be limited to the development footprint and the use of existing access roads must be prioritized so as to minimise construction of new access roads in these areas If possible, construction should be undertaken during the low rainfall season (April to September) to minimise erosion and sedimentation/siltation of the water course. Any construction work that involves site clearance, digging, excavation or trenching during construction services should be suspended during heavy rains to avoid erosion and sedimentation of the water course. When wet season construction cannot be avoided, sedimentation control measures, such as sedimentation basins or any silt trap method should be in place during construction activities. Dust suppression measures must be undertaken on the cleared areas during construction. Dirt roads must be well compacted to avoid erosion of the soil into the natural water course.	Environmental Officer Developer/Contractor To be implemented throughout the duration of construction phase	Development on the project footprint only No signs of erosion on site No signs of dust emanating from site	Frequent checks (e.g. Weekly) should be conducted to ensure mitigation measures are in place and the effectiveness will be verified through assessing the performance indicators
		Site clearing, stripping of topsoil, conducting earthworks / terracing, and excavation for foundations etc.	Minimise and keep the construction footprint as small as possible. Revegetation of the construction footprint as soon as possible. Storm water should be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow. Construction should take place during the dry season to minimise runoff. Sequential removal of the vegetation (not all vegetation immediately).	Environmental Officer & Developer/Contractor Construction Phase	Development on the project footprint only No additional signs of erosion on site.	Weekly

Project component/s	Potential Impact	Activities	Mitigation: Target/Objective	Responsibility & Timeframe	Performance Indicator	Monitoring
Site clearing, stripping of topsoil, conducting earthworks / terracing, and excavation for foundations etc.	Runoff containing pollutants and solid waste entering the surrounding watercourses cause deterioration in water and habitat quality	Hydrocarbons spills, general and hazardous material	The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites. The fuel storage facilities must be located on a hard standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilization of leaked hazardous substances. An emergency spillage response plan and spill kits should be in place and accessible to the responsible monitoring team. The Material Safety Data Sheets (MSDS) should be kept on site during construction for reference to anytime in terms of handling, storage and disposal of materials.	Environmental Officer Developer/Contractor To be implemented throughout the duration of construction phase	No signs of spillages on site Maintenance of vehicles and machinery on a regular basis Spillage kits put in place	Frequent checks (e.g. Weekly) should be conducted to ensure mitigation are in place and the effectiveness will verified through assessing the performance indicators
		Waste generation/disposal and working with hazardous products	▪ Ensure correct waste management (including domestic refuse, sewage, spillages, etc.); ▪ Ensure correct storage systems are used for the storage of hazardous products when constructing.	Environmental Officer Throughout the operation from Construction to Post-Closure phase.	No evidence of litter within the study area. No spillage incidents leading to contamination of surrounding watercourses.	Monthly
	Lowering of the watertable	Digging of foundations and instillation of liner	In areas where the foundation of structures is to be installed below the water level, dewatering of the aquifer to locally lower the watertable can be considered. The abstracted water can be utilised for dust suppression, vegetation or discharged to the storm water dams. However should all construction activities take place above the water table, there will be no impact to the groundwater. Installation of an appropriate liner at the ash dumps and coal stockpile.	Environmental Officer Developer/Contractor To be implemented throughout the duration of construction phase	Development on the project footprint only	Daily checks should be conducted to ensure mitigation is in place and the effectiveness are verified through assessing the performance indicators

Project component/s	Potential Impact	Activities	Mitigation: Target/Objective	Responsibility & Timeframe	Performance Indicator	Monitoring
	Sedimentation of downstream freshwater systems, resulting in impaired water quality	Construction and Operational related activities	Mitigation measures should ensure that no loss of ecological integrity takes place for the wetlands or any of the other freshwater features both within the proposed project area, as well as in the surrounding wetlands and freshwater systems further downstream.	Environmental Officer Developer/Contractor To be implemented throughout the duration of construction phase	Development on the project footprint only and operational phase checks	Daily checks should be conducted to ensure mitigation is in place and the effectiveness are verified through assessing the performance indicators
Disposal of ash on to ash dump and storage of coal onto coal stockpile (operational phase)	Groundwater contamination	The main impact that a power generation facility may have is from ash disposal and coal stockpile on the surface. However, such impacts are expected to be negligible with the application of a liner, together with a dry ash disposal.	Coal compaction prior deposition onto the coal stockpile. Should an impact be detected through monitoring, affected receptors should be compensated. Monitoring for surface and groundwater resources. Instillation of a liner system.	Environmental Officer Developer/Contractor To be implemented throughout the duration of project life	Ensure the implementation of an appropriately designed liner at the ash dump and coal stockpile, and dry ash deposition	Daily checks should be conducted to ensure mitigation is in place and the effectiveness are verified through assessing the performance indicators
Storage of fuel and lubricants, storage of coal, operation of pollution control dam and storm water management systems, ash disposal, generation and removal of domestic and hazardous waste, operational use of ash dump, pipeline transportation of	Operational Phase	Water contamination due to dirty water runoff reporting into the surrounding streams	Containment of dirty water runoff via the storm water channels into the runoff/storm water dams for re-use. Should the contained water be more than the water use requirement, BPGs advise that the water be recycled or as the last resort be treated to acceptable levels and discharged either to the natural environment or be supplied to other industries as a lower grade of water. Clean water emanating from upstream of the project area must be diverted away to the nearby natural environment.	Environmental Officer Developer/Contractor To be implemented throughout the duration of project life	No signs of spillages on site No signs of erosion on site Maintenance of vehicles and machinery on a regular basis Spillage kits put in place	Frequent checks (e.g. Weekly) should be conducted to ensure mitigation are in place and the effectiveness will verified through assessing the performance indicators

Project component/s	Potential Impact	Activities	Mitigation: Target/Objective	Responsibility & Timeframe	Performance Indicator	Monitoring
sewage and water.	Contamination of downstream watercourses through seepage from ash dump and ash runoff dam	Day to day operation of the power station, including ash disposal and storm water management	Ash should be conveyed directly to the ash dump, compacted, shaped and rehabilitated to prevent any potential contamination; Ash dump and ash-runoff dam should be lined with impermeable liners to prevent potential seepage into downstream watercourses Separate clean and dirty water systems should be engineered to discharge into streams and a proposed PCD, respectively; PCD should be over-engineered to include impermeable liner to prevent any potential seepage; Water within the PCD should be utilized within the operational area to facilitate the evaporation of the accumulated dirty water (e.g. dust suppression activities)	Environmental Officer Throughout the operation from Operational to Post-Closure phase.	Ensure no accumulated ponds/pools of water are present on-site.	Weekly/Monthly
Colonisation of Alien Invasive Plant Species as a result of disturbance to the project site.	Colonisation of Alien Invasive Species	Clearing related activities.	Implementation of an Alien Invasive Management Control Plan.	Environmental Officer	Adherence to plan	Quarterly checks
Decommissioning activities (demolition of power plant, rehabilitation of an area, generation and disposal of demolition waste and rehabilitation of access roads)	Decommissioning and closure	Siltation and contamination of natural water resources	Use of accredited contractors for removal or demolition of infrastructures. Re-vegetation of the rehabilitated area to ensure good drainage surface profile. The constructed dirty water channels will have to remain until post closure. This will ensure that dirty water is captured and contained during removal of infrastructures.	Environmental Officer Developer/Contractor To be implemented throughout the duration of decommissioning and closure phase	Decomissioning activities occurring within the project footprint only No signs of erosion on site No signs of dust emanating from site	Frequent checks (e.g. Weekly) should be conducted to ensure mitigation are in place and the effectiveness will verified through assessing the performance indicators

Project component/s	Potential Impact	Activities	Mitigation: Target/Objective	Responsibility & Timeframe	Performance Indicator	Monitoring
Presence of ash dump (decommissioning and post-closure	Groundwater contamination post closure	Rain water seeping through the ash dump is expected to dissolve contaminants and that would pollute the groundwater. The risk of leachate generation and its threat to the groundwater environment can be minimised by the liner and rehabilitation of the dump. A well-managed dry ash dump poses minimal threat to groundwater contamination (Hodgson et al. 1998)	The impact could be moderate with the liner installed and the ash dump rehabilitated. Formation of the pozzolanic layer is additional mitigation that occurs naturally over time. Continuous post-closure monitoring is required so that drastic deterioration in groundwater quality is detected soon as it occurs, allowing for mitigation measures to implemented early. Should an impact be detected through monitoring, affected receptors should be compensated.	Environmental Officer Developer/Contractor To be implemented throughout the duration of post-closure phase	Continuous post-closure monitoring of water quality changes	Monitoring for a period of 5 years with respect to vegetation establishment on the dump and then groundwater monitoring for a further 5 years.
	Contaminated surface runoff and elevated runoff velocities are likely to affect receiving watercourses.	Demolition and removal of the infrastructure will lead to potential negative impacts on the integrity of the associated aquatic ecosystems	Demolition activities should take place during the dry season to minimise runoff; and Sequential removal of infrastructure and subsequent revegetation should be conducted during the closure process.	Environmental Officer & Developer/Contractor Decommisioning and Post-Closure Phase	Contaminated surface runoff and elevated runoff velocities are likely to affect receiving watercourses.	Demolition and removal of the infrastructure will lead to potential negative impacts on the integrity of the associated aquatic ecosystems

Table 59: Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law

Specialist field	Applicable Standard, Practice, Guideline, Policy or Law	
Surface Water	National Water Act no 36 of 1998.	Department of Water Affairs and Forestry, 2006, "*Best Practice Guideline No. G1: Storm Water Management*". Department of Water Affairs and Forestry, 2000. Operational Guideline No. M6.1. Guideline document for the implementation of regulations on use of water for mining and related activities aimed at the protection of water resources. Second Edition.
Groundwater	National Water Act, 1998 (Act No. 36 of 1998).	Republic of South Africa, 2013. Government Gazette, 634(36784): August 23. Department of Water and Sanitation (DWS) (formerly DWAF). 2006. Best Practice Guideline G3: Water Monitoring Systems.

11 MONITORING

11.1 Aquatic Biomonitoring Programme

Based on the field survey undertaken, it is expected that these systems are highly likely to be dry throughout most of the year and as a result, it is suggested that an adaptive biomonitoring plan (inlcuding varied assessment indices and deceased frequency) be applied should the development be commissioned. The following table presents a tentative biomonitoring programme within the receiving watercourses:

Table 60: Proposed aquatic biomonitoring programme

Indicator	Proposed Frequency	Applicable Monitoring Sites
In situ water quality	Annually (wet-season)	If possible, assess the following sites: • Site VR1 and Site VR3; • Site DU3 and Site DU4, and • Site SR1 and Site SR2.
Invertebrate Habitat Assessment System (IHAS)	Annually (wet-season)	
Index for Habitat Integrity (IHI)	Annually (wet-season)	

Indicator	Proposed Frequency	Applicable Monitoring Sites
South African Scoring System (SASS) and Macroinvertebrate Response Assessment Index (MIRAI)	Annually (wet-season)	
Fish Community and Fish Response Assessment Index (FRAI)	Annually (wet-season)	
Integrated EcoStatus4	Annually (wet-season)	

While limited baseline data is available (excluding riparian habitat conditions) following this report, both spatial and temporal trends should be assessed within the study area to establish any annual variation. Also, the collection of diatom assemblages analysis at each of the aforementioned sampling sites should be considered in the event that these sites are not conducive to the intended monitoring programme (e.g. low water levels, insufficient habitat, etc.).

In addition, since the impoundments are likely to yield an improved probability of holding a limited volume of water for extended periods of time, it would be valuable to determine the potential toxicity of various aspects within the study area, if any.

Table 61: Proposed toxicity analysis monitoring programme

Indicator	Proposed Frequency	Applicable Monitoring Sites
Toxicity Assessment (Screening-level) of four biological levels	Annually (wet-season)	If possible, assess the following sites: • Site DU3 and Site DU4, and • Site SR1 and Site SR2.

It should be noted that the proposed biomonitoring programme should be reassessed following the final selection of the infrastructure layout should the development be authorised to be commissioned, as it may not be necessary to monitor the sensitive sites associated with the Du Toit farm (e.g. the downstream impoundments) if the infrastrucure remains within the south-eastern catchment area. With regards to the proposed alternatives, this would only be applicable if Option 2 was selected as an alternative. Although it is acknowledges that both other option may yield minor impacts upon the catchment and should anything be flagged during the monitoring phase, toxicity assessment should be re-considered for strategic implemention.

11.2 Wetland Monitoring

The health of the wetlands and the fresthwater systems as indicated in this report as well as in the desktop target ecological categories should be used as a baseline ecological management target going forward.

Monitoring of the wetlands and freshwater systems occurring within the project area, as well as in the vicinity of the proposed infrastructures should be monitored annually to determine any deviations from the baseline ecological state. These assessments should form part of an annual monitoring programme, which is to be implemented for the life of the proposed project.

11.3 Groundwater Monitoring

Groundwater monitoring should be undertaken to establish the following impacts of the ash dump and coal stockpile on the groundwater environment:

- Groundwater quantity trends, through monitoring of groundwater levels and is standard practise and will be a requirement with respect to the Water Use Licence; and
- Groundwater quality trends, through sampling.

Groundwater quality should be monitored because potentially contaminating leachate from the ash dump and stockpile may reach the local aquifer. Groundwater levels should be monitored because groundwater level recovery may occur if private boreholes cease abstraction; recovery (depending on the extent) may result in baseflow feeding the local streams and if the water quality if found to have deteriorated, the local streams may be impacts by project activities.

A total of 5 monitoring locations are recommended for groundwater monitoring; 2 existing and 3 to be drilled, shown in Figure 32 in relation to layout option 1.

Borehole selection was based on groundwater flow direction. Some located downstream to monitor potential contamination migration by advection and others located upstream in order to monitor potential contamination migration by dispersion (migration driven by a concentration gradient). Priority was given to existing boreholes from financial perspective. The depth of the boreholes is recommended to be approximately 40 m taking into consideration the local water levels.

Table 62: Recommended monitoring boreholes

Borehole ID	Latitude	Longitude	Comment
VRIBH2	-22.702	29.82695	Existing
DUTBH1	-22.6769	29.80434	Existing
MUTBH1	-22.6670	29.8179	New
MUTBH2	-22.689	29.839	New

Borehole ID	Latitude	Longitude	Comment
MUTBH3	-22.669	29.839	New

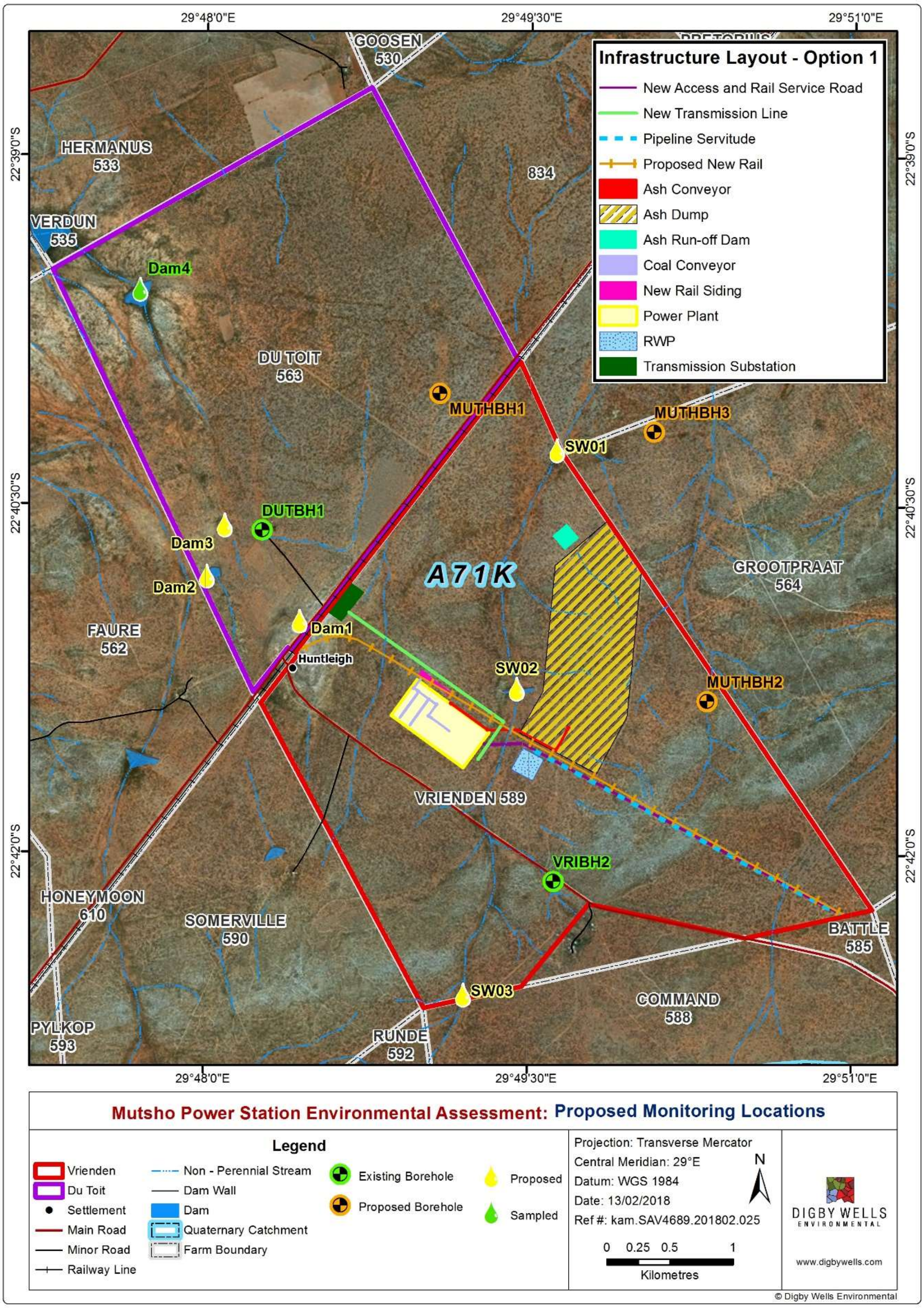

Figure 32: Proposed groundwater and surface water monitoring network

11.3.1Water Level

Groundwater levels must be recorded bi-annually to detect any changes or trends in groundwater elevation and flow direction. It is important to understand if the ash dump is impacting upon the water levels, thus it is recommended that this be undertaken.

11.3.2Water Sampling and Preservation

When sampling the following procedures are proposed:

- One (1) litre plastic bottles with a cap are required for the sampling exercises;
- Glass bottles are required if organic constituents are to be tested;
- Collected samples must be stored in cooler box or fridge while on site; and
- Sample bottles should be marked clearly with the borehole name, date of sampling, sampling depth and the sampler's name and submitted to a SANAS accredited laboratory.

11.3.3Sampling Frequency

Groundwater is a slow-moving medium and drastic changes in the groundwater composition are not normally encountered within days. Considering that the ash dump and coal stockpile facility will be lined and that the water level is at a reasonable depth currently, water quality monitoring should be conducted quarterly to reflect influences of wet and dry seasons. The sampling frequency could be adjusted based on the water quality trend analysis. Water quality trend analysis will serve as detection of rapid of slow water quality deterioration (if any changes occur at all).

Samples should be collected by using Water Research Commission (WRC), 2007, Groundwater Sampling: A Comprehensive Guide for Sampling Methods and should be analysed by a SANAS accredited laboratory.

It is suggested that the monitoring frequency established during the operational phase (after adjustments are made based on observing trends) be maintained post-closure until satisfactory groundwater quality is reached and thereafter signed off by the relevant authorities. Satisfactory groundwater quality is when stable quality trends are observed overtime, stability regarding the absence of water quality deterioration.

11.3.4Parameters to be Monitored

- TDS, EC, pH, Alkalinity;
- Major ions i.e. Ca, Mg, Na, K, SO4, NO3, F, Cl; and
- Minor and trace metals, including As, Al, Co, Cr, Zn, Cd, Cu, Fe, Ni, V, Mn.

11.3.5Data Storage

During any project, good hydrogeological decisions require good information developed from raw data. The production of good, relevant and timely information is the key to achieve qualified long-term and short-term plans. To minimize groundwater contamination, it is necessary to utilize all relevant groundwater data.

The generation and collection of this data is very expensive as it requires intensive hydrogeological investigations and therefore the data has to be managed in a centralised database to optimize on cost efficiency. Digby Wells has compiled a WISH-based database during the course of this investigation and it is highly recommended that the applicant utilise this database and continuously update and manage it as new data becomes available.

11.4 Surface Water Monitoring

A monitoring programme is essential as a management tool to detect any flaws as they arise and to ensure that the necessary mitigation measures are implemented. It also ensures that storm water management structures are in working order. Monitoring should be implemented throughout the life of the power plant.

Water quality monitoring within the power plant area should be conducted to determine the quality of water circulating within the system. This will help to understand the suitability of water in times where excess water needs to be discharged into natural streams. The monitoring programme is detailed in Table 63.

Table 63: Surface Water Monitoring Programme

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Grab samples should be collected from the monitoring points indicated on Figure 32 Ensure that monitoring of water circulating within the system is conducted (water within the runoff/storm water dams). Water quality parameters to be analysed include, but not limited to: Alkalinity, Cl, SO_4, NO_3, PO_4, NH_4, F,Ca, Mg, Na, K, Fe, Al, Mn, Cr, Cu, Ni, Pb, Zn, Cd, Co pH & Conductivity Total Hardness	Monthly	Environmental Officer

Monitoring Element	Comment	Frequency	Responsibility
Physical structures and storm water management infrastructure performance	Personnel should have a walk around facilities to determine the facilities conditions and pick out any anomalies in the storm water management systems such as blockages or overflows.	Weekly monitoring and immediately after extreme rainfall events. This will ensure that leaks and overflows are detected immediately before a significant impact occurs.	Environmental Officer / Any Designated personnel
	Dams are inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.	Monthly with the general maintenance schedule at the power plant.	
Meteorological data	Measure rainfall.	Real time automatic weather system if in place, otherwise collect rainfall readings after every rainfall event on a daily basis.	Environmental Technician Sampler

12 CONSULTATION UNDERTAKEN

Consultation with the farm owners in and around the project area was conducted before and during the site visits. Some of the farm owners assisted with granting access and others also accompanied the specialists around the site.

12.1 Comments and Responses

Comments from interested & affected parties have not been received. The comments from stakeholders and responses will be included in the public participation report.

13 SPECIALIST CONCLUSIONS AND RECOMMENDATIONS

13.1 Aquatics Conclusion

With the exception of Site DU3, each of the selected sampling sites was observed to be dry at the time of the survey despite the rains expected throughout the summer months. While this was to be expected as a result of the semi-arid nature of the study area and in light of the drought experienced across much of the country during the previous two years, only selected parameters could subsequently be measured and a limited number of assessment indices could be applied at the time of the survey. This was a notable limitation to the baseline assessment, as the only site that could be assessed was characteristic of a lentic (or standing) system, which inherently supports a lower diversity of aquatic biota, and as such, provides no insight regarding the Present Ecological State (PES) of two of the biological components (i.e. aquatic macroinvertebrates and fish) of the associated watercourses, as well as in the overall integrated EcoStatus. Consequently, for the purpose of determining a PES at the time of the survey, the only available desktop data indicated that the mainstem Sand River is representative of a moderately modified condition (i.e. Ecological Category C). This was largely confirmed by the small- to large- impacts originating from surrounding land-use activities, including the most notable agricultural activities (i.e. crop cultivation and livestock watering).

With regards to the mainstem Sand River, the Ecological Importance was defined to be high due to a moderate-to-high likelihood of occurrence for *Oreochromis mossambicus* (listed as Near Threatened) during periods of flow, a moderate-to-high representivity and rarity within the secondary catchment, as well as the occurrence of the study area within a Fresh Water Ecosystem Priority Area and provincially determined Ecological Support Area 1. Also, the Ecological Sensitivity was defined to be moderate-to-high, which was attributed to an elevated number of highly sensitive flow-dependent species, a number of species that were regarded as moderate-to-highly sensitive to water quality impairment, and a riparian vegetation component is well adapted to the fluctuating water levels within the associated alluvial system.

A number of moderately significant potential impacts were to be expected within the associated ephemeral drainage areas, as well as further downstream along the Sand River and adjoining tributaries. However, in general, the impact is expected to be limited to the proposed development area following the application of the proposed mitigation and minimisation measures, which results in only rare potential effect upon the mainstem portion of the Sand River, pending an extended contamination event. With regards to cumulative impacts, the proposed development is not likely to detrimentally impact the associated catchment, but it is acknowledged that a number of activities already place additional stress on the study area in terms of surface water availability (e.g. mining-related impacts, crop cultivation and livestock watering).

Should each of the recommended mitigation measures be implemented, it is the opinion of the aquatic ecologist that there will be a limited (or low) impact upon the associated aquatic biodiversity of the surrounding watercourses. However, changes to the inherent flow and/or inundation dynamics of the associated watercourses in direct vicinity of the project are to be expected, which is likely to affect the presence of confirmed microfauna within these system (including seed bank for branchiopod crustaceans). Also, should this project be authorised pending reasoned opinions from other Specialist Studies (especially groundwater investigation), a suitable aquatic biomonitoring programme should be drafted and implemented to determine seasonal (or annual) variation and to identify any causes for potential concern during the operational and post-closure phases of the operation.

Based on the largely desktop-determined baseline condition of the associated watercourses, the author is in agreement that the preferred development area should be concentrated upon Farm Vrienden 589 due to the presence of a denser network of ephemeral system within Farm Du Toit 563, especially concentrated within the north-western portion. Furthermore, in light of each of the proposed infrastructure layouts, the author is of the opinion that the impacts upon the associated watercourse (or ephemeral drainage lines) would be least affected by the implementation of Option 1. The major infrastructure (i.e. the ash dump and the proposed access route) will then be situated within the smaller eastern catchment and as a result, less likely to impact upon the mainstem Sand River should potential contamination occur. While it is acknowledged that a limited extent of fragmentation is to be expected with any of the proposed design layouts, the inherent nature of the upper reaches of these systems is not likely to support notable macro-fauna (i.e. macroinvertebrates and fish).

13.2 Wetland Conclusion

Two HGM units were identified in the vicinity of the project area, both characterised as pan wetlands. However, most of the freshwater features within project area consist of ephemeral drainage lines that cannot be defined as wetland or riparian resources. The freshwater features cover an approximate 147.5 ha.

The wetlands within the Project area exhibit Category B (*Largely Natural*) and Category C (*Moderately Modified*) PES values. The pans have not been impacted on to a great extent aside for grazing which alters the vegetation structure and composition. The geomorphological and Hydrological health has been altered minimally. The ephemeral drainage lines are considered to be Category C. They are mostly impacted on hydrologically due to the presence of earthen dams, which restrict the flow of water downstream. The geomorphological score was not impacted on greatly as the only impact was sediment deposition in the dams. Vegetation scores were not altered to a great extent.

EIS scores range from *Very High* (3.7) to *High* (2.5). Hydrological/Functional Importance' values were low as the pans don't perform well for streamflow regulation, erosion control, sediment trapping or phosphate assimilation. The drainage lines also have limited hydrological function in terms of true wetland systems. However, in terms of catchment yield and surface water recharge to the systems further downstream, as well is in the maintenance of healthy stormwater regulation, these systems are considered invaluable. 'Ecological Importance & Sensitivity' for the HGM unit 2 and 3 is Very High as various protected species are present within them or in close proximity. 'Direct Human Benefits' were not high in general. These features are not used culturally or recreationally. The HGM units are utilised for grazing and for watering of cattle and game. The score is higher for the drainage lines as some are dammed and the water is utilised by the farm owners.

EcoServices scores for the various HGM Units range from 1.3 to 1.6 (*Intermediate*).The HGM units provide similar EcoServices. Biodiversity maintenance through the harbouring of protected species, the provision of water sources and the provision of grazing land are important EcoServices. The drainage lines provide surface water recharge and trap sediment. The farms are not accessible for tourism, educational and cultural purposes and as such are not used for these purposes. Historical hunting activities were evident; however, through communication with ground staff, this is no longer common. Due to the nature of the systems, flood attenuation and streamflow regulation is low.

The proposed project has the potential to result in a number of impacts that can be considered to be 'medium' once appropriate mitigation measures are implemented.

13.3 Groundwater Conclusion

The outcomes of the groundwater impact assessment and associated investigations are the following:

- During the hydrocensus conducted by Digby Wells (January 2018) water levels on site were recorded to range between 23.25 and 35.68 mgbl. Groundwater flow direction on site is found to be towards the north-west.
- Samples were collected and taken to the laboratory for chemical analysis and compared against SAWQG for irrigation and domestic use. All boreholes (5) do not exceed the SAWQG for irrigation however all exceed domestic use standards. Evaluations indicate the following:
  - VRIBH1 exceeds domestic use standards for fluoride;
  - VRIBH2, DUTBH1, DUTBH2 and DUTBH3 exceed domestic use standards for sulphate; and
  - VRIBH1, VRIBH2, DUTBH1 and DUTBH2 exceed domestic use standards for magnesium.
- No boreholes were found to be in excess of the SAWQG for irrigation which is the local groundwater use of all the boreholes with the exception of DUTBH1;
- Groundwater characterisation was conducted and the groundwater quality at VRIBH1 and DUTBH3 are identified to be calcium-magnesium-bicarbonate type which is typically found at freshly recharged aquifers. VRIBH2, DUTBH1 and DUTBH2 are characteristic of calcium/sodium sulphate waters which associated with mining activities; mining activities are observed within a 25 km of the project area.
- The current water quality conditions at the project area are not pristine; this is consistent with the description of the regional hydrogeology. The region is expected to have poor water quality naturally. Additionally, impacts from mining activities are also observed in the water chemistry.
- All private boreholes with the exception of VRIBH2 are located downstream the ash dump and should be monitored. Losing stream groundwater-surface water interaction is expected at the project area therefore the local non-perennial streams aren't expected to receive the contamination plume via baseflow.

- Analytical model predictions indicate that seepage from both the ash dump and coal stockpile is expected to reach the watertable after approximately 7 years of operation without a liner.
- The liner simulated in the model scenario is a Class C liner, this is assumed based on experience from expected ash material geochemistry. This may vary based on the outcomes of the recommended geochemical studies to be conducted.
- The installation of a liner is observed to restrict leachate seepage significantly and therefore negligible impacts to the groundwater are expected with the installation of a liner.
- Formation of the pozzolanic layer is additional mitigation (to the installation of a liner) and it occurs naturally over time, therefore leachate formation is expected to cease at a certain point therefore reducing the risk to the groundwater over time post-closure.

Based on the groundwater impact assessment conducted for the proposed Mutsho Power Project the following recommendations are made to mitigate and manage any potential impacts to the groundwater:

- Drilling and aquifer testing of boreholes is recommended to obtain site-specific hydraulic parameters to improve model accuracy with respect to groundwater related impacts. This data would be required in order to accurately simulate what will happen with contamination plumes and the type of liner that would be required.
- Geochemical studies and waste classification is recommended to determine the elements of concerns and expected leachate quality from the ash material. This will be the basis on which liner recommendations can be made during final design.
- Construction phase mitigation:
  - No impact to the groundwater is expected if excavation does not exceed the depth of the watertable at the location of excavation. Local water levels range from 23.25 to 35.68 mbgl. If excavations exceed the depth of the watertable, the impact significance will depend on the depth of excavation below the watertable. In areas where the foundation of structures is to be installed below the water level, dewatering of the aquifer to locally lower the watertable is recommended. The abstracted water can be utilised for dust suppression, vegetation or discharged to the storm water dams.
  - Installation of suitable liner to significantly reduce potential impacts to groundwater environment during the construction phase and then determine capping requirements for the closure phase.
- Operational phase mitigation:
  - Coal compaction prior deposition onto the coal stockpile;

  - Groundwater monitoring;
  - Should an impact be detected through monitoring, affected receptors should be compensated, with an alternative water supply.
- Decommissioning phase mitigation:
  - Continuous post-closure monitoring is required so that drastic deterioration in groundwater quality is detected soon as it occurs, allowing for mitigation measures to implemented early. Monitoring is recommended to be conducted until satisfactory groundwater quality is reached and thereafter signed off by the relevant authorities.
  - Should an impact be detected through monitoring, affected receptors should be compensated, with an alternative water supply.
- Three layout alternatives are considered for the Mutsho Power Project. Considering environmental sensitivity a fault located in the northern part of the farm Du Toit was identified. Based on that observation, Option 1 layout is recommended as the most suitable as the location of the ash dump for this option is located furthest from the fault. The ash dump and coal stockpile location is most critical as these facilities are the main concern regarding impacts to the groundwater. Structures that could potentially act as preferential pathways, such as the fault, should be avoided with regards to the placement of the facilities. No groundwater sensitive areas were identified for the proposed locations of the coal stockpile for all layout options.
- A total of 5 monitoring locations are recommended for groundwater monitoring; 2 existing and 3 to be drilled. The location of these is reflected in Figure 8.1.

13.4 Surface Water Conclusion

The establishment of the Coal-Fired Power Station and Associated infrastructure have the potential to negatively impact on the natural water resources. As such, a surface water assessment was undertaken in support of the environmental authorisation applications. A site assessment was conducted on the 18th and 19th of January 2018 to assess and verify the hydrological characteristics of the area together with collection of surface water samples to determine the baseline water quality of the surrounding area prior to commencement of the project.

Sand River is the only major river (ephemeral) within this quaternary catchment (approximately 8 km from the western side of the project area). The Sand River flows from the South-west side of the project area towards the north-east side where it eventually joins the Limpopo River approximately 50 km away from the project area.

Few drainage lines exist within the demarcated project area and runoff from this site drains from the southern side in a north western direction via these drainage line and finally reports to the Sand River approximately 8 km west of the project site.

Water quality in this region or along the Sand River has existing monitoring data which indicated elevated levels of various salts which exceed the South African Water Quality

Guidelines for irrigation and livestock use. This is mostly attributed to upstream irrigation activities and domestic effluent from the upper Sand River catchment.

The identified potential surface water/hydrological impacts that could emanate from the project and its associated activities include:

- Siltation of surface water resources leading to a poor water quality as a result of eroded material reporting into the streams;
- Contamination of surface water resources when dirty water runoff from the power station reports into the nearby streams; and
- Reduction in runoff to the natural streams when all the dirty water runoff is contained within the power station footprint.

The following mitigation/management measures to prevent, and/or minimise the identified potential surface water impacts have been recommended. These include but are not limited to:

- Clearing of vegetation must be limited to the development footprint and the use of existing access roads must be prioritized so as to minimise construction of new access roads in these areas;
- If possible, construction should be undertaken during the low rainfall season (April to September) to minimise erosion and sedimentation/siltation of the water course;
- Any construction work that involves site clearance, digging, excavation or trenching during construction services should be suspended during heavy rains to avoid erosion and sedimentation of the water course;
- Dust suppression measures must be undertaken on the cleared areas during construction;
- Dirt roads must be well compacted to avoid erosion of the soil into the natural water course;
- All the dirty water runoff emanating from dirty areas (ash dump, plant and coal stockpile areas) should be contained within the dirty water dams. This water should be stored for re-use within the power plant so as to prevent unnecessary discharge into the environment;
- Should the contained water be more than the water use requirement, the BPGs advise that the water be recycled or as the last resort be treated to acceptable levels and discharged to the natural environment;
- Development of storm water management infrastructure should be in line with Regulation 704 of the NWA, 1998 (GN 704);
- Clean water emanating from upstream of the project area must be diverted away into the natural catchment;
- All spillages must be contained to the smallest possible area and must be cleaned immediately;

- The constructed storm water infrastructure will have to remain until post closure. This will ensure that dirty water is captured and contained during removal of infrastructure and thereby prevent siltation and contamination of the identified streams/drainages;
- All rehabilitated areas must be vegetated. Until vegetation has successfully been established, sedimentation should be mitigated by installing silt traps at areas where the surface runoff enters the surface water resources;
- The surface profile of the rehabilitated area should try and resemble the natural conditions prior to the project, this should ensure that the surface profile encourages natural drainage, such that no ponding or standing water occurs after a rainfall event;
- Dust suppression measures must be undertaken during this phase to prevent deposition of dust particle into the stream; and
- Use of accredited contractors for removal or demolition of infrastructures.

This study has identified Pption 2 and 3 as the most suitable infrastructure areas with negligible or insignificant impacts on the natural surface water resources whilst Option 1 is the least suitable since the ash dump is located on top of the drainage lines, please note these the drainage lines that may be affected by Option 1 have been classified as moderate sensitive on the sensitivity analysis above, and thus the potential impacts on these would not have great or highly-significant impact on the hydrology of the area.

This assessment has also provided the appropriate mitigation/management measures to prevent, and/or minimise the identified potential surface water impacts, should they occur.

With all the mitigation and management measures in place, this project is unlikely to pose a significant threat to the natural water courses and the hydrological features within and around the project area. The proposed establishment of the Coal-Fired Power Station and Associated Infrastructure can therefore go ahead.

14 FINAL CONCLUSION

Each of the proposed infrastructures options affect portions of the ephemeral drainage lines identified within the Project area at the time of the assessment. Based on the ecological integrity of the ephemeral drainage lines observed on site, as well as the extent of the catchment potentially affected as a result of the proposed infrastructures, preference is given to Option 1 taking into account the findings of each specialist assessment. The Groundwater Assessment took into consideration the location of the faults within the project area and also contributed to recommending Option 1 as the preferred alternative.

In terms of reduced impacts to the ephemeral drainage lines present, Option 2 is also considered a reasonable alternative, as this option utilises the existing road for construction of the new railway line, is more compact in terms of footprint area and is likely to result in less fragmentation of the systems present as fewer crossings of the freshwater resources present are required.

It is the opinion of the ecologist that should this project proceed, further impacts to the freshwater ecology of the greater area are deemed likely, with special mention of loss of catchment yield, loss of biodiversity, potential groundwater impacts and impacts associated with the ash dump and associated infrastructure. It is thus the opinion of the ecologist, that this project not be granted unless strict adherence to the mitigation measures provided in this report be assured and appropriately implemented. It is the opinion of the ecologist that further investigation and if possible optimisation of the proposed infrastructure layouts is necessary to avoid impacts to the water resources further downstream, which are already being placed under increasing pressure as a result of cumulative impacts within the greater catchment.

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Appendix A: Photographs of Sampling Sites

Farm Vrienden 589

Site VR1 – Upstream site along unnamed ephemeral drainage line

Site VR2 – Upstream site along unnamed ephemeral drainage line

Site VR3 – Downstream site along unnamed ephemeral drainage line

Farm Du Toit 563

Site DU1 - Small impoundment along upper reaches of an unnamed tributary of the Sand River

Site DU2 - Small impoundment along upper reaches of an unnamed tributary of the Sand River

Site DU3 – Farm dam along lower reaches of an unnamed tributary of the Sand River

Site DU4 – Downstream site along an unnamed tributary of the Sand River

Sand River

Site SR1 – Upstream site along the main stem Sand River

Site SR2 – Downstream site along the main stem Sand River

Appendix B: Surface Water and Groundwater Monitoring Results

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report Page 1 of 1

Client: Digby Wells & Associates
Address: 48 Grosvenor Road, Turnberry Office Park, Bryanston, 2191
Report no: 48829
Project: Digby Wells & Associates

Date of certificate: 29 January 2018
Date accepted: 24 January 2018
Date completed: 29 January 2018
Revision: 0

Lab no:				3914
Date sampled:				18-Jan-2018
Sample type:				Water
Locality description:				SW1-Dam 4
	Analyses	**Unit**	**Method**	
A	pH @ 25°C	pH	ALM 20	8.62
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	23.0
A	Total alkalinity	mg CaCO3/l	ALM 01	135
A	Chloride (Cl)	mg/l	ALM 02	2.97
A	Sulphate (SO_4)	mg/l	ALM 03	13.7
A	Nitrate (NO_3) as N	mg/l	ALM 06	0.209
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.038
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.007
A	Fluoride (F)	mg/l	ALM 08	<0.263
A	Calcium (Ca)	mg/l	ALM 30	44.1
A	Magnesium (Mg)	mg/l	ALM 30	6.95
A	Sodium (Na)	mg/l	ALM 30	2.81
A	Potassium (K)	mg/l	ALM 30	11.5
A	Aluminium (Al)	mg/l	ALM 31	0.014
A	Iron (Fe)	mg/l	ALM 31	<0.004
A	Manganese (Mn)	mg/l	ALM 31	0.015
A	Chromium (Cr)	mg/l	ALM 31	<0.003
A	Copper (Cu)	mg/l	ALM 31	0.005
A	Nickel (Ni)	mg/l	ALM 31	<0.002
A	Zinc (Zn)	mg/l	ALM 31	0.007
A	Cobalt (Co)	mg/l	ALM 31	<0.003
A	Cadmium (Cd)	mg/l	ALM 31	<0.002
A	Lead (Pb)	mg/l	ALM 31	<0.004
A	Arsenic (As)	mg/l	ALM 34	<0.006
A	Carbonate alkalinity	mg CaCO3/l	ALM 26	5.12
N	Balancing	%	ALM 26	98.51
A	Anions	meq	ALM 26	3.10
A	Cations	meq	ALM 26	3.20
A	Difference	%	ALM 26	1.49

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; The results relates only to the test item tested.
Results reported against the limit of detection.
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

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aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: Digby Wells & Associates
Address: 48 Grosvenor Road, Turnberry Office Park, Bryanston, 2191
Report no: 48828
Project: Digby Wells & Associates
Date of certificate: 30 January 2018
Date accepted: 24 January 2018
Date completed: 30 January 2018
Revision: 0

	Analyses	Unit	Method	3909	3910	3911	3912	3913
	Lab no:			3909	3910	3911	3912	3913
	Date sampled:			17-Jan-2018	17-Jan-2018	17-Jan-2018	18-Jan-2018	18-Jan-2018
	Sample type:			Water	Water	Water	Water	Water
	Locality description:			DUTBH1	DUTBH2	DUTBH3	VRIBH1	VRIBH2
A	pH @ 25°C	pH	ALM 20	7.46	7.18	7.57	7.47	7.25
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	198	238	160	146	311
A	Total alkalinity	mg CaCO3/l	ALM 01	463	455	605	598	767
A	Chloride (Cl)	mg/l	ALM 02	403	467	87.4	221	861
A	Sulphate (SO_4)	mg/l	ALM 03	275	463	319	78.2	280
A	Nitrate (NO_3) as N	mg/l	ALM 06	2.54	0.757	<0.194	8.18	7.66
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.105	0.032	0.242	0.051	0.015
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.182	0.030	0.012	0.017	0.041
A	Fluoride (F)	mg/l	ALM 08	0.920	1.17	1.25	1.55	0.825
A	Calcium (Ca)	mg/l	ALM 30	123	159	43.9	64.4	141
A	Magnesium (Mg)	mg/l	ALM 30	109	125	41.1	98.8	313
A	Sodium (Na)	mg/l	ALM 30	289	358	330	217	332
A	Potassium (K)	mg/l	ALM 30	21.3	22.6	8.40	11.6	16.4
A	Aluminium (Al)	mg/l	ALM 31	0.015	0.004	<0.002	0.005	0.008
A	Iron (Fe)	mg/l	ALM 31	<0.004	<0.004	<0.004	<0.004	<0.004
A	Manganese (Mn)	mg/l	ALM 31	0.158	<0.001	0.124	0.092	0.001
A	Chromium (Cr)	mg/l	ALM 31	<0.003	<0.003	<0.003	<0.003	<0.003
A	Copper (Cu)	mg/l	ALM 31	0.141	<0.002	<0.002	0.005	<0.002
A	Nickel (Ni)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002
A	Zinc (Zn)	mg/l	ALM 31	0.252	0.025	0.066	0.047	0.021
A	Cobalt (Co)	mg/l	ALM 31	<0.003	<0.003	<0.003	<0.003	<0.003
A	Cadmium (Cd)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002
A	Lead (Pb)	mg/l	ALM 31	<0.004	<0.004	<0.004	<0.004	<0.004
A	Arsenic (As)	mg/l	ALM 34	<0.006	<0.006	<0.006	<0.006	<0.006
A	Carbonate alkalinity	mg CaCO3/l	ALM 26	1.25	0.651	2.11	1.66	1.29
N	Balancing	%	ALM 26	96.95	96.52	97.30	98.55	98.22
A	Anions	meq	ALM 26	26.59	32.04	21.30	20.49	46.04
A	Cations	meq	ALM 26	28.26	34.35	20.18	21.10	47.71
A	Difference	%	ALM 26	3.05	3.48	-2.70	1.45	1.78

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