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## ZITHOLELE CONSULTING (PTY) LTD

# Hydrogeological Impact Assessment for Medupi Flue Gas Desulphurisation Retrofit Project

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REPORT

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Golder Associates

# Executive Summary

## Introduction

Golder Associates Africa (Golder) has been appointed by Zitholele Consulting (Pty) Ltd to provide a hydrogeological specialist impact assessment for the Medupi Flue Gas Desulphurisation (FGD) Retrofit Project. This investigation is part of Eskom's Environmental Impact Assessment (EIA), Waste Management Licence (WML) application and Water Use Licence Application (WULA) for the proposed Flue Gas Desulphurisation retrofit to Medupi Power Station.

This document reports on the Impact Assessment for groundwater at the Medupi FGD Retrofit Project as per Scope of Work.

## Objectives

The main objectives of the groundwater specialist study are to:

- Characterise the prevailing groundwater situation;
- Define the water bearing strata in the area;
- Determine current groundwater level distribution and flow directions;
- Determine baseline groundwater quality;
- Conduct a *qualitative* assessment of the impact of the proposed Medupi FGD Retrofit Project on the groundwater system; and
- Provide a conceptual model of groundwater impacts.

## Scope of Work

The Confirmed scope of work assessed in this DEIR includes assessment of the following activities and infrastructure:

- Construction and operation of a rail yard/siding to transport Limestone from a source defined point via the existing rail network to the Medupi Power Station and proposed rail yard / siding. The rail yard infrastructure will include storage of fuel (diesel) in above ground tanks and 15m deep excavation for tippler building infrastructure;
- Construction and operation of limestone storage area, preparation area, handling and transport via truck and conveyor to the FGD system located near the generation units of the Medupi Power Station;
- The construction and operation of the wet FGD system that will reduce the $SO_2$ content in the flue gas emitted;
- Construction and operation of associated infrastructure required for operation of the FGD system and required services to ensure optimal functioning of the wet FGD system. The associated FGD infrastructure include a facility for storage of fuel (diesel), installation of stormwater infrastructure and conservancy tanks for sewage;
- The handling, treatment and conveyance of gypsum and effluent from the gypsum dewatering plant. Disposal of gypsum on the existing ADF is not included in the current EIA application and will be addressed in the ADF WML amendment application.
- Pipeline for the transportation of waste water from the gypsum dewatering plant and its treatment at the WWTP that will be located close to the FGD infrastructure within the Medupi Power Station;
- Construction and operation of the WWTP;

- Management, handling, transport and storage of salts and sludge generated through the waste water treatment process at a temporary waste storage facility. In terms of the EIA process impacts related to the management of salts and sludge will be considered in the EIR. However, licencing of the storage activity and requirements relating to the waste storage facility will be assessed in the WML registration application process.
- The transportation of salts and sludge via trucks from the temporary waste storage facility to a final Waste Disposal Facility to be contracted by Eskom for the first 5 years of operation of the FGD system. Long term disposal of salts and sludge will be addressed though a separate independent EIA process to be commissioned by Eskom in future.
- Disposal of gypsum together with ash on the existing licenced ash disposal facility (ADF), with resulting increase in height of the ADF from 60m to 72m.

The following groundwater scope of work was followed for the Medupi FGD Retrofit Project to adhere to the objectives mentioned above:

- Desk Study;
- Site visit and hydrocensus;
- Groundwater sampling x 10 samples;
- Conceptual Hydrogeological model of Medupi FGD Retrofit Project;
- Provide a qualitative assessment of the potential impacts that may be associated with the construction of the proposed rail yard and FGD infrastructure;
- Provide mitigation measures for prevention and/or mitigation of any potential groundwater impacts; and
- Groundwater specialist report.

# Groundwater Baseline

## *Locality*

Medupi Power Station is located approximately 17km west of Lephalale and 6km SW of Matimba Power Station on the farm Naauwontkomen 509LQ, Limpopo Province. The Medupi FGD Retrofit Project fall within the A42J quaternary catchment area.

# Climate and Rainfall

## *Climate*

The climate of Medupi Power Station and surrounding regions is characterised by hot, moist summers and mild, dry winters. The area experiences high temperatures in the summer months, with daily maximum temperatures exceeding 40 degrees on a regular basis.

The occurrence of frost is rare during winter, but occurs occasionally in most years, but usually not severely (IGS 2008).

## *Rainfall*

The long-term annual average rainfall for the study area is 429.1mm as measured since 1977 to 2007, of which 90% falls between October and March (SA Weather Service, 2008).

# Geology

## *Local Geology*

The local geology of the area can be subdivided into a northern and southern type. The Matimba Power station and all its facilities, except for the ash dump, as well as Grootegeluk Mine, lies on Karoo sediments. The existing licensed disposal facility, Medupi Power Station and the Matimba ash dump lie on Waterberg sandstone, just south of the Eenzaamheid fault.

The existing licensed disposal facility and Medupi Power Station are underlain by the sediments of the Waterberg Group (siliclastic red bed successions). This is part of the up-thrown sediments comprising the fining upward conglomerate-quartzites facies assemblages of the Mogalakwena Formation. The Waterberg sediments are somewhat recrystallised and fully oxidised; hence the hardness and red colour of the rock. A thin but permeable layer of sandy topsoil overlies it (IGS 2008).

# Regional Hydrogeology

## *Regional Hydrogeology*

Two distinct and superimposed groundwater systems are present in the geological formations of the coal fields in South Africa, as described by Hodgson and Grobbelaar (1999). They are the upper weathered aquifer and the system in the fractured rock below (IGS 2008).

## *Weathered Aquifer System*

The top 5-15 m normally consists of soil and weathered rock. The upper aquifer is associated with the weathered horizon. In boreholes, water may often be found at this horizon. The aquifer is recharged by rainfall.

## *Fractured Aquifer System*

The grains in the fresh rock below the weathered zone are well cemented, and do not allow significant water flow. All groundwater movement therefore occurs along secondary structures such as fractures, cracks and joints in the rock. These structures are best developed in sandstone and quartzite; hence the better water-yielding properties of the latter rock type. Dolerite sills and dykes are generally impermeable to water movement, except in the weathered state.

# Hydrocensus

A total of 17 boreholes were surveyed during a hydrocensus conducted in September 2015 at Medupi FGD Retrofit Project and surrounding area. The 16 water levels were measured ranging between 4.41 to 69.98mbgl (metres below ground level), whereas the average water level is 30.4mbgl.

All coordinates were measured with a hand-held GPS using the WGS 84 reference datum.

Groundwater samples were collected at 10 of these boreholes, as per Golder's standard sampling procedures and submitted to Waterlab Laboratories in Pretoria an accredited laboratory.

# Hydrocensus Groundwater Quality

The following constituents of the hydrocensus groundwater samples exceed the SANS 241 (2011) maximum allowable standard:

- EC, boreholes BU02 and BU03;
- TDS, boreholes BU02 and BU03;
- Na, boreholes BU02 and GE03;
- Cl, boreholes BU01, BU02 and BU03;
- N, boreholes BU02 and BU03. These two boreholes have elevated Nitrate values (Class III; 16mg/l and IV; 66mg/l respectively). This water quality poses chronic health risks is and represents poor and unacceptable water quality. The elevate nitrate concentrations is probably related to point source pollution caused by animal farming and stockades;
- Al, boreholes KR01,KR03 and KR05;
- F, boreholes BU01, BU02,BU03 and KR03;
- Fe, boreholes KR01,KR05, BU02, VER05 and GE01; and
- Mn, borehole BU02.

### *Baseline Groundwater Quality*

The baseline groundwater quality of the Medupi FGD Retrofit Project area is based on macro chemistry analyses of the sampled hydrocensus boreholes. The concentrations are compared to the SANS 241:2011 water quality standard and the baseline quality are represented by the Median of the concentrations. The baseline water quality of the combined sampled boreholes is summarised in table below.

Baseline Groundwater Quality

| Item | Physical Parameters | | | Macro Determinants (Major Ions and Trace Metals) | | | | | | | | Minor Determinant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | EC mS/m | TDS mg/l | Ca mg/l | Mg mg/l | Na mg/l | K mg/l | Cl mg/l | SO4 mg/l | NO3 mg/l | MALK Mg/l | F mg/l | Fe mg/l | Mn mg/l |
| No. of Records | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10% Percentile | 5.67 | 15.35 | 112.8 | 6.165 | 1.9525 | 11.804 | 2.5892 | 16.2 | 5 | 0.2 | 8 | 0.2 | 0.0408 | 0.0421 |
| ***Median Baseline water Quality*** | **7.3** | **75.8** | **450** | **27.66** | **21.385** | **80.285** | **6.7065** | **101.5** | **38** | **0.25** | **242** | **1.1** | **1.5715** | **0.106** |
| Average | 7 | 103.19 | 642.2 | 57.1504 | 30.3111 | 105.095 | 10.1201 | 207 | 34.3 | 8.58 | 201.2 | 1.3 | 2.5966 | 0.1782 |
| 90% Percentile | 7.53 | 212.4 | 1377.6 | 140.5 | 67.629 | 203.87 | 18.855 | 532.6 | 62.9 | 21 | 357.2 | 2.34 | 6.6366 | 0.3691 |
| Max. Allowable Limit (SANS 241:2011) | <5 >9 | <170 | <1200 | <300 | <100 | <200 | <100 | <300 | <500 | <11 | - | <1.5 | <0.3 | <0.5 |

## Aquifer Recharge

The Chloride Ratio Method was used to estimate the aquifer recharge for the Medupi FGD Retrofit Project area. Recharge =1.8 % of the MAP 429.1mm =7.7mm per annum. This recharge value (7.7mm) is slightly lower but more site specific than the values indicated on the published hydrogeological maps as 10 to 15mm per annum.

## Groundwater Conceptual Model

The conceptual model is based on two distinct types of aquifers which are present in the geological formations of the coal fields in South Africa:

- Upper weathered aquifer system; and
- Fractured weathered aquifer system.

## Existing Groundwater Monitoring Boreholes

Groundwater quality and water levels are currently monitored by Eskom at Medupi Power station at 30 existing boreholes. Some of these boreholes are positioned around the Medupi FGD Retrofit Project area and could act as monitoring boreholes for the facility. However, three of these boreholes (MBH08. MBHO9 and MBH07) are dry or water levels are too low to sample.

The water quality of the existing boreholes is largely poor quality, with classes ranging from Class 0 to Class IV, water quality.

## Groundwater Levels and Flow Directions

From available data and previous groundwater studies, the groundwater flow from the Medupi FGD Retrofit Project is primarily away from the site, towards the east/south-east and northeast towards the non-perennial Sandloop River.

## Groundwater Risk Rating

The Medupi FGD Retrofit Project area scores a risk rating of 16 and poses a moderate risk of impacting on the surrounding groundwater regime. Possible impacts on the groundwater need to be investigated further.

These ratings are consistent with the National vulnerability map of South Africa prepared by the WRC (Water Research Commission), using the DRASTIC methodology.

## Impact Assessment Medupi FGD Project Area

In order to address the amended scope of work for Medupi FGD (2017) the following SOW are included based on the Impact assessment methodology provided by Zitholele:

- Construction and operation of the FGD system within the Medupi Power Station Footprint;
- Construction and operation of the railway yard/siding and diesel storage facilities, and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF;
- A qualitative opinion on impact on groundwater, if any, if ash and gypsum is disposed together on the existing ADF considering the ADF will have an appropriate liner since both ash and gypsum is classified as type 3 wastes; and
- Provide a qualitative opinion whether groundwater could potentially be impacted with the construction of the FGD within the Medupi PS footprint. From the aerial view it is evident that the entire Medupi GD footprint area is disturbed during the construction activities at the power station.

The potential groundwater impacts that the **FGD system** and the **operation of the railway yard/siding, diesel storage facilities** and **limestone and gypsum handling facilities between the Medupi Power Station and existing ADF**, poses to the groundwater regime are discussed as follows for the different phases:

- Existing impacts – these are current activities that potentially have an impact on the groundwater regime. These activities include Matimba Power Station and ADF, Medupi Power station and the existing licensed disposal facility, however Grootegeluk mine are excluded due to the Eenzaamheid fault serving as a barrier to interactions.
- Cumulative impacts - **include the existing activities plus the FGD system** and **the operation of the railway yard/siding, diesel storage facilities and limestone** and **gypsum handling facilities between the Medupi Power Station and existing ADF**; and
- Residual impacts- are the post-mitigation activities. This rating considers the cumulative impacts when proposed mitigation measures are effectively implemented.

The existing activities and the FGD system pose the following potential impacts on the groundwater:

- A change in the groundwater quality;
- A change in the volume of groundwater in storage or entering groundwater storage (recharge); or
- A change in the groundwater flow regime.

### Potential Impacts from the FGD System

#### Groundwater Quality

The predicted impacts from the FGD system on the ambient groundwater quality is:

- Of Moderate significance during pre-construction, construction and operational phases; and
- Low significance during the decommissioning phase.

### Groundwater Volume and Flow Regime

The construction and operation of the FGD system, is expected to have a minor change in the volume of water entering groundwater storage (reduced recharge in comparison to status quo conditions) and with negligible changes expected in the groundwater flow regime.

The predicted impact of the FGD system on the groundwater volume and flow is:

- Of Low significance during pre-construction phase and Low to moderate during the construction and operational phases. The significance during the decommissioning phase is Low.

## Potential Impacts from the Railway Yard/siding, diesel storage facilities and Limestone and gypsum handling facilities between the Medupi Power Station and existing ADF

### Groundwater Quality

The predicted impacts from the railway yard/siding, diesel storage facilities and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF activities on the ambient groundwater quality is:

- Of Low significance during pre-construction and of moderate significance during the construction and operational phases; and
- Low of significance during the decommissioning phase.

### Groundwater Volume and Flow Regime

The predicted impact that the railway yard/siding, diesel storage facilities and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF activities on the groundwater volume and flow may have include:

- Of Low significance during pre-construction phase and of low to moderate significance during the construction phase. The significance during the operational and decommissioning phases is of Low significance.

## Professional Opinion on trucking of Type 1 waste to Hazardous Disposal Facility

For the first five (5) years of the operational phase, sludge and salts will be stored at a temporary waste storage facility, after which it will be trucked to a licensed hazardous waste disposal site. During transportation of hazardous waste, the trucking contractor should adhere to all regulations and standards of both environmental and mining acts. Safe working procedures (SWP) for transportation of hazardous waste must be in place, to minimize the risk of contamination to the environment and groundwater should a spillage occur.

A hazardous spillage could contaminate the groundwater, and samples of any nearby boreholes should be analysed and monitored after a spillage incident. Storage of the Type 1 waste (hazardous waste) on site may result in risks to contamination the groundwater regime. This risk can be managed by ensuring that construction is done to good quality, after the facility is registered, and prepared in line with NEMWA Norms and Standards for Storage of Waste. Trucking of Type 1 waste to a licensed hazardous waste disposal site is effectively would effect a positive impact on site.

Possible impacts on the groundwater regime associated with trucking process of Type 1 waste, to a licensed hazardous waste disposal site are based on a simplified groundwater risk assessment and are presented in the table below. The risk rating is based on a possible risk/impact that activities from the trucking process of type 1 waste poses to the groundwater regime. Assessment is based on positive and negative outcome of impact/risk to the groundwater regime.

| Activity | Positive Impacts | Negative Impacts |
|---|---|---|
| Removal of hazardous waste from temporary waste storage facility | Removal of contamination source | None |
| Transportation of hazardous waste to a licensed hazardous waste disposal site | Removal and transportation of hazardous waste | None |
| Spillage during transportation of hazardous waste | None | Contamination of groundwater and impacting on existing users in vicinity of spillage |
| Disposal of hazardous waste | Disposal of hazardous waste | None |

## Qualitative Opinion on Impact on Groundwater, if Ash and Gypsum is Disposed together on the Existing ADF

The existing licensed disposal facility is designed for a 50 year life period and will have a liner that is designed according to the appropriate waste classification of the ash. The liner for the facility will be installed at appropriate frequencies, e.g. every two years. This is to reduce risk of damage to the liner due to exposure for long periods of time.

Considering that the ADF is proposed to have a Class C liner, in line with waste classification as per the NEMWA GNXX, since both ash and gypsum classified as Type 3 wastes will be disposed, the disposal of ash and gypsum together will probably not have a significant impact on the groundwater regime. This rehabilitation of WDF approach serves as a mitigation measure against groundwater contamination and poses a minimal risk of contamination on the groundwater.

## Qualitative Opinion whether Groundwater could potentially be impacted with the Construction of the FGD within the Medupi Power Station Footprint

During any construction phase involving disturbing of top soil by earth moving equipment and trucks, possible spillage could occur which could contaminate the groundwater. This contamination, however, will be point source only and within the site boundaries.

Safe working procedures (SWP) for construction work must be in place, to minimize the risk of contamination to the environment and groundwater should a spillage occur. Any accidental spillage should be cleaned up immediately to limit contamination and if intensity is high, the impact must be reversed with the applicable mitigation and management actions.

The potential impact whether groundwater could potentially be impacted with the Construction of the FGD within the Medupi Power Station Footprint is considered as a low to moderate significance.

## Conclusions

The following groundwater conclusions are made from the investigation and available data for the Medupi FGD Project:

- The existing licensed disposal facility is mainly underlain by Waterberg sediments comprising of sandstone, subordinate conglomerate, siltstone and shale;
- The initial regional groundwater conceptual model identifies two aquifer zones namely weathered, and fractured aquifer zones, but needs to be confirmed and updated, supported by future test pumping and borehole logs;
- The average groundwater level measured during the hydrocensus for the area of investigation is 30.4mbgl;

- Based on the hydrocensus water quality analyses , the background groundwater quality of the existing licensed disposal facility is Marginal (Class II) to Poor (Class III - IV) water Quality;
- Only boreholes GE06 and VER02 groundwater quality are representative of calcium magnesium bicarbonate type of water (Ca, Mg–($HCO_3$). This water type represents unpolluted groundwater (mainly from direct rainwater recharge) and are probably representative of the pristine background water quality;
- The following inorganic constituents as identified during the hydrocensus exceed the SANS 241 (2011) drinking water compliance standards EC, TDS, Na, Cl, N, Al, F, Fe and Mn;
- The groundwater vulnerability of the existing licensed disposal facility proposed is shown on the national groundwater vulnerability map as low to medium;
- According to simplified groundwater risk rating assessment, the existing licenced disposal facility have a risk rating of 16, and poses a moderate risk of impacting on the surrounding groundwater regime. Possible impacts on the groundwater need to be investigated further;
- Following a decision by ESKOM to utilize the existing licenced disposal facility, a qualitative impact assessment was conducted on this site. Gypsum and ash are to be disposed on the existing licenced disposal facility;
- Based on the qualitative impact assessment, the existing activities and the licensed disposal facility poses the following potential impacts on the groundwater system:
  - A change in the groundwater quality;
  - A change in the volume of groundwater in storage or entering groundwater storage (recharge); or
  - A change in the groundwater flow regime.
- The predicted impacts from the FGD system (2017 SOW) on the ambient groundwater quality is:
  - Of Moderate significance during pre-construction, construction and operational phases; and
  - Low significance during the decommissioning phase.
- The predicted impact of the FGD system on the groundwater volume and flow is:
  - Of Low significance during pre-construction phase and Low to moderate during the construction and operational phases. The significance during the decommissioning phases are Low.
- The predicted impacts from the railway yard and limestone and gypsum handling facilities (2017 SOW) between the Medupi Power Station and existing ADF activities on the ambient groundwater quality is:
  - Of Low significance during pre-construction and of Moderate significance during the construction and operational phases; and
  - Low of significance during the decommissioning phase.
- The predicted impact the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF activities on the groundwater volume and flow is:
  - Of Low significance during pre-construction phase and of Low to Moderate significance during the construction phase. The significance during the operational and decommissioning phases are of Low significance.

## Recommendations

Following the groundwater baseline and IA investigation the following is recommended:

- Monthly monitoring of exiting Eskom monitoring boreholes groundwater levels and quality. Monitoring should be conducted to be consistent with the existing WUL (Licence no.: 01 /A1042/ABCEFGI/5213);

- Monitoring boreholes MBH08, MBHO9 and MBH07 which are dry or water level are too low to sample and need to be replaced to ensure monitoring coverage in these areas;
- Aquifer testing of new monitoring boreholes to determine hydraulic parameters and update initial groundwater conceptual model. The groundwater conceptual model with aquifer parameters provide the basic input into a groundwater numerical model;
- Groundwater sampling of newly drilled monitoring boreholes;
- The newly-drilled monitoring boreholes should be incorporated into the existing monitoring programme. The following monitoring tasks should be conducted to be consistent with the existing WUL Licence no.: 01 /A1042/ABCEFGI/5213;
- Bi-annually groundwater monitoring of existing groundwater user's boreholes in the area surrounding the existing licensed disposal facility (In radius of ~ 3.0 km).
- Development of a numerical groundwater flow & transport model (or update of existing models) and Impact Assessment. This model to include Medupi Power station (MPS) and the Medupi FGD Project;
- Use model predictions to predict the pollution plume from the Medupi FGD Project area and Medupi Power station;
- Update mitigation and management measures for the Medupi FGD Project on numerical model outcome and predictions.

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Document Limitations

# 1.0 INTRODUCTION

Golder Associates Africa (Golder) has been appointed by Zitholele Consulting (Pty) Ltd to provide a hydrogeological specialist impact assessment for the Medupi Flue Gas Desulphurisation (FGD) Retrofit Project. This investigation is part of Eskom's Environmental Impact Assessment (EIA), Waste Management Licence (WML) application and Water Use Licence Application (WULA) for the proposed Flue Gas Desulphurisation retrofit to Medupi Power Station.

This document reports on the Impact Assessment for groundwater at the Medupi FGD Retrofit Project as per Scope of Work.

# 2.0 STUDY AREA

The Medupi FGD Retrofit Project is located within a radius of 10 km from the existing Medupi Power Station, Lephalale.

# 3.0 OBJECTIVES

The main objectives of the groundwater specialist study are to:

- Characterise the prevailing groundwater situation;
- Define the water bearing strata in the area;
- Determine current groundwater level distribution and flow directions;
- Determine baseline groundwater quality;
- Conduct a *qualitative* assessment of the impact of on the groundwater system; and
- Provide a conceptual model of groundwater impacts.

# 4.0 SCOPE OF WORK

The Confirmed scope of work assessed in this DEIR includes assessment of the following activities and infrastructure:

- Construction and operation of a rail yard/siding to transport Limestone from a source defined point via the existing rail network to the Medupi Power Station and proposed rail yard / siding. The rail yard infrastructure will include storage of fuel (diesel) in above ground tanks and 15m deep excavation for tippler building infrastructure;
- Construction and operation of limestone storage area, preparation area, handling and transport via truck and conveyor to the FGD system located near the generation units of the Medupi Power Station;
- The construction and operation of the wet FGD system that will reduce the $SO_2$ content in the flue gas emitted;
- Construction and operation of associated infrastructure required for operation of the FGD system and required services to ensure optimal functioning of the wet FGD system. The associated FGD infrastructure include a facility for storage of fuel (diesel), installation of stormwater infrastructure and conservancy tanks for sewage;
- The handling, treatment and conveyance of gypsum and effluent from the gypsum dewatering plant. Disposal of gypsum on the existing ADF is not included in the current EIA application and will be addressed in the ADF WML amendment application.
- Pipeline for the transportation of waste water from the gypsum dewatering plant and its treatment at the WWTP that will be located close to the FGD infrastructure within the Medupi Power Station;
- Construction and operation of the WWTP;
- Management, handling, transport and storage of salts and sludge generated through the waste water treatment process at a temporary waste storage facility. In terms of the EIA process impacts related to

the management of salts and sludge will be considered in the EIR. However, licencing of the storage activity and requirements relating to the waste storage facility will be assessed in the WML registration application process.

- The transportation of salts and sludge via trucks from the temporary waste storage facility to a final Waste Disposal Facility to be contracted by Eskom for the first 5 years of operation of the FGD system. Long term disposal of salts and sludge will be addressed though a separate independent EIA process to be commissioned by Eskom in future.
- Disposal of gypsum together with ash on the existing licenced ash disposal facility (ADF), with resulting increase in height of the ADF from 60m to 72m.

The following groundwater scope of work was followed for the Medupi FGD Retrofit Project to adhere to the objectives mentioned above:

- Desk Study;
- Site visit and hydrocensus;
- Groundwater sampling x 10 samples;
- Conceptual Hydrogeological model of Medupi FGD Retrofit Project;
- Provide a qualitative assessment of the potential impacts that may be associated with the construction of the proposed rail yard and FGD infrastructure;
- Provide mitigation measures for prevention and/or mitigation of any potential groundwater impacts; and
- Groundwater specialist report.

# 5.0 GROUNDWATER BASELINE

## 5.1 Locality

Medupi Power Station is located approximately 17km west of Lephalale and 6km SW of Matimba Power Station on the farm Naauwontkomen 509LQ, Limpopo Province (Figure 1). The Medupi FGD Retrofit Project area fall on the A42J quaternary catchment area.

## 5.2 Topographical Setting

### 5.2.1 Existing Licensed Disposal Facility

The topography of the Medupi FGD Retrofit Project area slopes gently to the east and the site falls within the A42J quaternary catchment area (Figure 1). The maximum elevation on existing licensed disposal facility is to the west of the site and is indicated as 913 mamsl. The site slopes gently at ~ 0.3% towards the east. The fall from west to east along the site is ~ 10m. The lowest point on site is ~903 mamsl.

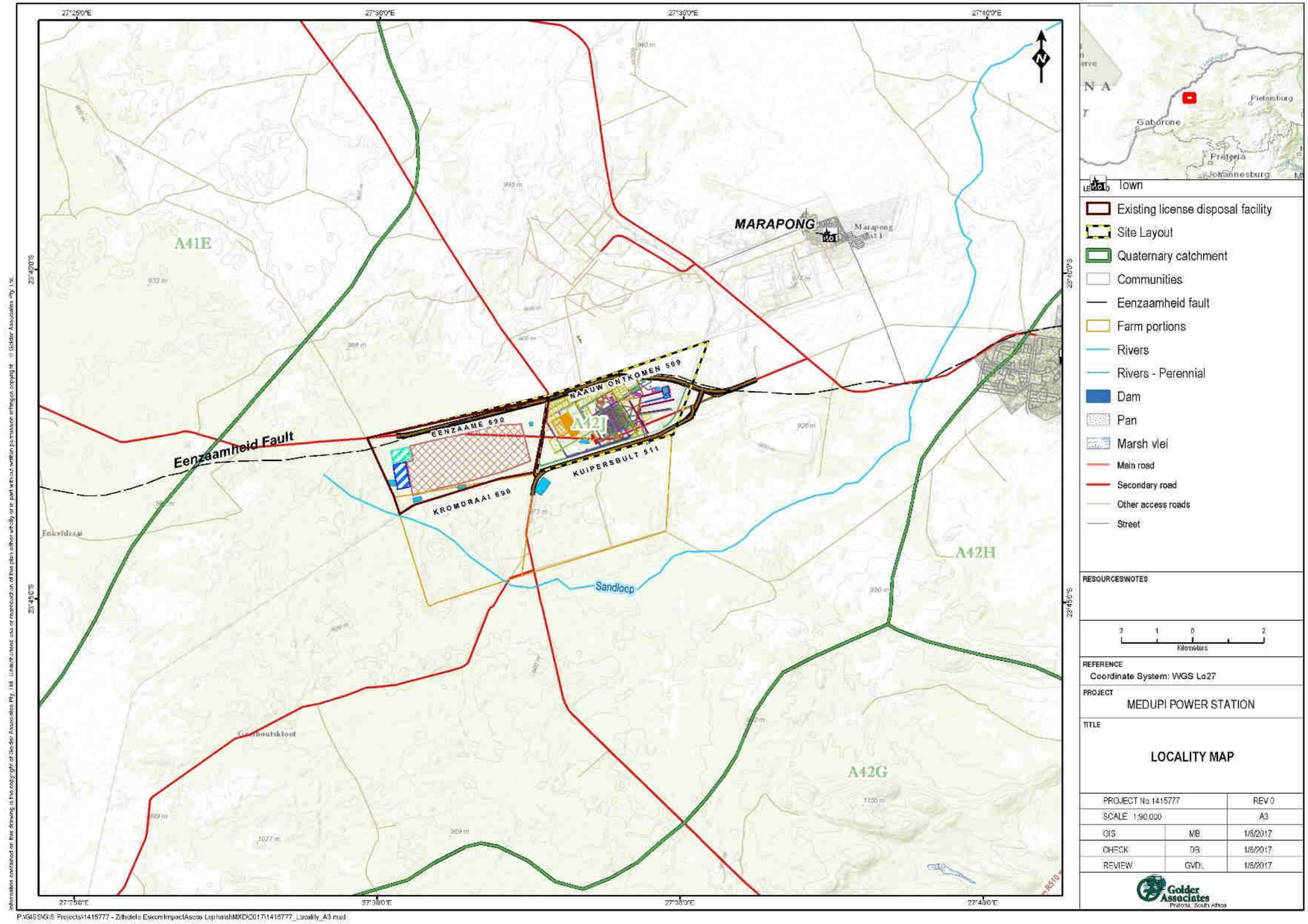


*Figure 1: Locality Map*

## 5.3 Climate and Rainfall

### 5.3.1 Climate

The climate of Medupi Power Station and surrounding regions is characterised by hot, moist summers and mild, dry winters. The area experiences high temperatures in the summer months, with daily maximum temperatures exceeding 40 degrees on a regular basis.

The occurring of frost is rare during winter, but occurs occasionally in most years, but usually not severely (IGS 2008).

### 5.3.2 Rainfall

The long-term annual average rainfall for the study area is 429.1mm (Figure 2) measured since 1977 to 2007, of which 90% falls between October and March (SA Weather Service, 2008).

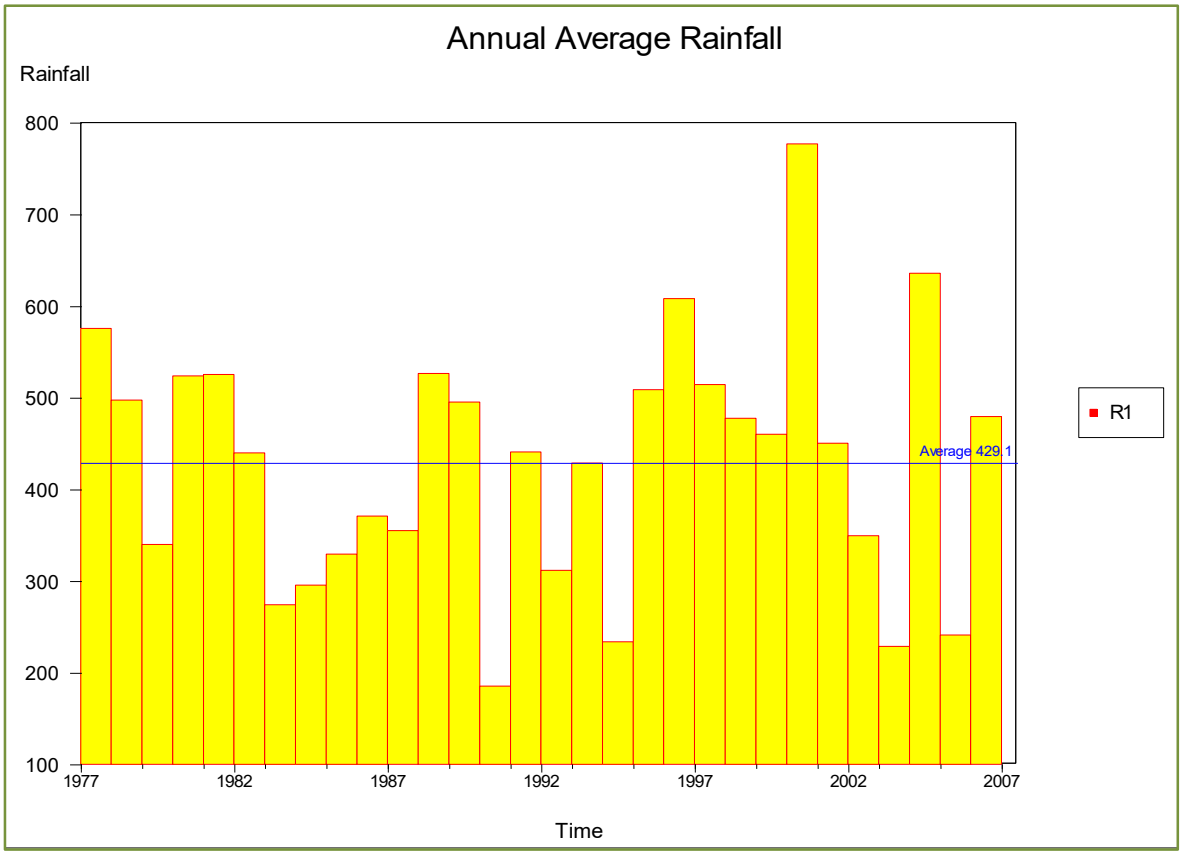


*Figure 2: Annual Rainfall for the Medupi Area, Weather Bureau (IGS 2008)*

## 5.4 Geology

### 5.4.1 Regional Geology

Based on 1:250 000 geological map series 2326, Ellisras (Council for Geoscience), the regional geology in the area is characterised by sedimentary rocks of the Karoo Supergroup (Figure 3). The Waterberg Coalfield is composed of sediments of the Karoo Supergroup and forms a graben structure, bound in the north by the Zoetfontein fault and in the south by the Eenzaamheid fault (Figure 3). The Daarby fault subdivides the coalfield into the shallow open-cast able western part of the coalfield and the deeper north-eastern part of the coalfield (IGS 2008).

The Zoetfontein fault resulted from pre-/during Karoo depositional tectonism, whilst the Eenzaamheid and Daarby faults resulted from post-Karoo depositional tectonism. All the units of the Karoo Supergroup are present in this coalfield, and the subdivision of the Karoo Sequence is mainly based on lithological boundaries, consisting, from top to bottom, of the Stormberg Group (Letaba), followed by the Beaufort

Group, the Ecca Group and the Dwyka Group. The Waterberg Group represents the basin depositional floor, which is mainly composed of the Paleoproterozoic (mokolian) quartzites, arkoses and conglomerates. Regionally, the Waterberg sediments rest on the rocks of the Transvaal Sequence (IGS 2008).

### 5.4.2 Structural Geology

The Daarby fault is a major north-east, then north-west trending fault, assumed to be part of one set of events, as both legs exhibit the same throw and throw direction. Thus both faults are combined into one name. The Daarby fault has a down throw of 360m to the north, and the fault dips at an angle of between 50° and 60° to the north. It serves to bring the up-thrown Beaufort and Ecca Groups to the south into contact with the down-thrown Letaba, Clarens, Elliott and Molteno formations to the north (IGS 2008).

The Eenzaamheid fault (Figure 3), situated south of the Daarby fault, and has a throw of 250m to the north, bringing the up-thrown Waterberg sediments on the southern side of the fault into contact with the down-thrown Beaufort and Ecca groups on the northern side of the fault. The angle of the Eenzaamheid fault is near vertical (IGS 2008).

### 5.4.3 Local Geology

The local geology of the area can be subdivided into a northern and southern type. The Matimba Power station and all its facilities, except for the ash dump, as well as Grootegeluk Mine, lies on Karoo sediments. The existing licensed disposal facility, Medupi Power Station and the Matimba ash dump lie on Waterberg sandstone, just south of the Eenzaamheid fault (Figure 4).

The existing licensed disposal facility and Medupi Power Station is underlain by the sediments of the Waterberg Group (siliclastic red bed successions). This is part of the up-thrown sediments comprising the fining upward conglomerate-quartzites facies assemblages of the Mogalakwena Formation. The Waterberg sediments are somewhat recrystallised and fully oxidised; hence the hardness and red colour of the rock. A thin but permeable layer of sandy topsoil overlies it (IGS 2008).

#### *5.4.3.1 Medupi FGD Retrofit Project Geology*

The Medupi FGD Retrofit Project area is intersected by the EW trending Eenzaamheid Fault near the northern boundary (Figure 4). This regional fault separates the Waterberg rocks from the Karoo strata to the north.

South of the fault the site is generally overlain by sandy soil at surface. On the southern side of the Eenzaamheid fault, below the sandy soil the site is underlain by Waterberg sediments (Figure 4) comprising of sandstone, subordinate conglomerate siltstone and shale.

The portion of the existing licensed disposal facility site north of the Eenzaamheid fault zone is underlain by Karoo sediments of the Beaufort and Ecca groups, comprising of mudstones, sandstone, grit, siltstone, carbonaceous shale and coal.

This Eenzaamheid fault zone could act as a preferred groundwater flow path.

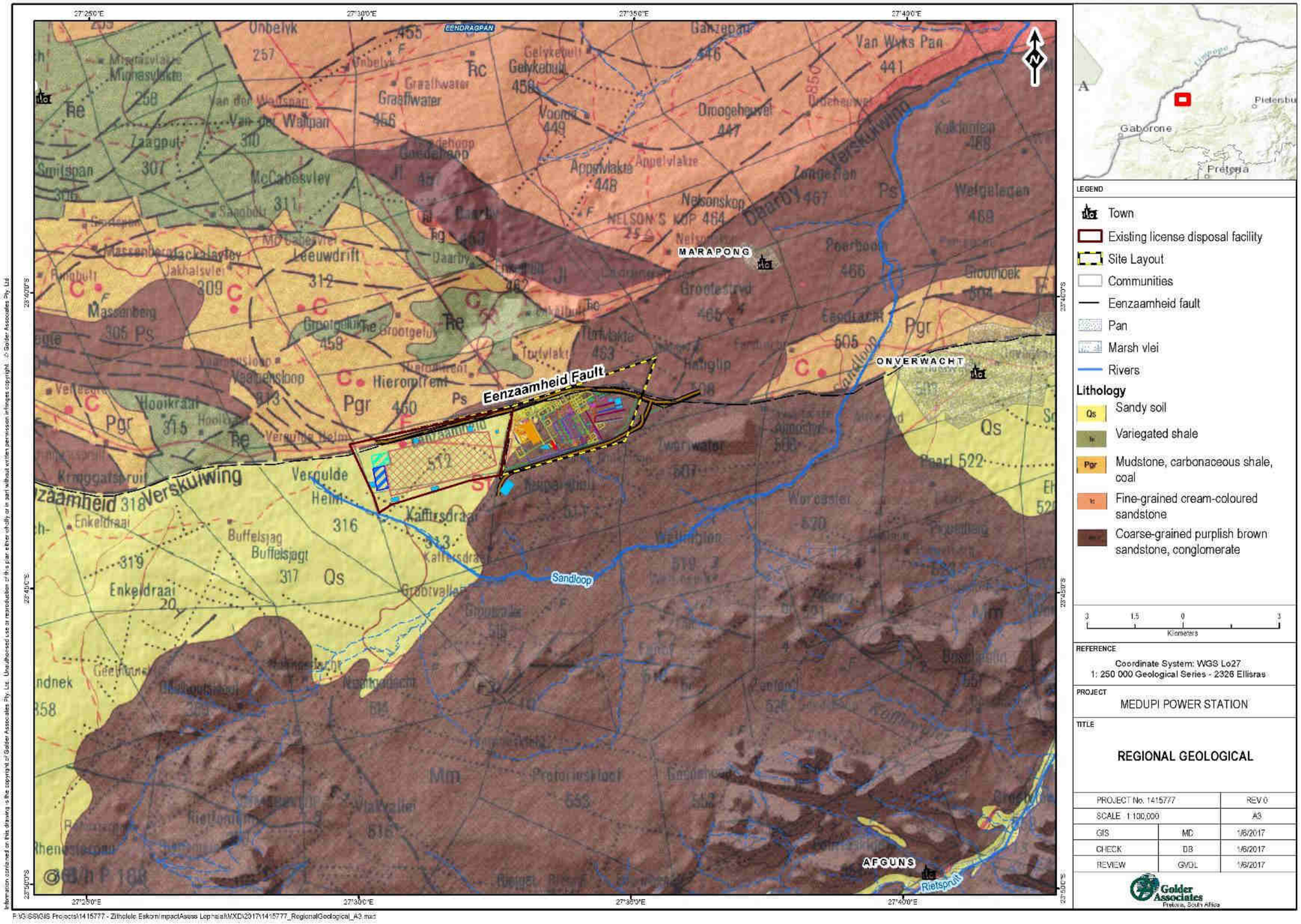


*Figure 3: Regional Geology*

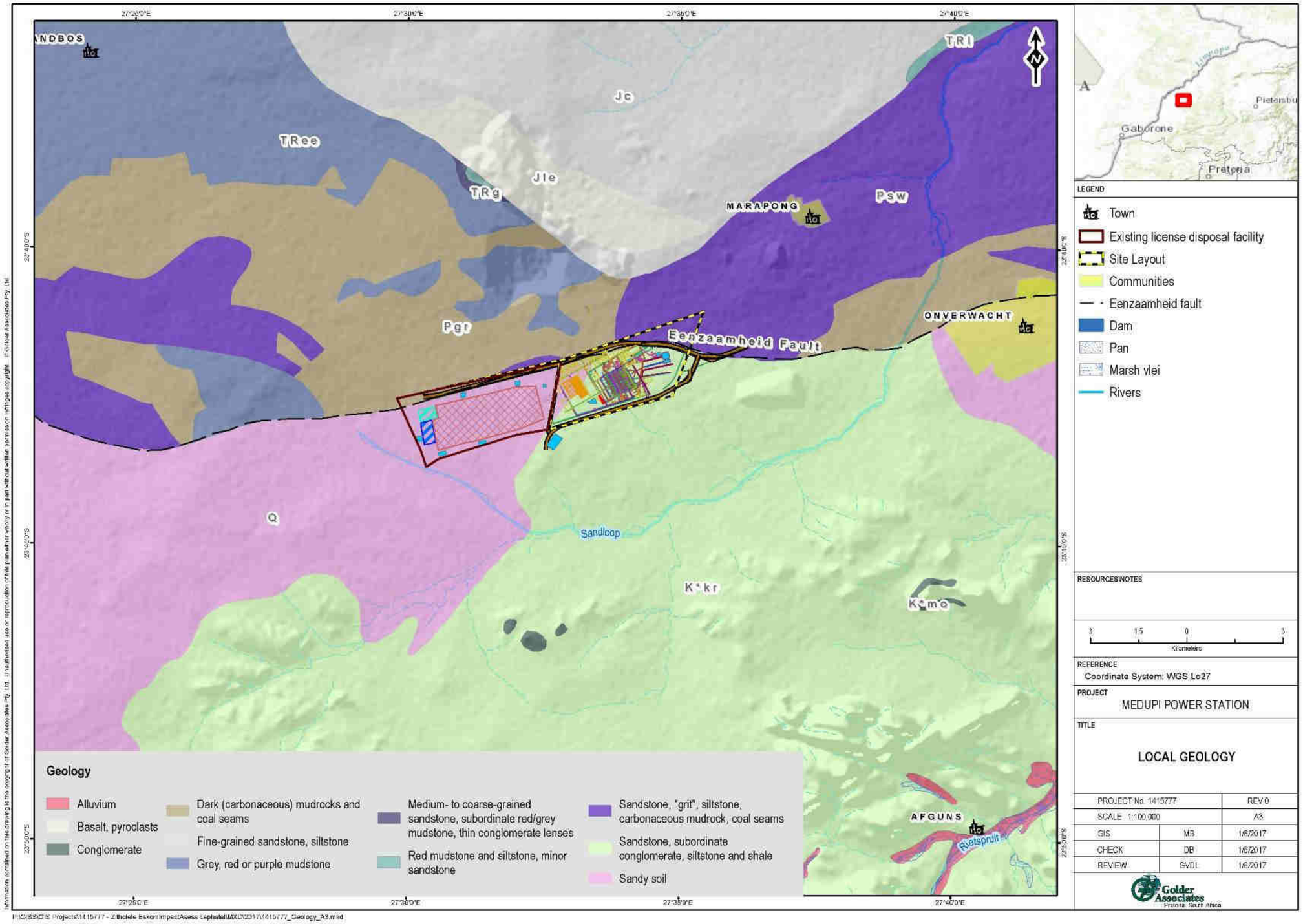


*Figure 4: Local Geology*

## 5.5 Regional Hydrogeology

### 5.5.1 Aquifer Systems

Two distinct and superimposed groundwater systems are present in the geological formations of the coal fields in South Africa, as described by Hodgson and Grobbelaar (1999). They are the upper weathered aquifer and the system in the fractured rock below (IGS2008).

#### *5.5.1.1 Weathered Aquifer System*

The upper 5-15 m of the weathered aquifer system normally consists of soil and weathered rock. The upper aquifer is associated with the weathered horizon. In boreholes, water may often be found at this horizon. The aquifer is recharged by rainfall.

Rainfall that infiltrates into the weathered rock reaches impermeable layers of solid rock underneath the weathered zone. Movement of groundwater on top of the solid rock is lateral and in the direction of the surface slope. This water reappears on surface at fountains, where the flow paths are obstructed by barriers such as dolerite dykes, paleo-topographic highs in the bedrock, or where the surface topography cuts into the groundwater level at streams; the Waterberg coalfields area is drier than most other coal areas, and the effect will be less significant. It is suggested that less than 60% of the water recharged to the weathered zone eventually emanates in streams (Hodgson and Krantz, 1998). The rest of the water is evapotranspirated or drained by other means (IGS2008).

The weathered zone is generally low-yielding, because of its insignificant thickness. Few farmers therefore tap this water by boreholes. The quality of the water is normally excellent and can be attributed to many years of dynamic groundwater flow through the weathered sediments. Leachable salts in this zone have been washed from the system long ago (IGS2008).

#### *5.5.1.2 Fractured Aquifer System*

The fractured aquifer system (~ 15 to 40m) present in the fresh rock below the weathered zone are well cemented, and do not allow significant water flow. All groundwater movement therefore occurs along secondary structures such as fractures, cracks and joints in the rock. These structures are best developed in sandstone and quartzite; hence the better water-yielding properties of the latter rock type. Dolerite sills and dykes are generally impermeable to water movement, except in the weathered state.

In terms of water quality, the fractured aquifer always contains higher salt loads than the upper weathered aquifer. The higher salt concentrations are attributed to a longer contact time between the water and rock (IGS2008).

## 5.6 Hydrocensus

A hydrocensus as was conducted during September 2015 at the Medupi FGD Retrofit Project and surrounding area is indicated on Figure 5. A total of 17 boreholes were surveyed and are summarised in Table 1.

The objective of the hydrocensus was to:

- Locate private owned boreholes and springs;
- Determine the status of existing boreholes;
- Borehole use and equipment;
- Record GPS coordinates of boreholes;
- Measure static water levels; and
- Collect representative groundwater samples to determine current baseline groundwater quality.

The hydrocensus was conducted on accessible farms and surrounding areas. Three boreholes KR01, KR02 (blocked), KR03 were located on the farm Kromdraai to the south of the Medupi FGD Retrofit Project area. KR01 is used for domestic all-purpose whereas KR03 is used for stock watering.

The 14 remaining hydrocensus boreholes are located to the west and south west of the Medupi FGD Retrofit Project area (Figure 5), on the farms surrounding the existing licensed disposal facility. Groundwater in the investigation area is mainly used for domestic and stock watering purposes, with no irrigation use reported.

From the available groundwater flow data, the inferred groundwater flow is primarily westwards and towards the Sandloop River from the Medupi FGD Retrofit Project area. Any contamination plume originating from the Medupi FGD Retrofit Project area will disperse towards groundwater users in these directions, impacting the groundwater quality negatively. Should it be proven that the existing licensed disposal facility have negatively impacted the groundwater quality, existing groundwater users will have to be provided with an alternative water supply.

Towards the north of Medupi FGD Retrofit Project area, the Eenzaamheid fault will probably prevent contamination spreading north and dewatering from Grootegeluk mine to affect the investigation area and existing groundwater users.

The 17 water levels that were measured during the hydrocensus area, range between 4.41 to 69.98mbgl (metres below ground level), whereas the average water level is 30.4mbgl.

All coordinates were measured with a hand-held GPS using the WGS 84 reference datum.

Groundwater samples were collected at 10 of these boreholes as indicated on Figure 7. These samples were collected as per Golder's standard sampling procedures and submitted to Waterlab Laboratories in Pretoria an accredited laboratory.

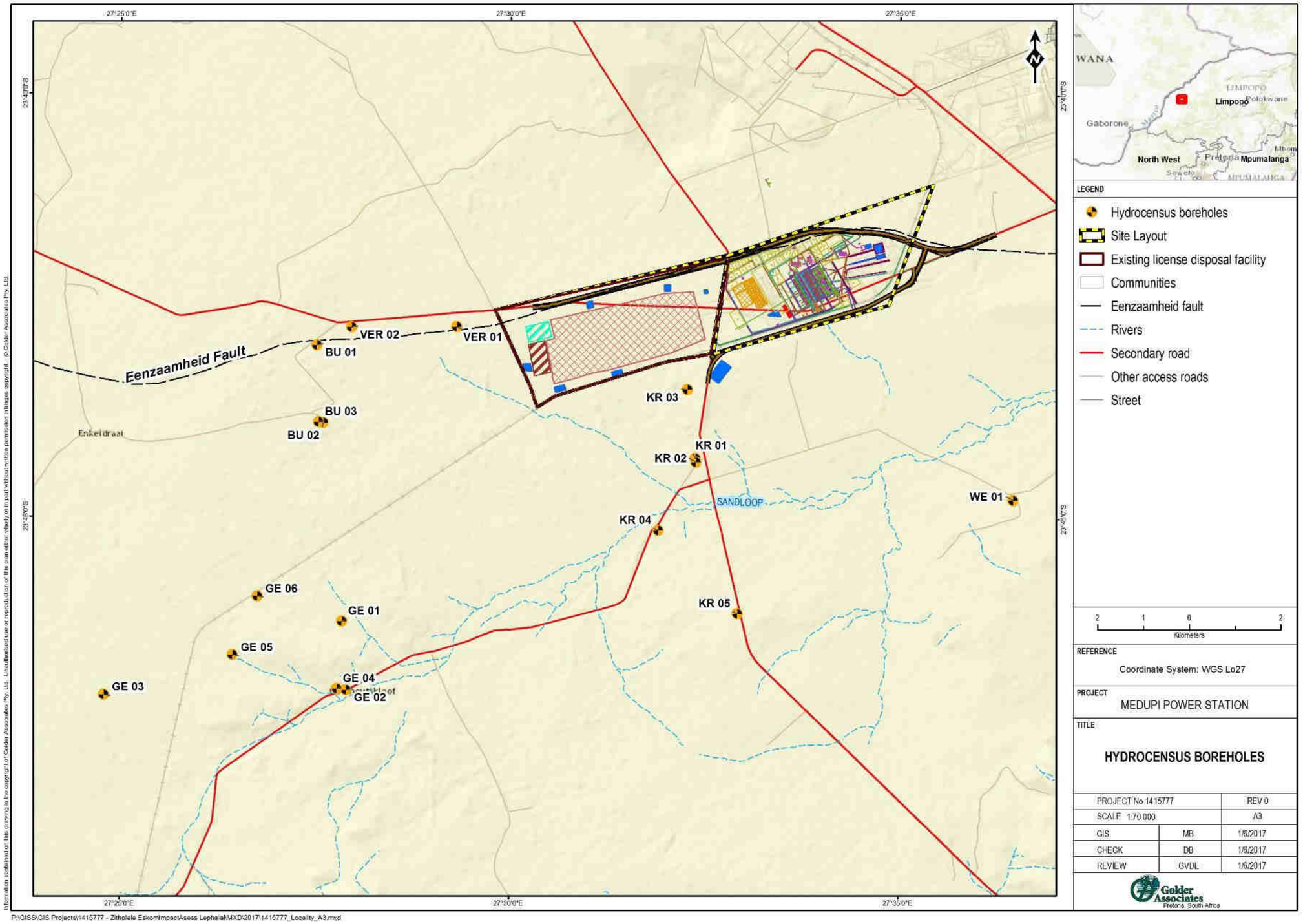


*Figure 5: Hydrocensus Borehole Positions*

**Table 1: Hydrocensus Boreholes**

| Borehole No. on Map | Latitude | Longitude | Site Name | Owner | Equipment | Diameter (mm) | SWL (mbgl) | Use | Condition of Facility |
|---|---|---|---|---|---|---|---|---|---|
| BU 01 | -23.71608 | 27.45864 | BUFFELSJAGT | - | Submersible | 165 | 59.18 | Domestic/All purpose | Working |
| VER 01 | -23.71242 | 27.48856 | VERGULDE HELM | Hendri Hills | None | 165 | 42.32 | Unused | Open |
| VER 02 | -23.71256 | 27.46608 | VERGULDE HELM | Hendri Hills | Submersible | - | 69.99 | Domestic/All purpose | Working |
| BU 02 | -23.73142 | 27.46008 | BUFFELSJAGT | - | Submersible | 165 | 64.63 | Domestic/All purpose | Working |
| BU 03 | -23.73122 | 27.45906 | BUFFELSJAGT | - | Submersible | 165 | 66.98 | Domestic/All purpose | Working |
| GE 01 | -23.77053 | 27.46417 | GEELHOUTSKLOOF | - | None | 165 | 13.88 | Unused | Open |
| GE 02 | -23.78397 | 27.46506 | GEELHOUTSKLOOF | - | Submersible | 165 | 9.47 | Domestic/All purpose | Working |
| GE 03 | -23.78503 | 27.41322 | GEELHOUTSKLOOF | - | Submersible | 165 | 55.56 | Domestic/All purpose | Working |
| GE 04 | -23.78378 | 27.46308 | GEELHOUTSKLOOF | - | Windmill | 165 | 9.17 | Unused | Broken |
| GE 05 | -23.77717 | 27.44075 | GEELHOUTSKLOOF | - | Submersible | 165 | 9.78 | Domestic/All purpose | Not Working |
| GE 06 | -23.76558 | 27.44603 | GEELHOUTKLOOF | - | Submersible | 165 | 24.21 | Stock Watering | Working |
| KR 01 | -23.73822 | 27.53972 | KROMDRAAI | Eskom (Lessee Mr Etienne Rossouw) | Submersible | 165 | 4.41 | Domestic/All purpose | Working |
| KR 02 | -23.73897 | 27.53986 | KROMDRAAI | Eskom (Lessee Mr Etienne Rossouw) | None | 165 | Blocked | Unused | Open |
| KR 03 | -23.72469 | 27.53794 | KROMDRAAI | Eskom (Lessee Mr Etienne Rossouw) | Submersible | 165 | 15.28 | Stock Watering | Working |
| KR 04 | -23.75239 | 27.53183 | KROMDRAAI | Eskom (Lessee Mr Etienne Rossouw) | None | 165 | 5.72 | Unused | Open |
| KR 05 | -23.76881 | 27.54878 | KROMDRAAI | Eskom (Lessee Mr Etienne Rossouw) | Submersible | 165 | 26.62 | Domestic/All purpose | Working |
| WE 01 | -23.74628 | 27.60775 | WELLINGTON | Chris Booysen | Windmill | 165 | 8.82 | Unused | Not Working |
| Minimum | | | | | | | 4.41 | | |
| Maximum | | | | | | | 69.99 | | |
| Average | | | | | | | 30.4 | | |

## 5.7 Groundwater Quality

The published hydrogeological maps (DWAF 1996) indicate the average Electrical conductivity (EC) at the existing licensed disposal facility in the range of 70-300mS/m, this value is higher than the SANS 241:2011 drinking water compliance limit of 170mS/m (Figure 6).

### 5.7.1 Baseline Groundwater Quality, 2015

A total of 10 groundwater samples were collected in the investigation area during the hydrocensus (Figure 7). The hydrocensus was conducted on accessible farms and surrounding area of the existing licensed disposal facility.

These samples were collected as per Golder's standard sampling procedures submitted to Waterlab Laboratories in Pretoria an accredited laboratory.

The objective of the groundwater sampling was to determine the baseline groundwater quality of the investigation area and water quality (class) of existing groundwater users.

The Analytical Result Certificates of the samples taken during hydrocensus are attached in Appendix A.

### 5.7.2 Groundwater Chemical Parameters

The groundwater samples were analysed for the following constituents:

- pH, EC, TDS, Total Alkalinity;
- Standard cations Ca, Mg, Na, K;
- Standard anions Cl, SO4, $NO_3$; and
- ICP-MS Scan for soluble metals.

### 5.7.3 Water quality Standards

The analytical results of the groundwater samples were compared to the following standards;

- Department of Water Affairs and Forestry, domestic water quality guidelines, volume 1,1996 and Water Research Commission, water quality guidelines, 1998;
- South African National Standards, drinking water standards, 2011 (SANS 241:2011); and
- South African Water Quality Guidelines (SAWQG), Volume 5: Agricultural Use – Livestock Watering (DWAF, 1996).

The SANS 241:2011 drinking water standard is used as reference in Table 3, whereas the DWAF 1998 guidelines were used to classify water quality classes (Table 2).

**Table 2: DWAF Water Quality Classes (1998)**

| Water quality class | Description | Drinking health effects |
|---|---|---|
| **Class 0** | Ideal water quality | No effects, suitable for many generations. |
| **Class 1** | Good water quality | Suitable for lifetime use. Rare instances of sub-clinical effects |
| **Class 2** | Marginal water quality, water suitable for short-term use only | May be used without health effects by majority of users, but may cause effects in some sensitive groups. Some effects possible after lifetime use. |
| **Class 3** | Poor water quality | Poses a risk of chronic health effects, especially in babies, children and the elderly. May be used for short-term emergency supply with no alternative supplies available. |
| **Class 4** | Unacceptable water quality | Severe acute health effects, even with short-term use. |

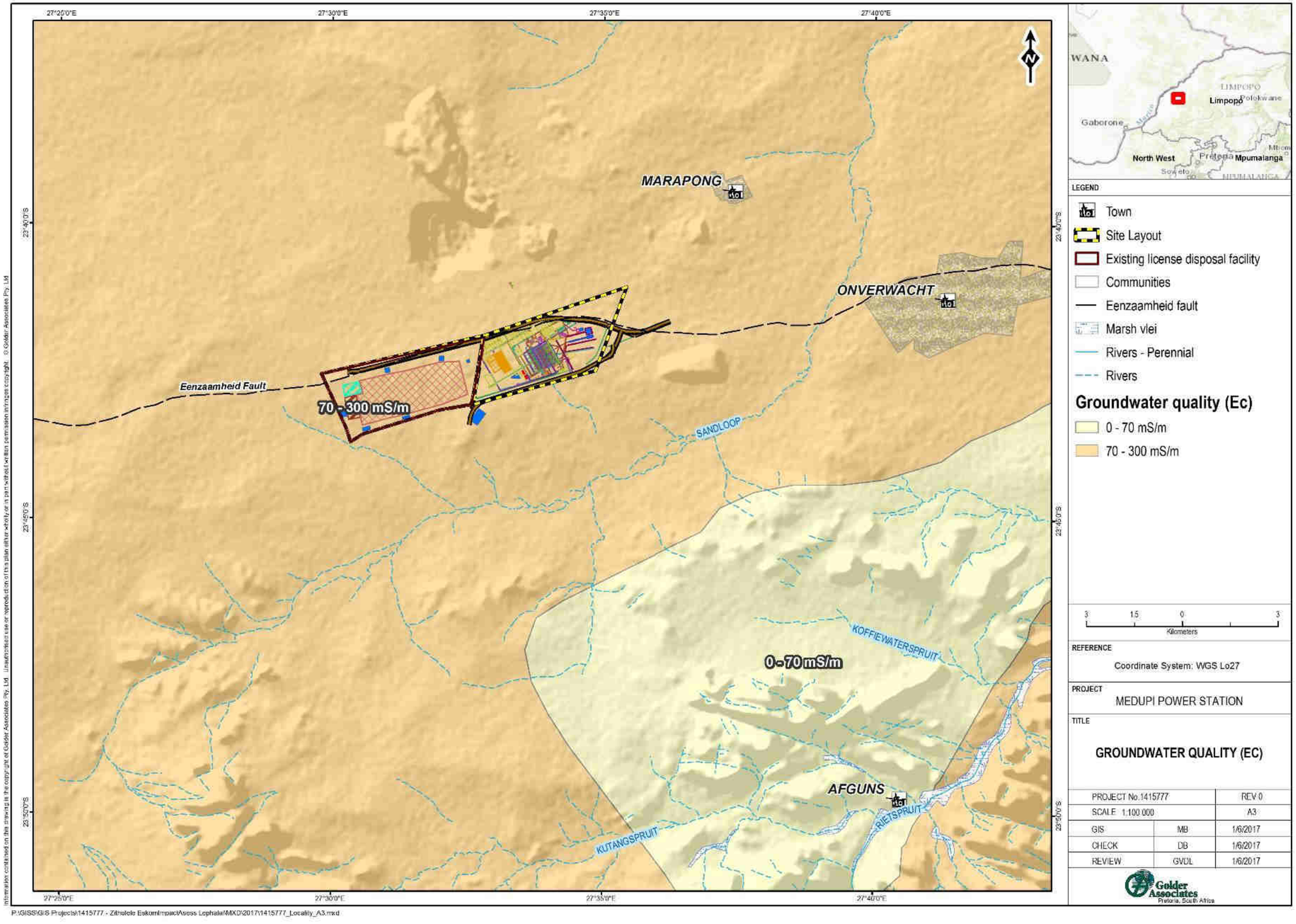




*Figure 6: Hydrogeological Map Series Average Groundwater Electrical conductivity (EC) Values*

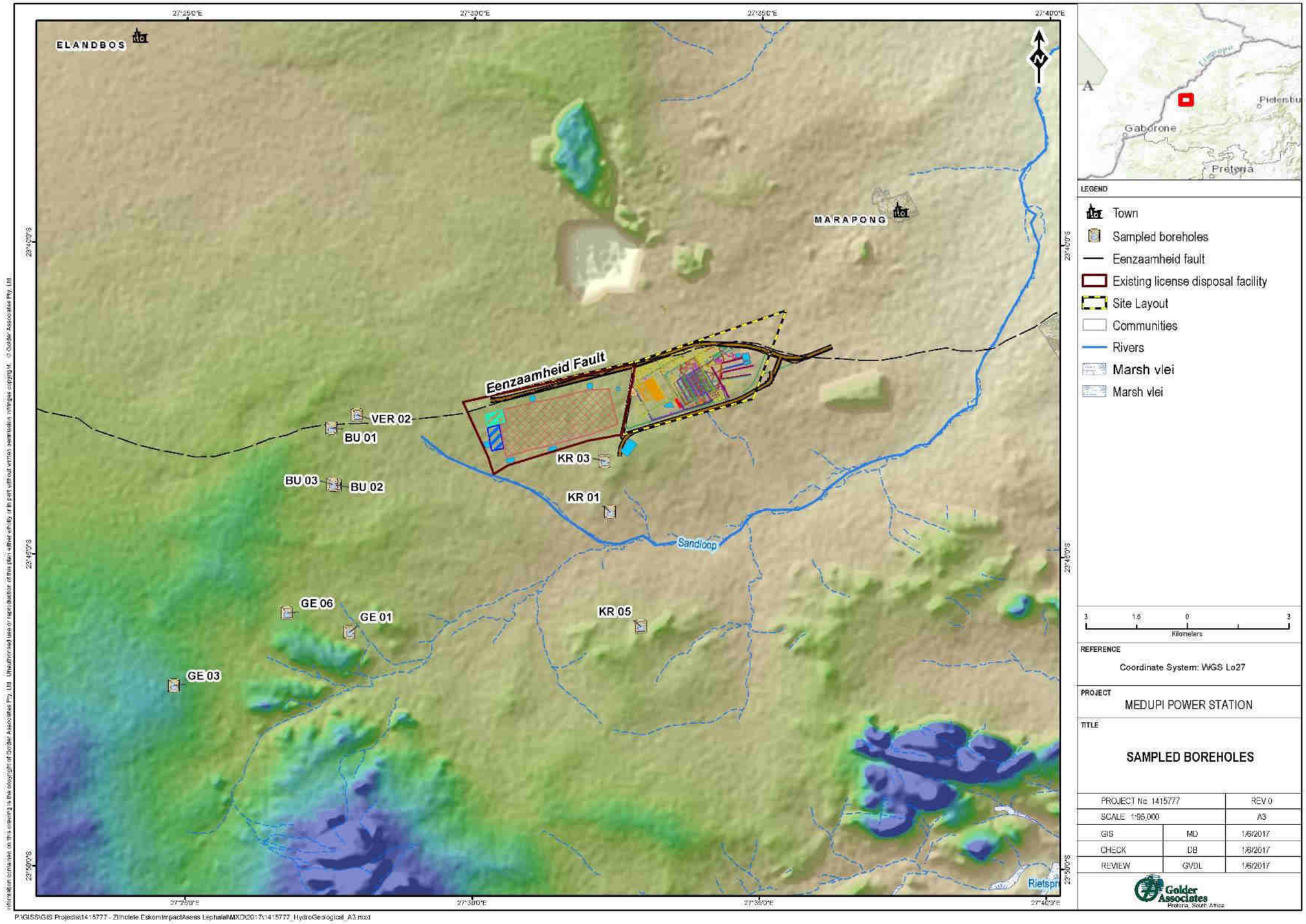


*Figure 7: Sampled Boreholes*

### 5.7.4 Groundwater Analytical Results

The analytical results (major cations and anions) of sampled boreholes are listed in Table 3. A highlighted value in red exceeds the SANS 241:2011 maximum allowable limit, whereas the water quality classes are classified using the DWAF (1998) drinking water standards (black highlighted values exceeding class I).

The following constituents of the groundwater samples exceed the SANS 241 (2011) maximum allowable standard:

- EC, boreholes BU02 and BU03;
- TDS, boreholes BU02 and BU03;
- Na, boreholes BU02 and GE03;
- Cl, boreholes BU01, BU02 and BU03;
- N, boreholes BU02 and BU03. These two boreholes have elevated Nitrate values (Class III; 16mg/l and IV; 66mg/l respectively). This water quality poses chronic health risks is and represents poor and unacceptable water quality. The elevate nitrate concentrations is probably related to point source pollution caused by animal farming and stockades;
- Al, boreholes KR01,KR03 and KR05;
- F, boreholes BU01, BU02,BU03 and KR03;
- Fe, boreholes KR01,KR05, BU02, VER05 and GE01; and
- Mn, borehole BU02.

The constituents of borehole GE06 are all below the SANS 241 (2011) maximum allowable standard, and are representing a Class 0 water quality.

The boreholes with elevated EC, TDS, Na, Cl, Al, F, Fe and Mn concentrations are probably related to the geology of the surrounding area.

None of the sampled boreholes have elevated $SO_4$ concentrations above background groundwater quality levels.

**Table 3: Hydrocensus Analytical Results**

| Borehole Number | Physical Determinants | | | Chemical Determinants | | | | | | | | | | | Water Quality Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | EC (mS/m) | TDS (mg/l) | MALK (mg/l) | Ca (mg/l) | K (mg/l) | Mg (mg/l) | Na (mg/l) | Cl (mg/l) | $NO_3$ as N (mg/l) | $SO_4$ (mg/l) | Al (mg/l) | F (mg/l) | Fe (mg/l) | Mn (mg/l) | |
| | | | | | | | | | | | | | | | | |
| KR05 | 7.3 | 31 | 180 | 160 | 14.57 | 2.601 | <2 | 52.47 | 9 | <0.2 | 8 | **0.715** | 0.3 | **2.143** | 0.044 | III |
| BU03 | 7.3 | **288** | **1896** | 292 | **186.4** | 22.59 | **95.25** | **237.8** | **664** | **66** | 62 | 0.1 | **2.2** | 0.108 | <0.025 | IV |
| KR01 | 5.7 | 15.7 | 116 | 8 | 6.462 | 6.399 | 3.619 | 11.21 | 25 | <0.2 | 24 | **0.576** | **0.9** | **7.056** | 0.068 | I |
| KR03 | 5.4 | 27.4 | 198 | 8 | 11.26 | 6.992 | 5.197 | 23.29 | 36 | 2 | 51 | **2.207** | **2.7** | 0.566 | **0.138** | III |
| BU02 | 7.5 | **204** | **1320** | 288 | **135.4** | 16.99 | 64.56 | **194.8** | **518** | **16** | 36 | 0.255 | **2.2** | **6.59** | **0.775** | III |
| VER02 | 7.4 | **112** | **652** | 356 | 77.3 | 15.34 | 34.14 | **108.1** | **167** | 0.5 | 40 | <0.100 | 1.3 | **3.614** | **0.324** | III |
| BU01 | 7.5 | **178** | **1058** | 368 | 81.3 | 18.44 | 54.05 | **194.4** | **336** | <0.2 | 71 | 0.103 | **2.3** | **1** | 0.09 | II |
| GE03 | 7.8 | **124** | **670** | 276 | 23.38 | 6.421 | 16.57 | **200.1** | **280** | <0.2 | 41 | <0.100 | 0.7 | 0.042 | **0.122** | II |
| GE01 | 7.1 | 12.2 | 84 | 48 | 3.492 | 2.483 | 1.525 | 16.91 | 18 | <0.2 | <5 | 0.13 | <0.2 | **4.817** | **0.131** | III |
| GE06 | 7 | 39.6 | 248 | 208 | 31.94 | 2.945 | 26.2 | 11.87 | 17 | 0.3 | <5 | <0.100 | <0.2 | 0.03 | 0.065 | 0 |
| SANS241: 2011 Max. Allowable Limit | 9.7 | <170 | 1200 | - | - | - | - | 200 | 300 | 11 | 500 | 0.3 | 1.5 | 0.3 | 0.5 | |
| Class 0 Max. Allowable Limit | 9.5 | <70 | <450 | - | <80 | <25 | <70 | <100 | <100 | <6 | <200 | - | <0.7 | <0.01 | <0.1 | 0 |
| Class 1 Max. Allowable Limit | 10 | 150 | 1000 | - | 150 | 50 | 100 | 200 | 200 | 10 | 400 | - | 0.7-1.0 | 0.01-0.2 | 0.1-0.4 | I |
| Class 2 Max. Allowable Limit | 10.5 | 370 | 2400 | - | 300 | 100 | 200 | 400 | 600 | 20 | 600 | - | 1.0-1.5 | 0.2-2.0 | 1.0-4.0 | II |
| Class 3 Max. Allowable Limit | 11 | 520 | 3400 | - | >300 | 500 | 400 | 1000 | 1200 | 40 | 1000 | - | 1.5-3.5 | 2.0-10.0 | 4.0-10.0 | III |
| Class 4 Max. Allowable Limit | >11 | >520 | >3400 | - | | >500 | >400 | >1000 | >1200 | >40 | >1000 | - | >3.5 | >10.0 | >10.0 | IV |
| **South African Water Quality Guidelines (SAWQG), Volume 5 – Agricultural Use – Livestock Watering Target Range** | - | 154 | 1000 | - | 1000 | - | 500 | 2000 | 1500 | 1000 | 100 | 5.0 | 2.0 | 10 | 10 | |
| **Minimum** | 5.4 | 12.2 | 84 | 8 | 3.492 | 2.483 | <2 | 11.2 | 9 | <0.2 | <5 | <0.100 | <0.2 | 0.030 | <0.025 | |
| **Maximum** | 7.8 | 288 | 1896 | 368 | 186.4 | 22.59 | 95.250 | 237.8 | 664 | 66.0 | 71 | 2.207 | 2.7 | 7.056 | 0.775 | |
| **Average** | 7 | 103.19 | 642.2 | 201.2 | 57.1504 | 10.1201 | 30.311 | 105.1 | 207 | 8.6 | 34 | 0.439 | 1.3 | 2.597 | 0.178 | |

### 5.7.5 Baseline Groundwater Quality

The baseline groundwater quality of the Medupi FGD Retrofit Project area is based on macro chemistry analyses of the hydrocensus sampled boreholes. The concentrations are compared to the SANS 241:2011 water quality standard and the baseline quality are represented by the Median of the concentrations. The baseline water quality of the combined sampled boreholes are summarised in Table 4 below.

**Table 4: Baseline Groundwater Quality**

| Item | Physical Parameters | | | Macro Determinants (Major Ions and Trace Metals) | | | | | | | | Minor Determinant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | EC mS/m | TDS mg/l | Ca mg/l | Mg mg/l | Na mg/l | K mg/l | Cl mg/l | SO4 mg/l | NO3 mg/l | MALK Mg/l | F mg/l | Fe mg/l | Mn mg/l |
| No. of Records | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 10% Percentile | 5.67 | 15.35 | 112.8 | 6.165 | 1.9525 | 11.804 | 2.5892 | 16.2 | 5 | 0.2 | 8 | 0.2 | 0.0408 | 0.0421 |
| ***Median Baseline water Quality*** | **7.3** | **75.8** | **450** | **27.66** | **21.385** | **80.285** | **6.7065** | **101.5** | **38** | **0.25** | **242** | **1.1** | **1.5715** | **0.106** |
| Average | 7 | 103.19 | 642.2 | 57.1504 | 30.3111 | 105.095 | 10.1201 | 207 | 34.3 | 8.58 | 201.2 | 1.3 | 2.5966 | 0.1782 |
| 90% Percentile | 7.53 | 212.4 | 1377.6 | 140.5 | 67.629 | 203.87 | 18.855 | 532.6 | 62.9 | 21 | 357.2 | 2.34 | 6.6366 | 0.3691 |
| Max. Allowable Limit (SANS 241:2011) | <5 >9 | <170 | <1200 | <300 | <100 | <200 | <100 | <300 | <500 | <11 | - | <1.5 | <0.3 | <0.5 |

### 5.7.6 Groundwater Classification

The groundwater quality results of sampled boreholes are visually represented on Piper and expanded Durov diagrams to distinguish between the different water quality classes/types.

## Piper Diagrams

Piper diagrams graphically represent the relative percentages of anions and cations in water samples. The cation percentages are plotted in the left triangle and the anion percentages in the right triangle. A projection of these cation and anion presentations onto the central diamond presents the chemical signature of the major ion composition of the water.

The sampled boreholes GE06 and VER02 groundwater quality on the Piper diagram (Figure 8) show a signature of calcium magnesium bicarbonate type of water (Ca, Mg)$(HCO_3)_2$. This type of water is associated with recent rainfall recharge and unpolluted groundwater (blue sector).

Sampled boreholes GE01 and KR05 groundwater quality on the Piper diagram (Figure 8) show a signature of sodium bicarbonate/chloride type of water (green sector), whereas BU01, BU02, BU03, KR01 show a signature of calcium/sodium sulphate water and GE03 (black sector) show a signature of sodium chloride type of water respectively.

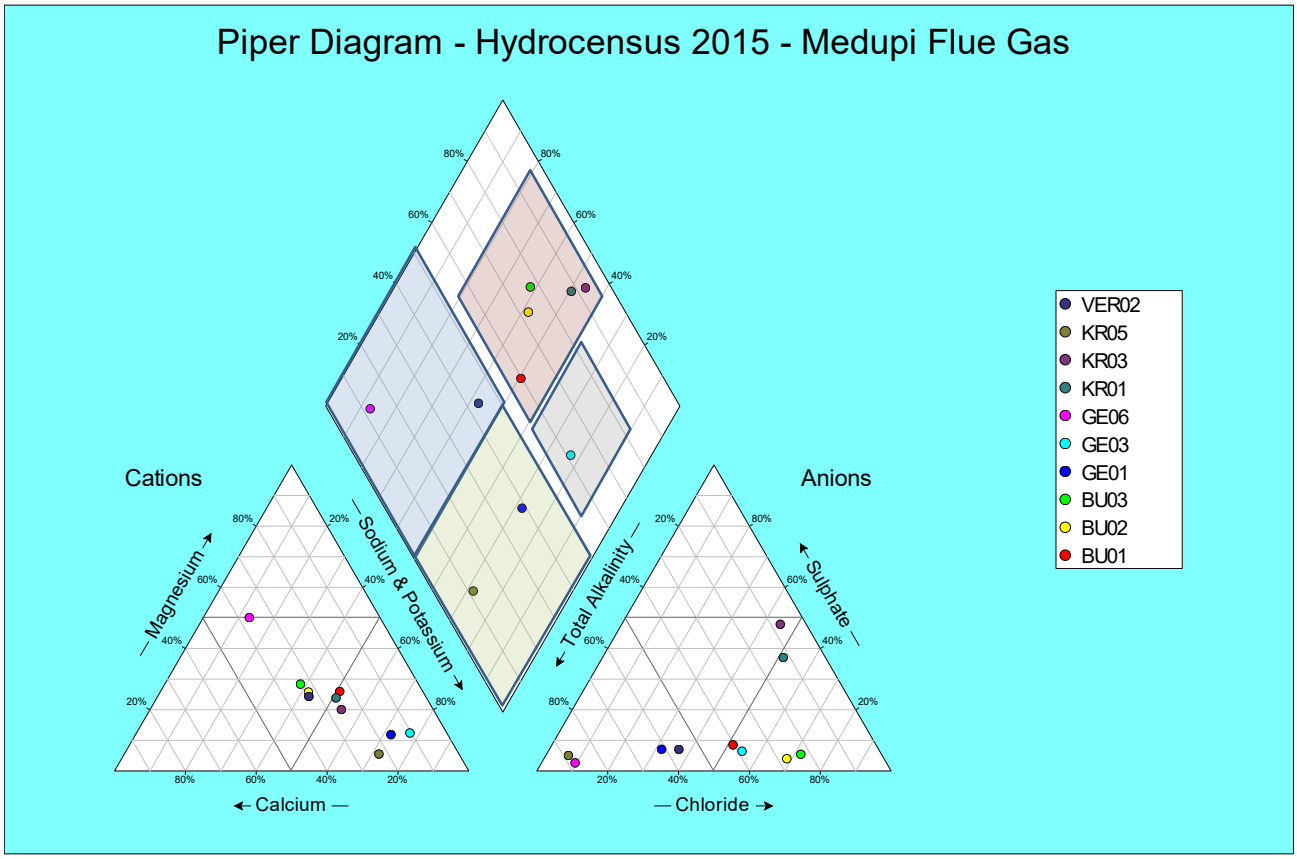


*Figure 8: Piper Diagram Hydrocensus Boreholes*

## Expanded Durov Diagrams

Expanded Durov diagrams graphically represent the relative percentages of anions and cations in water samples. The cation percentages are plotted in the top part of the diagram and the anion percentages in the left part. A projection of these cation and anion percentages onto the central area presents the chemical signature of the major ion composition of the water. The chemical signature can be related to various hydrochemical environments and conditions.

The expanded Durov diagram Figure 8 differentiates between five types of water:

- On the Expanded Durov Diagram boreholes GE06 and VER02 plot on the blue sector of the diagram and represent [recharged] unpolluted groundwater.
- The results of sample GE01 and KR05 plot on the red sector representative of sodium potassium bicarbonate type of water (Na, K)$(HCO_3)_2$. The plot position on the diagram indicates towards minor sodium potassium enrichment.
- Sampled borehole KR03 plot on the green sector and are representative of sodium potassium sulphate type of water (Na, K)$SO_4$. The plot position on the diagram indicates water with minor sodium, potassium and sulphate enrichment.
- Sampled boreholes BU02 and BU03 plot on the yellow sector and are representative of magnesium chloride type of water (Mg) Cl. The plot position on the diagram indicates water with minor magnesium and chloride enrichment.
- Samples BU01, GE03, and KR01 plot on the purple sector representative of sodium, potassium chloride type of water (Na, K)Cl. The plot position on the diagram indicates water with minor sodium, potassium and chloride enrichment, associated with natural saline water and deep mine water.

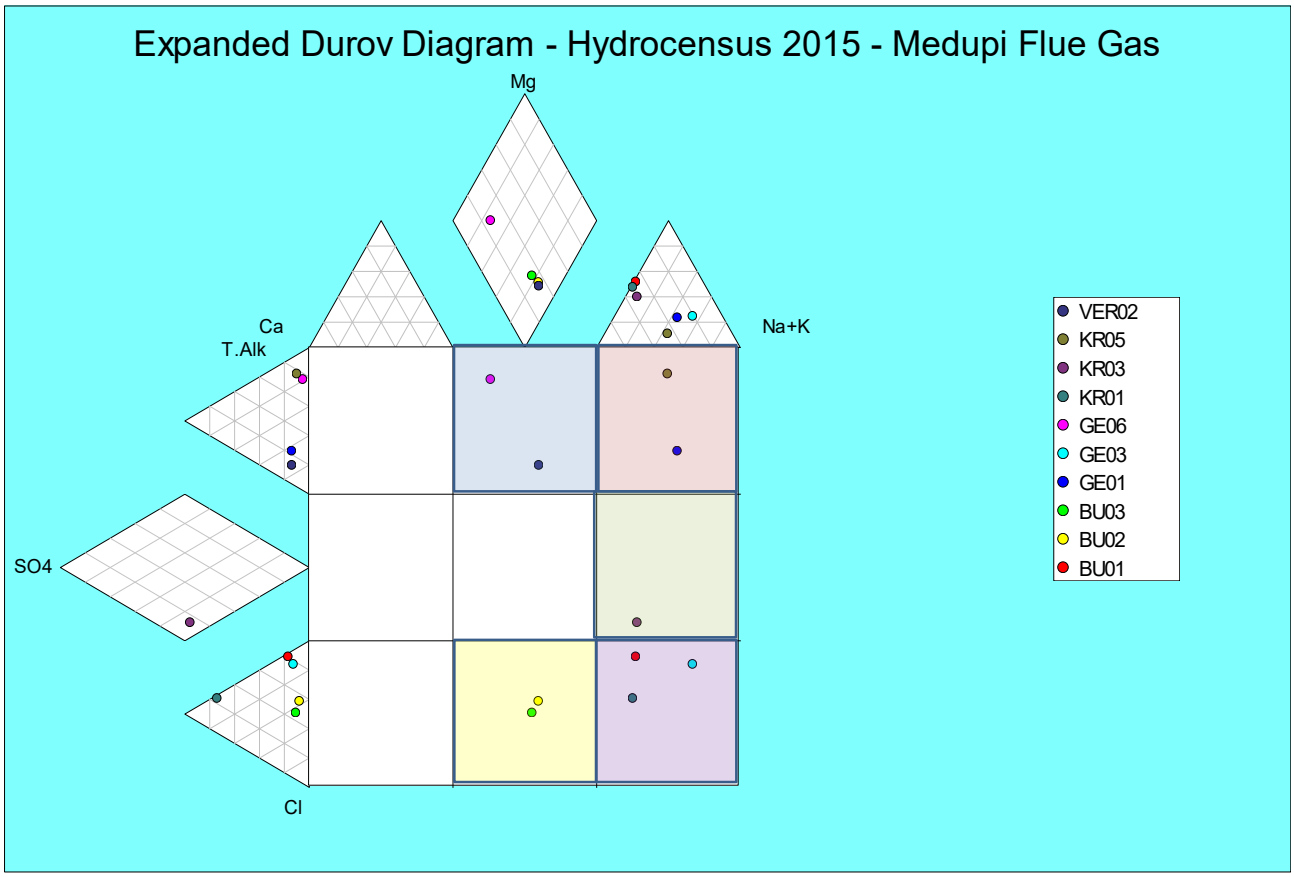


*Figure 9: Expanded Durov Diagram Hydrocensus Boreholes*

## 5.8 Aquifer Recharge

### 5.8.1 Regional Aquifer Recharge

From the published hydrogeological maps (DWAF 1996) the average recharge for Medupi FGD Retrofit Project area is shown as between 10 to 15mm per annum (Figure 10).

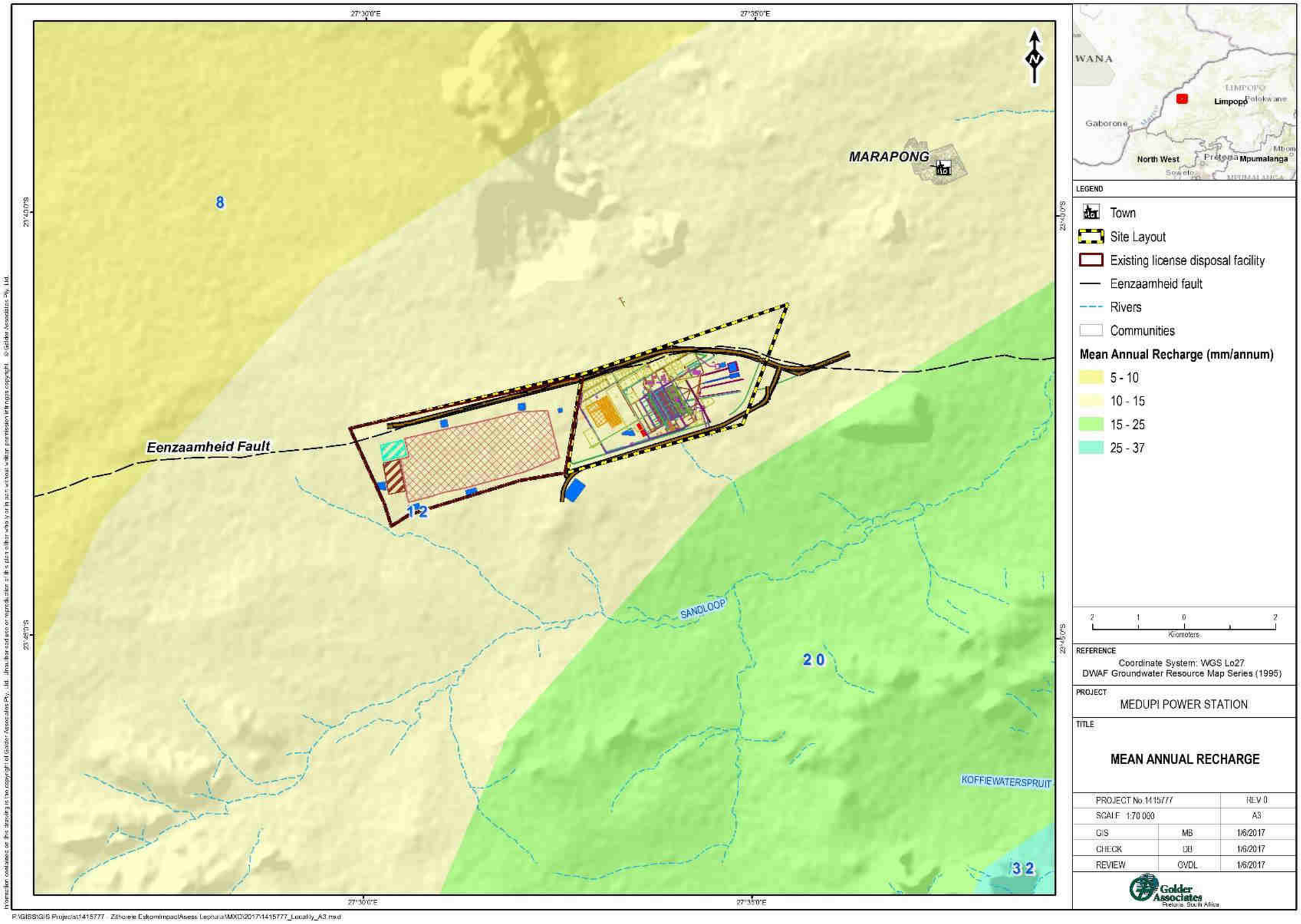


*Figure 10: Groundwater Mean Annual Recharge (Vegter 1996)*

### 5.8.2 Chloride Ratio Method

The Chloride Ratio Method was used to estimate the aquifer recharge for the Medupi FGD Retrofit Project area. The Chloride method calculates the recharge using the ratio between the average chloride in rainfall and the average chloride in the groundwater.

The chloride concentration should only result from the natural, hydrological, and evaporative processes as expressed below:

$$\mathbf{RE}\ \% = \frac{\mathbf{Clr}}{\boldsymbol{Clgw}}\boldsymbol{X100}$$

Where: $Cl_r$ is the concentration of chloride in rainfall (mg/l)

$Cl_{gw}$ is the concentration of chloride in the groundwater (mg/l)

= 0.6 mg/l / 32.34 mg/l (Harmonic Mean groundwater samples)

=1.8%

The Harmonic mean of chloride was calculated from the hydrocensus groundwater samples analysed in 2015. The current accepted concentration of chloride concentration in rainfall for the area is 0.6 mg/l.

Recharge =1.8 % of the MAP 429.1mm =7.7mm per annum. This recharge value (7.7mm) is slightly lower but more site specific than the values indicated on the published hydrogeological maps as 10 to 15mm per annum (Figure 10).

## 5.9 Groundwater Vulnerability

Groundwater vulnerability gives an indication of how susceptible an aquifer is to contamination. Aquifer vulnerability is used to represent the intrinsic characteristics that determine the sensitivity of various parts of an aquifer to being adversely affected by an imposed contaminant load.

A national scale groundwater vulnerability map of South Africa was prepared by the WRC (Water Research Commission), using the DRASTIC methodology that includes the following components:

- **D**epth to groundwater;
- **R**echarge due to rainfall;
- **A**quifer media;
- **S**oil media;
- **T**opography;
- **I**mpact of the vadose zone; and
- Hydraulic **C**onductivity.
- Groundwater vulnerability was classified into six classes ranging from very low to very high.

Groundwater vulnerability for the Medupi FGD Retrofit Project area is shown on the national groundwater vulnerability map (Figure 11) is indicated as low to medium.

The probability that the Medupi FGD Retrofit Project area site will have a major impact on the groundwater is limited but needs to be monitored.

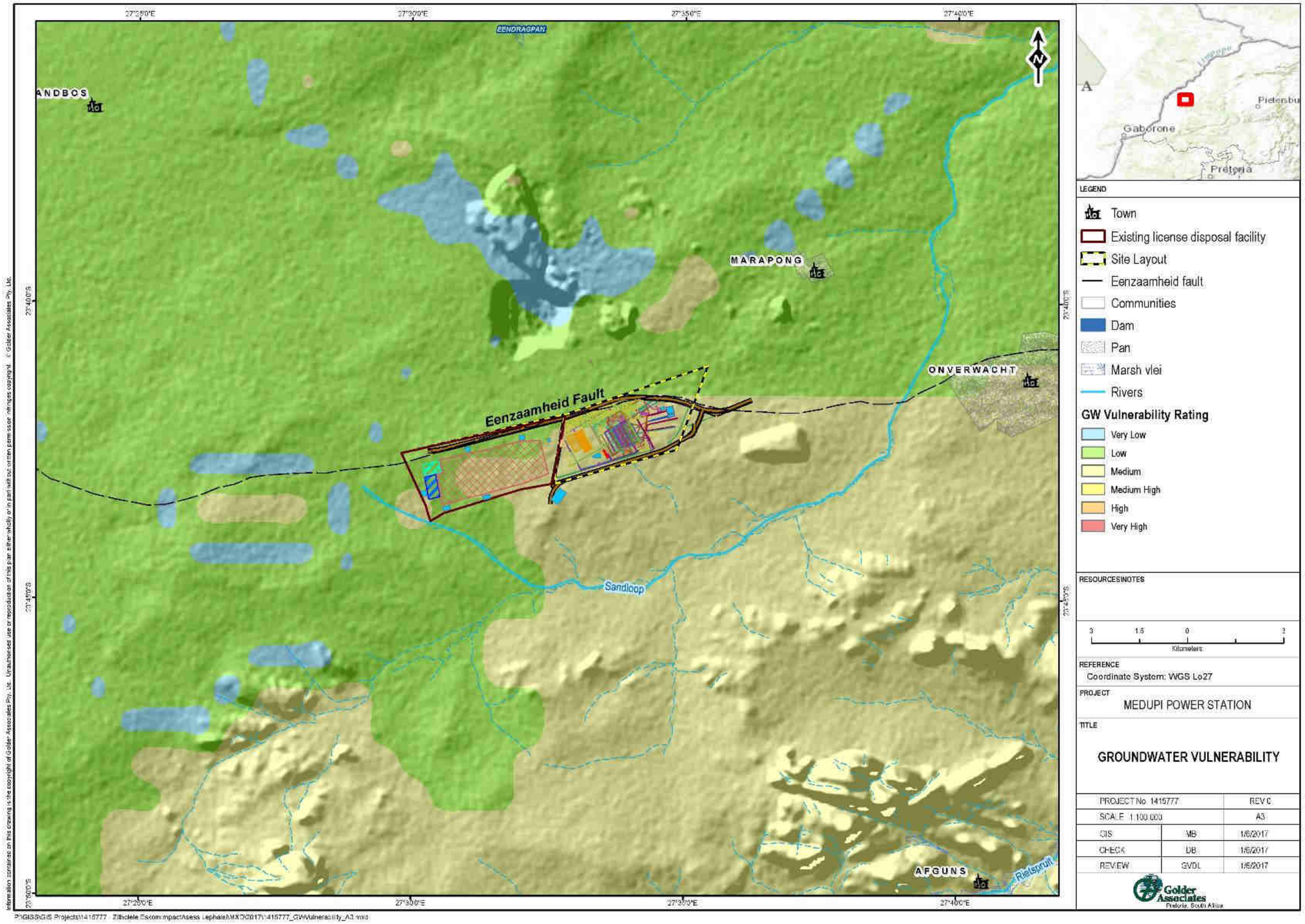


*Figure 11: Groundwater Vulnerability Map*

## 5.10 Groundwater Conceptual Model

*A conceptual groundwater model is an interpretation of the characteristics and dynamics of an aquifer system which is based on an examination of all available hydrogeological data for a modelled area. This includes the external configuration of the system, location and rates of recharge and discharge, location and hydraulic characteristics of natural boundaries, and the directions of groundwater flow throughout the aquifer system.*

The conceptual model forms the basis for the understanding of the groundwater occurrence and flow mechanisms in the area of investigation, and will be used as a basis for future numerical groundwater modelling of the Medupi FGD Retrofit Project.

Based on the available data an initial groundwater conceptual model was compiled for the Medupi FGD Retrofit Project area (Figure 12).

The Golder 2009 site investigation summarized the hydraulic parameters for the Medupi Power station as follows:

- The average k value for dry boreholes subjected to falling head tests is 0.025 m/d;
- Slug test K values varied from 0.035 m/d (GA036) to 3.01 m/day (GA009) with an average value of 0.89 m/d;
- Transmissivity values obtained for the 5 main boreholes tested inside the current pit average 22$m^2$/d;
- Transmissivity for tested boreholes outside of the excavated area is < 8$m^2$/d; and
- The storage coefficient for the shallow aquifer is estimated to be between 4.4 x $10^{-5}$ and 2.2 x$10^{-4}$.

The conceptual model is based on two distinct types of aquifers which are present in the geological formations of the coal fields in South Africa:

- Upper weathered aquifer system; and
- Fractured aquifer system.

### 5.10.1 Weathered Aquifer System

The upper weather aquifer zone is ~ 5-15m and comprises of soil and weathered rock. The aquifer is recharged by rainfall.

### 5.10.2 Fractured Aquifer System

The fractured aquifer zone is ~ 15-40m and comprises of fractured rock.

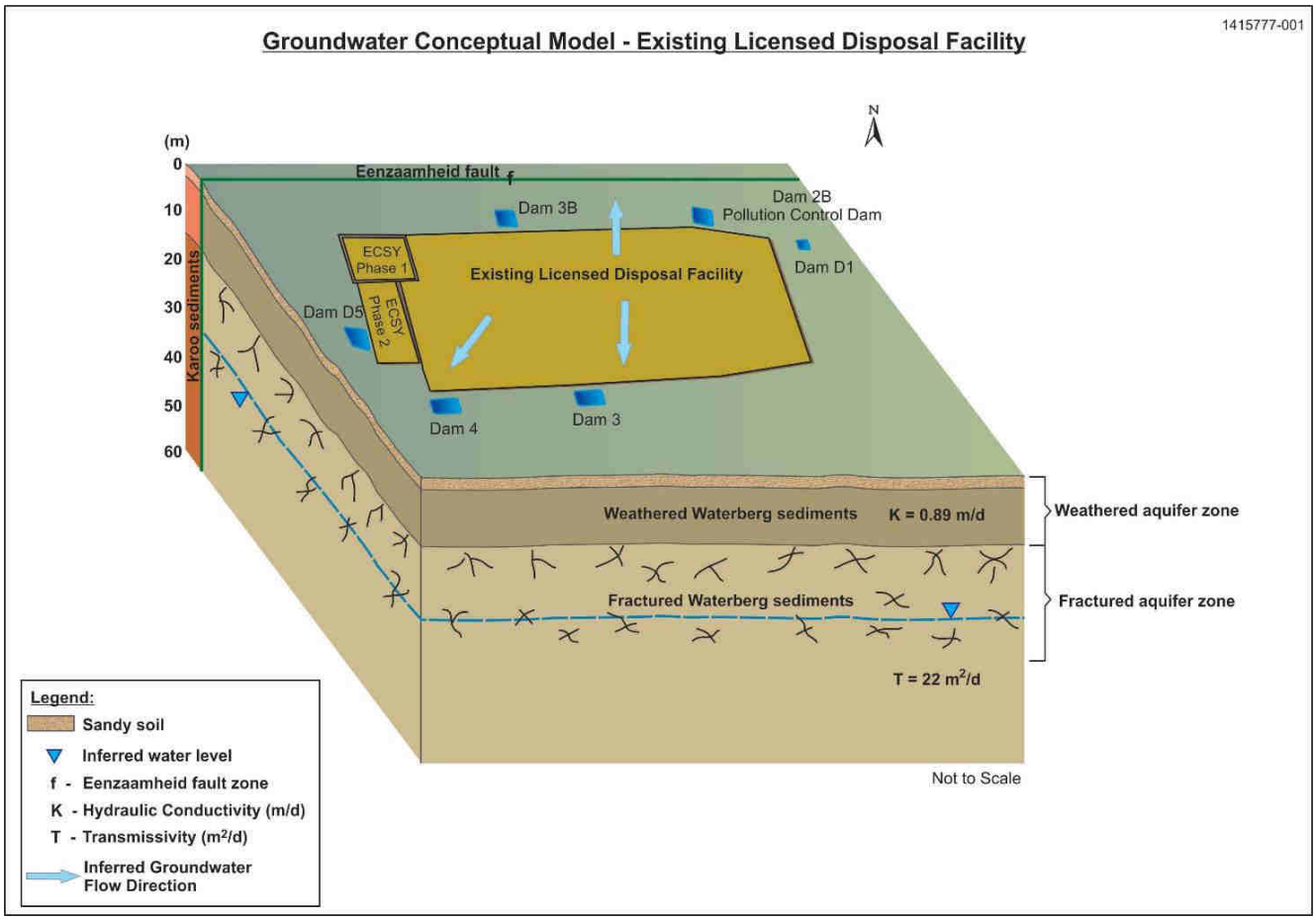


*Figure 12: Initial Groundwater Conceptual Model for Medupi FGD Retrofit Project area and existing disposal facility*

## 5.11 Aquifer Classification and Borehole Yield

The hydrocensus did not yield any specific borehole yielding information. The published hydrogeological maps series by DWAF (1996) was used to define the regional aquifer classification (Figure 13). The aquifer is classified as a minor aquifer system with fractured aquifer zones (Figure 14).

The published hydrogeological maps (DWAF 1996) indicate that the average borehole yield in the area is between 0.5l/s and 2.0l/s (Figure 14).

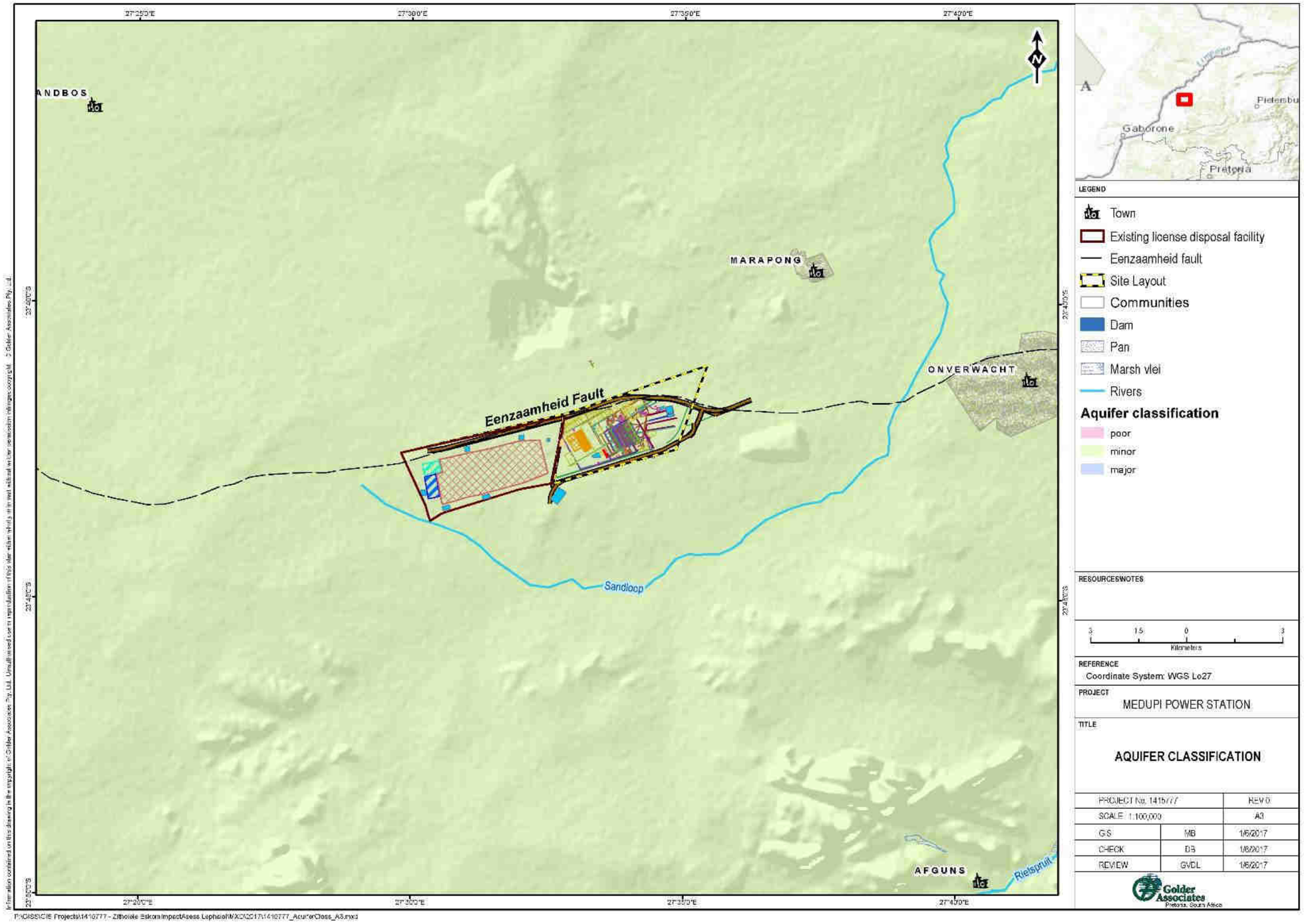


*Figure 13: Aquifer Classification*

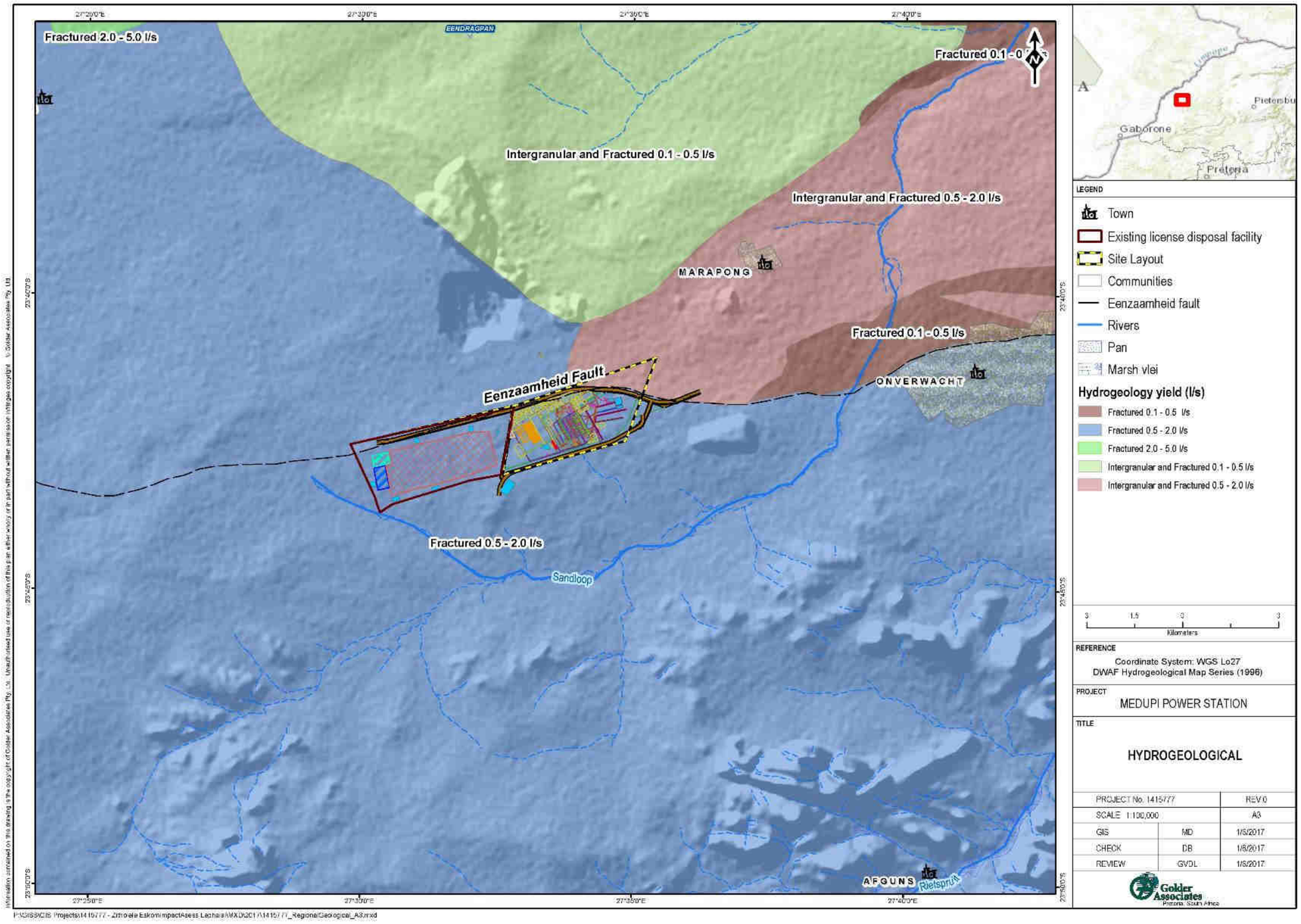


*Figure 14: Hydrogeology Map*

## 5.12 Existing Groundwater Monitoring

Groundwater quality and water levels are currently monitor by Eskom at Medupi Power station at 30 existing boreholes as indicated on Figure 15. Some of these boreholes are positioned around the Medupi FGD Retrofit Project area and could act as monitoring boreholes for the FGD project. However, three of these boreholes (MBH08. MBHO9 and MBH07) are dry or water level are too low to sample and need to be replaced to ensure monitoring coverage in these areas.

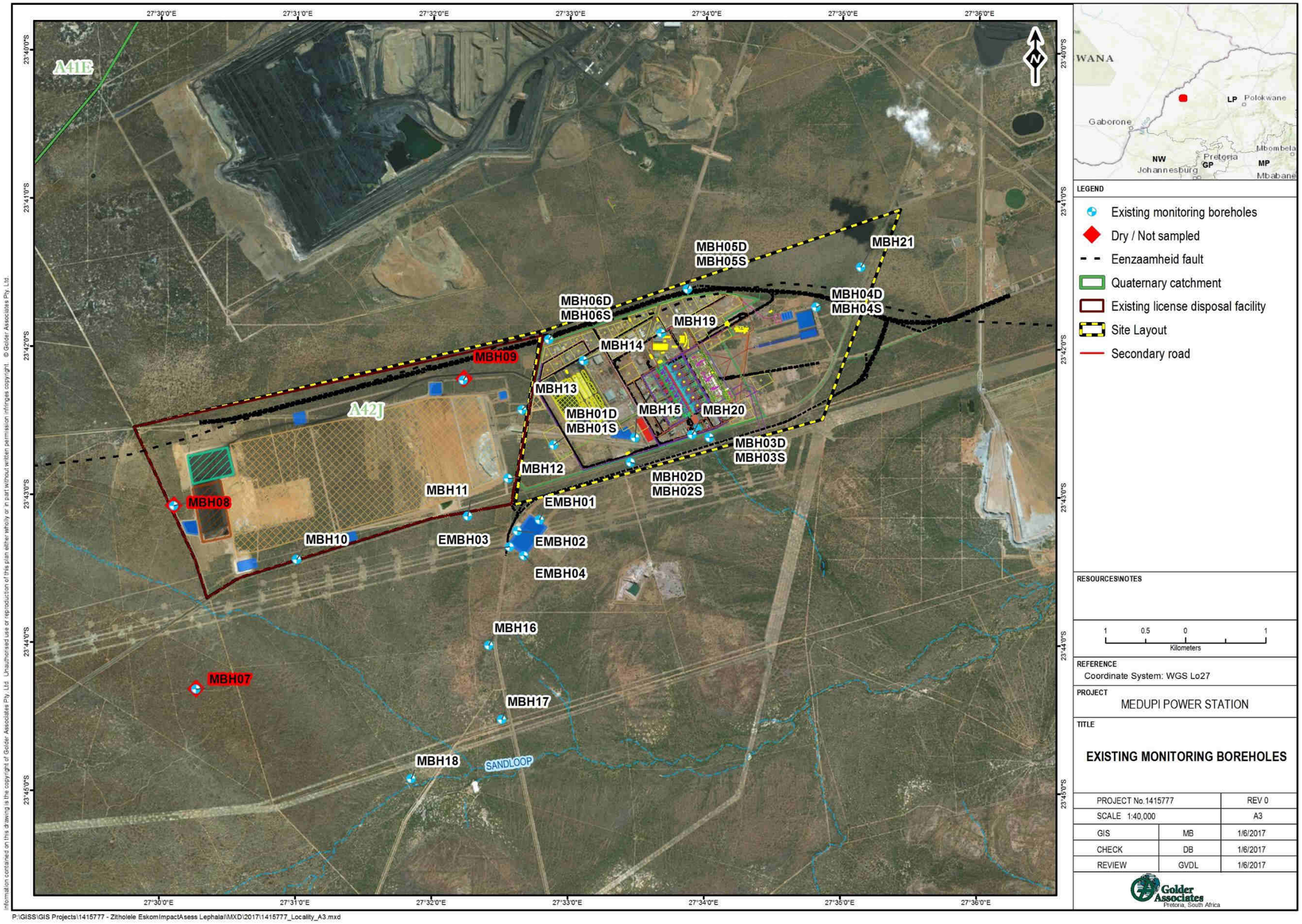




*Figure 15: Exiting Groundwater Monitoring Boreholes*

### 5.12.1 Existing Borehole Groundwater Quality

The latest 2016 analytical results (client database) of the existing groundwater monitoring boreholes were compared to the following standards;

- Department of Water Affairs and Forestry, domestic water quality guidelines, volume 1,1996 and Water Research Commission, water quality guidelines, 1998;
- South African National Standards, drinking water standards, 2011 (SANS 241:2011); and
- South African Water Quality Guidelines (SAWQG), Volume 5: Agricultural Use – Livestock Watering (DWAF, 1996).

The SANS 241:2011 drinking water standard is used as reference in Table 6, whereas the DWAF 1998 guidelines were used to classify water quality classes (Table 5).

**Table 5: DWAF Water Quality Classes (1998)**

| Water quality class | Description | Drinking health effects |
|---|---|---|
| **Class 0** | Ideal water quality | No effects, suitable for many generations. |
| **Class 1** | Good water quality | Suitable for lifetime use. Rare instances of sub-clinical effects |
| **Class 2** | Marginal water quality, water suitable for short-term use only | May be used without health effects by majority of users, but may cause effects in some sensitive groups. Some effects possible after lifetime use. |
| **Class 3** | Poor water quality | Poses a risk of chronic health effects, especially in babies, children and the elderly. May be used for short-term emergency supply with no alternative supplies available. |
| **Class 4** | Unacceptable water quality | Severe acute health effects, even with short-term use. |

### 5.12.2 Groundwater Analytical Results

The analytical results (major cations and anions) of the existing monitoring boreholes are listed in Table 6. A highlighted value in red exceeds the SANS 241:2011 maximum allowable limit, whereas the water quality classes are classified using the DWAF (1998) drinking water standards (black highlighted values exceeding class I).

The following constituents of the existing groundwater samples exceed the SANS 241 (2011) maximum allowable standard; EC, TDS, Na, Cl, N, $SO_4$, Al, F, Fe; and Mn,

The water quality of the existing boreholes is largely poor quality, with classes ranging from Class 0 to Class IV, water quality.

**Table 6: Summarised Chemistry of Existing Boreholes (Nov 2016)**

| Borehole Number | Physical Determinants | | | Chemical Determinants | | | | | | | | | | | | Water Quality Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | EC (mS/m) | TDS (mg/l) | MALK (mg/l) | Ca (mg/l) | K (mg/l) | Mg (mg/l) | Na (mg/l) | Cl (mg/l) | $NO_3$ as N (mg/l) | $SO_4$ (mg/l) | Al (mg/l) | F (mg/l) | Fe (mg/l) | Mn (mg/l) | |
| MBH2 | 5.22 | 10.4 | 76 | 9.48 | 1.51 | 6.15 | 2.96 | 7.97 | 13 | 0.423 | 14.1 | <0.005 | 0.263 | <0.004 | <0.001 | 0 |
| MBH3 | 5.77 | 13.2 | 84 | 26.9 | 4.97 | 6.49 | 5.42 | 7.85 | 17.2 | 0.293 | 10.8 | 0.211 | **0.917** | <0.004 | <0.001 | I |
| MBH3D | 6.57 | 23.6 | 144 | 61.2 | 13.7 | 8.93 | 7.51 | 15.3 | 18.7 | 0.212 | 33.7 | <0.004 | 0.441 | <0.001 | <0.003 | 0 |
| MBH4 | 6.29 | 16.5 | 86 | 86 | 8.03 | 7.81 | 8.19 | 7.74 | 8.41 | 0.258 | 11 | <0.002 | **1.84** | <0.001 | <0.003 | I |
| MBH4S | 4 | **1754** | **10208** | <1.99 | 115 | 110 | 281 | **2885** | **6815** | 0.194 | <0.141 | <0.002 | <0.263 | <0.001 | <0.003 | IV |
| MBH4D | 8.17 | **356** | **1798** | 718 | 37.6 | **35.2** | 81.2 | **695** | **788** | 0.538 | 38.2 | <0.002 | **4.13** | <0.002 | <0.001 | II |
| MBH5D | 6.65 | **433** | **3468** | 167 | 272 | **44.7** | 142 | **472** | **1187** | 0.196 | **291** | <0.002 | **1.26** | <0.001 | <0.003 | III |
| MBH6D | 6.09 | **77.4** | **518** | 115 | 28.6 | 15.8 | 16.4 | **119** | 99.1 | **11.7** | 70.9 | <0.002 | **5.02** | <0.001 | <0.003 | II |
| MBH10D | 5.67 | 32.6 | 226 | 51.4 | 8.99 | 10.4 | 9.4 | 35.3 | 77.7 | 0.476 | 4.25 | <0.002 | 0.263 | <0.002 | 0.001 | 0 |
| MBH11 | 6.97 | **711** | **4386** | 678 | 191 | 173 | 264 | **1063** | **2002** | 0.718 | 350 | <0.005 | **2.79** | <0.005 | <0.005 | IV |
| MBH12 | 6.51 | **450** | **2746** | 169 | 198 | **37.9** | 184 | **525** | **1152** | 0.42 | **453** | <0.001 | **1.06** | <0.005 | <0.001 | III |
| MBH13 | 6.96 | **519** | **3074** | 657 | 141 | **66.5** | 156 | **864** | **1357** | 6.12 | 111 | <0.002 | **4.98** | <0.003 | <0.001 | III |
| MBH14 | 6.82 | **203** | **1632** | 179 | 140 | 20.5 | 104 | **252** | **101** | **45.1** | **714** | <0.007 | **4.08** | <0.011 | <0.001 | IV |
| MBH15 | 7.53 | **683** | **5088** | 911 | 172 | 70 | 361 | **1108** | **757** | **368** | **836** | <0.007 | **4.92** | <0.009 | <0.001 | IV |
| MBH17 | 6.88 | 55.2 | 342 | 200 | 25.2 | 7.13 | 19.1 | 71.5 | 74.4 | 0.52 | 9.37 | <0.005 | **2.1** | <0.009 | <0.001 | 0 |
| MBH18 | 7.84 | **278** | **1538** | 607 | 11.3 | 16.6 | 12.5 | **632** | **533** | 0.372 | 173 | <0.005 | **8.96** | <0.009 | <0.007 | II |
| MBH19 | 6.75 | **681** | **4780** | 247 | **592** | **25.6** | 326 | **420** | **2174** | 0.914 | 96.9 | <0.005 | **1.01** | <0.009 | **0.37** | IV |
| MBH20 | 4.75 | 19.1 | 144 | 5.03 | 6.46 | 5.82 | 4.92 | 15.3 | 29.8 | 3.57 | 17.6 | **0.713** | **0.88** | <0.009 | <0.001 | I |
| MBH21 | 7.3 | **175** | **1086** | 504 | 129 | **37.4** | 41.1 | **206** | **232** | 5.28 | 117 | <0.005 | **2.29** | <0.009 | <0.001 | II |
| SANS241: 2011 Max. Allowable Limit | 9.7 | <170 | 1200 | - | - | - | - | 200 | 300 | 11 | 500 | 0.3 | 1.5 | 0.3 | 0.5 | |
| Class 0 Max. Allowable Limit | 9.5 | <70 | <450 | - | <80 | <25 | <70 | <100 | <100 | <6 | <200 | - | <0.7 | <0.01 | <0.1 | 0 |
| Class 1 Max. Allowable Limit | 10 | 150 | 1000 | - | 150 | 50 | 100 | 200 | 200 | 10 | 400 | - | 0.7-1.0 | 0.01-0.2 | 0.1-0.4 | I |
| Class 2 Max. Allowable Limit | 10.5 | 370 | 2400 | - | 300 | 100 | 200 | 400 | 600 | 20 | 600 | - | 1.0-1.5 | 0.2-2.0 | 1.0-4.0 | II |
| Class 3 Max. Allowable Limit | 11 | 520 | 3400 | - | >300 | 500 | 400 | 1000 | 1200 | 40 | 1000 | - | 1.5-3.5 | 2.0-10.0 | 4.0-10.0 | III |
| Class 4 Max. Allowable Limit | >11 | >520 | >3400 | - | | >500 | >400 | >1000 | >1200 | >40 | >1000 | - | >3.5 | >10.0 | >10.0 | IV |
| **South African Water Quality Guidelines (SAWQG), Volume 5 – Agricultural Use – Livestock Watering Target Range** | - | 154 | 1000 | - | 1000 | - | 500 | 2000 | 1500 | 1000 | 100 | 5 | 2 | 10 | 10 | |
| **Minimum** | 4.00 | 10.4 | 76 | 5.0 | 1.51 | 5.8 | 2.96 | 7.74 | 8.41 | 0.194 | 4.25 | 0.211 | 0.263 | <0.001 | 0.001 | |
| **Maximum** | 8.17 | 1754.0 | 10208 | 911.0 | 592.0 | 173.0 | 361.0 | 2885.0 | 6815.0 | 368.0 | 836.0 | 0.713 | 8.96 | <0.011 | 0.37 | |
| **Average** | 6.46 | 341.6 | 2180 | 299.6 | 110.3 | 37.2 | 106.7 | 494.84 | 917.7 | 23.437 | 186.21 | 0.462 | 2.62 | | 0.1855 | |

### 5.12.3 Possible Impacted Boreholes

The latest Sulphate and EC concentrations, of both the hydrocensus and existing boreholes were classed based on the DWAF water quality classification and are indicated figures Figure 16 and Figure 17. The groundwater quality status of these boreholes were used to illustrate potential deteriorating of groundwater quality in boreholes, associated with possible impacts from existing pollution sources.

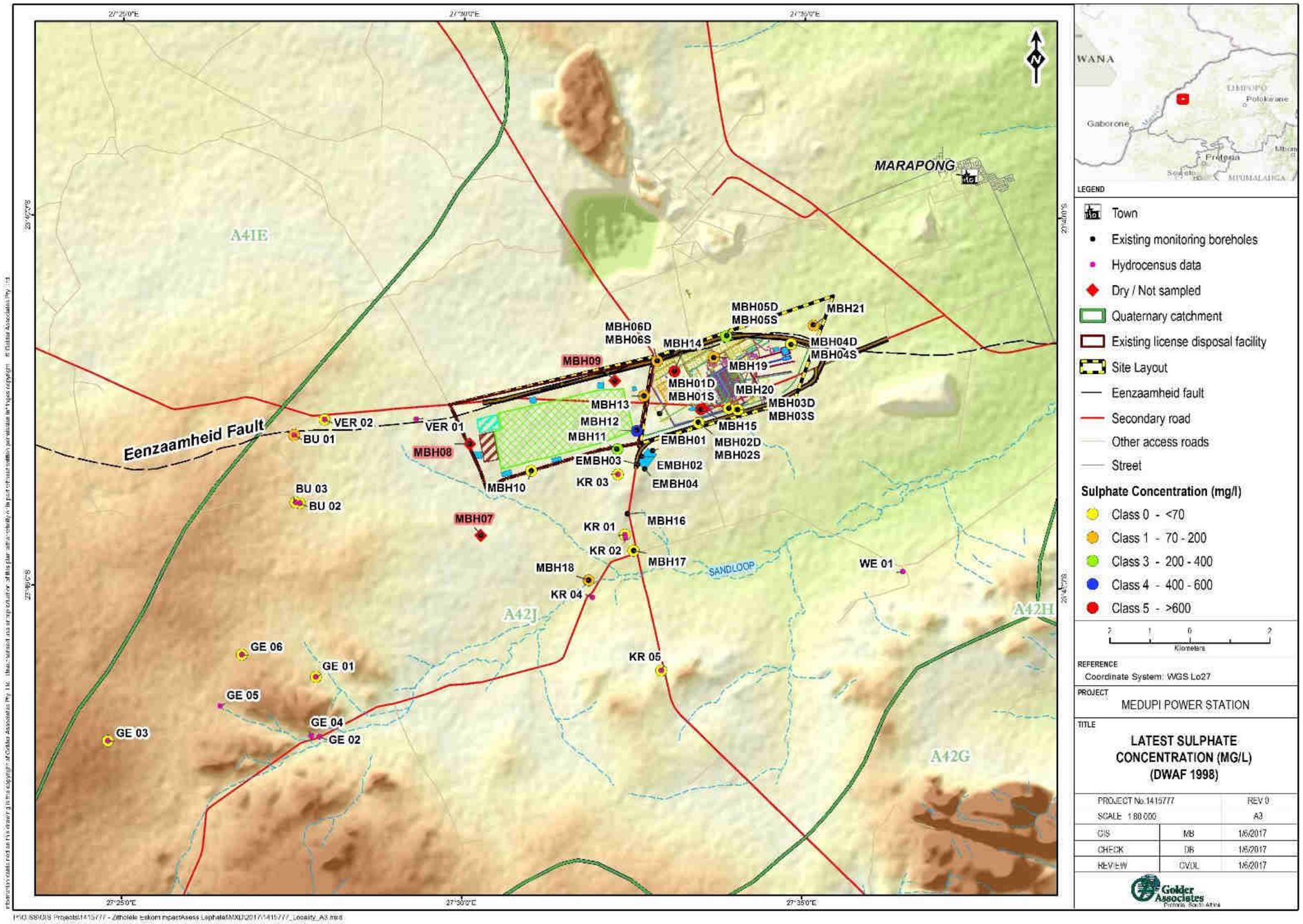


*Figure 16: Latest Sulphate Concentrations (mg/l)*

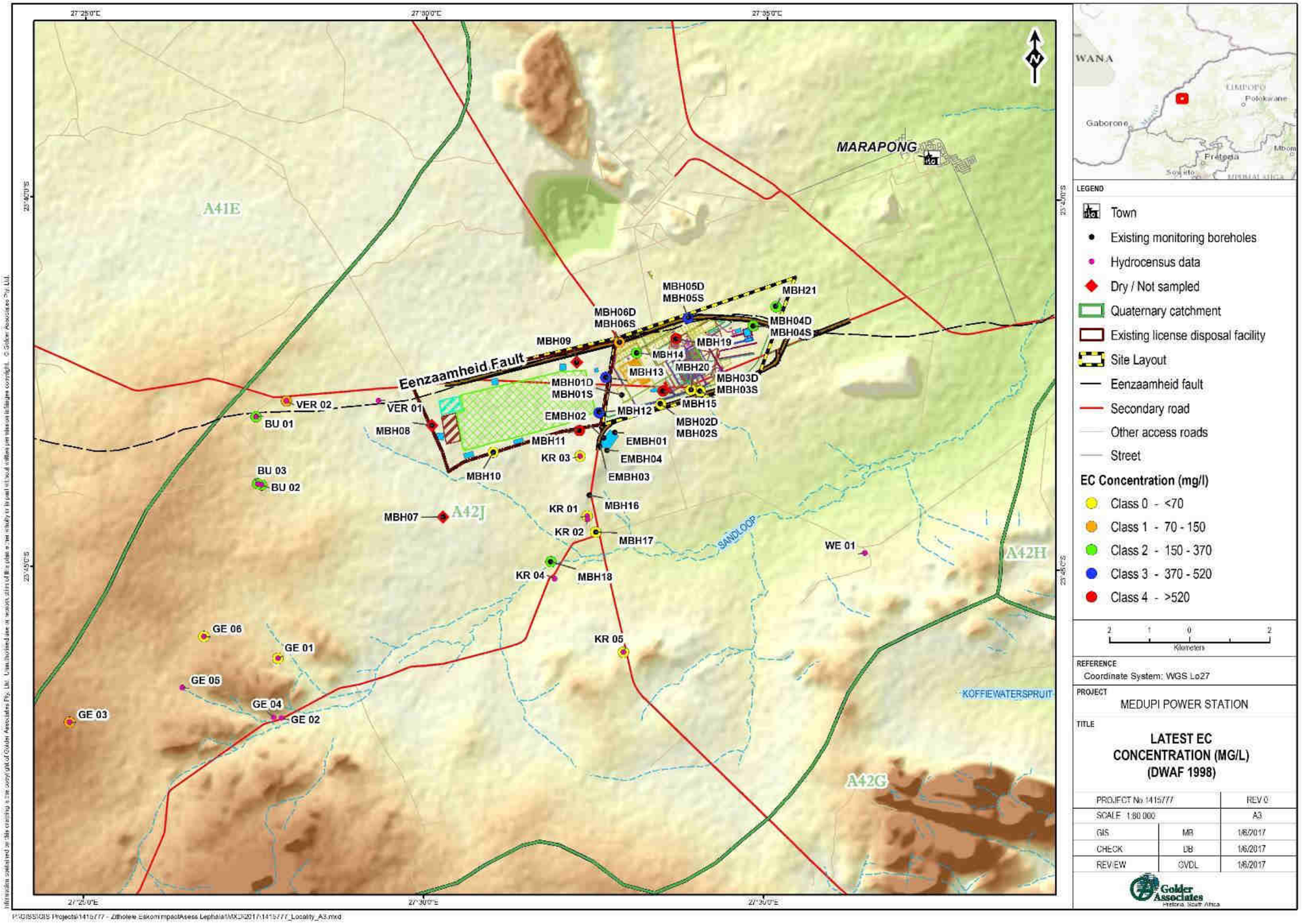


*Figure 17: Latest EC Concentrations (mg/l)*

## 5.13 Groundwater Levels and Flow Direction

The published hydrogeological maps (DWAF 1996) indicate the water level to be between 20 to 40mbgl (Figure 18).

The water levels measured during the hydrocensus ranges between 4.41 to 69.98mbgl, with the average water level as 30.4mbgl.

Sixteen water levels were measured during the 2015 hydrocensus and are listed in Table 7. It must be noted that the some of these water levels may be influenced by pumping and may not be static levels.

**Table 7: Water Levels 2015**

| Borehole Number | Altitude (mamsl) | SWL(mbgl) | SWL (mamsl) |
|---|---|---|---|
| BU 01 | 933 | 59.18 | 874 |
| VER 01 | 921 | 42.32 | 878 |
| VER 02 | 927 | 69.99 | 857 |
| BU 02 | 936 | 64.63 | 871 |
| BU 03 | 934 | 66.98 | 867 |
| GE 01 | 931 | 13.88 | 917 |
| GE 02 | 926 | 9.47 | 916 |
| GE 03 | 968 | 55.56 | 912 |
| GE 04 | 927 | 9.17 | 918 |
| GE 05 | 939 | 9.78 | 929 |
| GE 06 | 949 | 24.21 | 925 |
| KR 01 | 899 | 4.41 | 895 |
| KR 03 | 914 | 15.28 | 899 |
| KR 04 | 893 | 5.72 | 888 |
| KR 05 | 919 | 26.62 | 893 |
| WE 01 | 889 | 8.82 | 880 |
| Minimum | 889 | 4.41 | 857 |
| Maximum | 968 | 69.99 | 929 |
| Average | 925 | 30.4 | 895 |

From the available data and previous groundwater studies, the groundwater flow from the Medupi FGD Retrofit Project area is primarily away from the site, towards the east/south-east and northeast towards the non-perennial Sandloop River (Figure 19). The initial groundwater level and flow directions at the Medupi FGD Retrofit Project area and Medupi Power station are indicated in Figure 20 (IGS 2008)

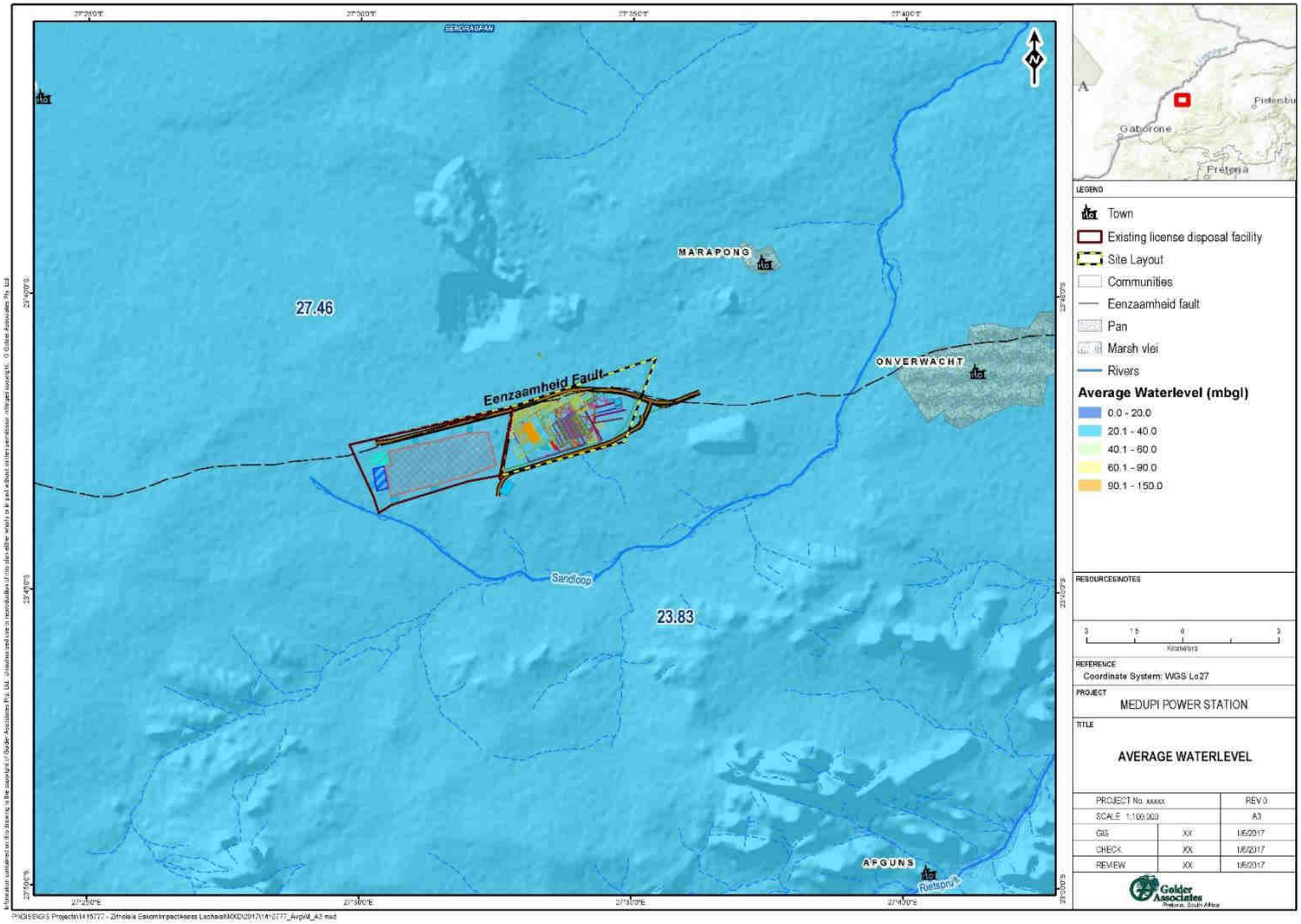


*Figure 18: Average Ground Water Level (DWAF 1996)*

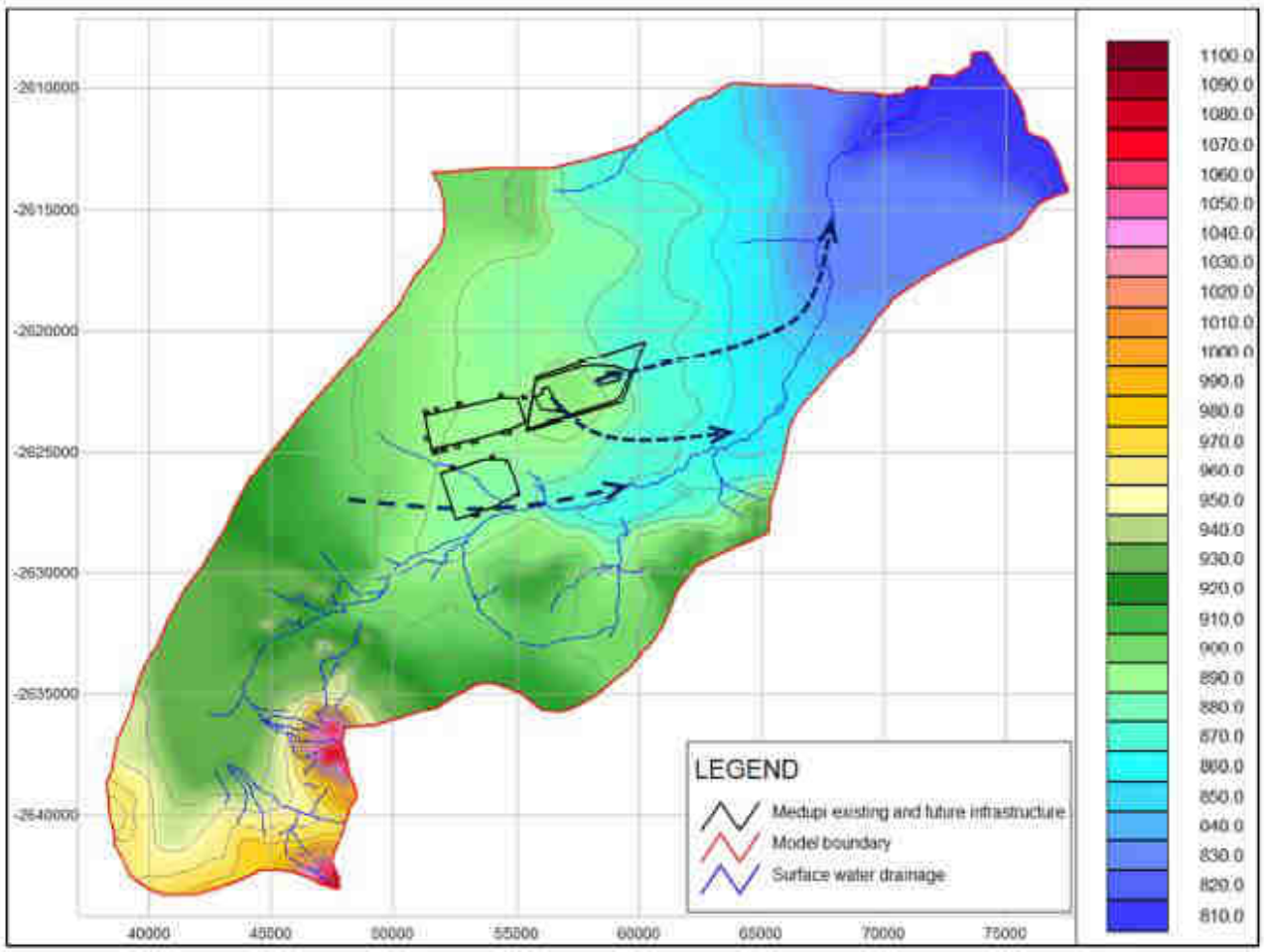


*Figure 19: Groundwater Elevation Contour map (Adapted from Groundwater Complete - 2017).*

### 5.13.1 Possible Plume Prediction

Institute for Groundwater Studies (IGS) constructed a groundwater numerical model in 2008, where the mass transport model was run for a simulation period of 50 years. The contamination sites included in the study, were the existing licenced disposal facility, coal stockyard and dirty terrace dam.

The simulation of a possible plume prediction over 50 years is indicated in Figure 21 . This simulation correspond with the inferred groundwater flow directions for the existing licenced disposal facility.

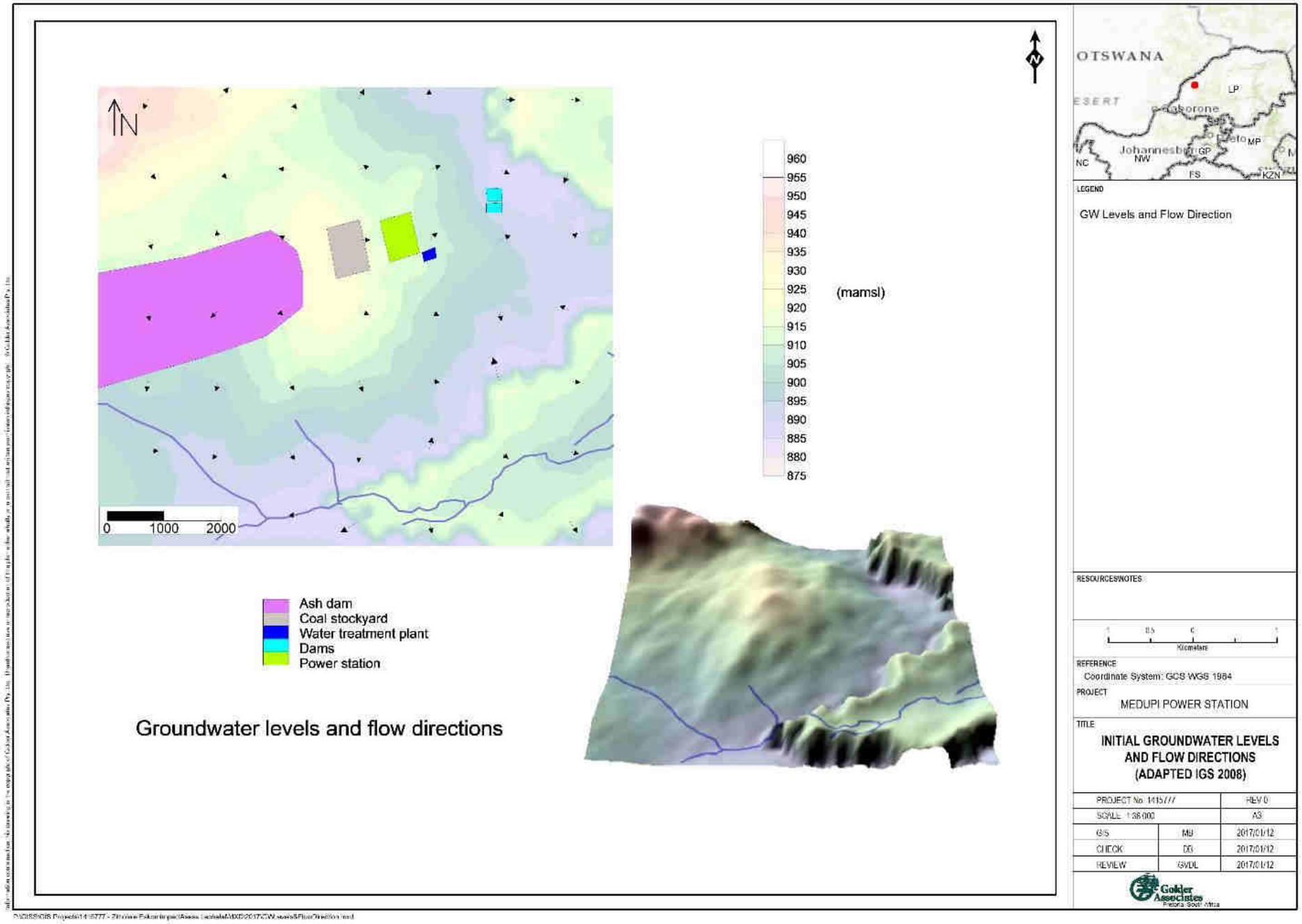


*Figure 20: Initial Groundwater Levels and Flow Directions (Adapted IGS 2008)*

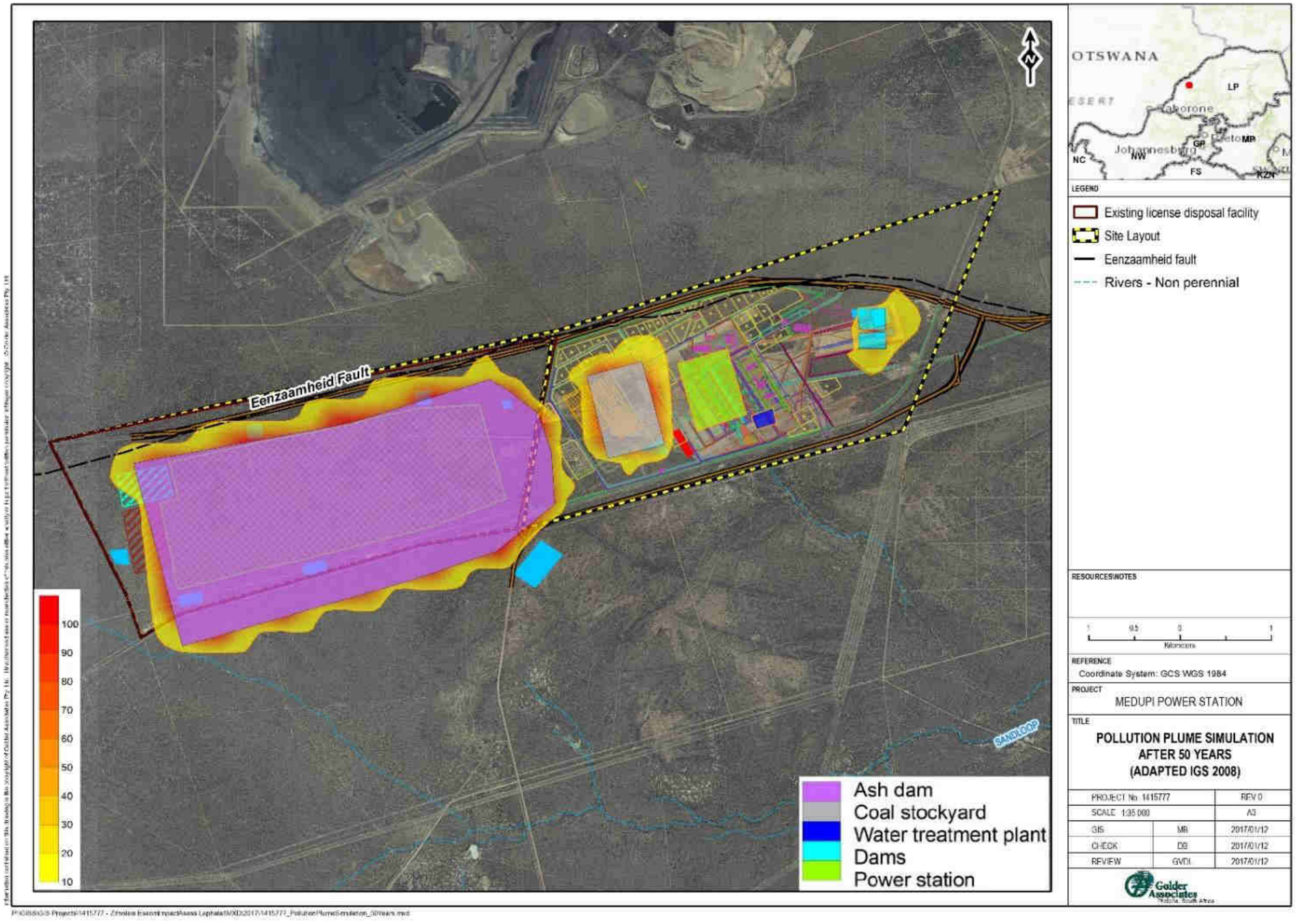


*Figure 21: Pollution Plume Simulation after 50 years (Adapted IGS 2008)*

# 6.0 GROUNDWATER RISK RATING

Possible impacts on the groundwater regime from the Medupi FGD Retrofit Project area were based on a simplified groundwater risk rating assessment and are presented in Table 8. Risk rating is based on a possible risk/impact that the Medupi FGD Retrofit Project area poses to the groundwater regime. Rating is on a scale of 1 to 5 pending on number of classes assigned, with 1 the lowest rating and 5 the highest possible risk.

The following hydrogeological criteria were applied to the risk rating of the Medupi FGD Retrofit Project area:

## 6.1 Aquifer Classification

The aquifer classification is based on the National groundwater aquifer classification map of South Africa:

- Major – rating of 3;
- Minor – rating of 2; and
- Poor - rating of 1;

## 6.2 Aquifer Systems

Aquifer systems in South Africa are grouped in four basic Categories based on the character of the water bearing features of the formation material:

- Karst – rating of 4;
- Intergranular – rating of 3;
- Intergranular and fractured – rating of 2; and
- Fractured – rating 1.

## 6.3 Borehole Yield Classes

Based on national groundwater borehole yield classes, yield is classed into 4 classes:

- Yields from 0.1- 0.5l/s rating of 1;
- Yields from 0.5 – 2.0l/s rating of 2;
- Yields from 2.0- 5.0/s rating of 3;
- Yields from >0.5l/s rating of 4;

## 6.4 Local Geology Structures

Local geology structure was grouped into 3 classes based on higher groundwater occurrences and Transmissivity values associated with these structures:

- Fault zones, rating of 4;
- Dolerite dyke contact zones, rating of 3;
- Lineaments and quartz veins ranting of 2; and
- No know structures, rating of 1.

## 6.5 Groundwater Quality

The groundwater quality classes are based on the National groundwater quality (electrical conductivity (EC/mS/m) map information. The risk rating for groundwater quality is based on that all water resources should be protected against water quality deterioration from a specific standard. A risk rating of 4 is therefore allocated to Class 0:

Class 0, (EC<70mS/m) – rating of 4;

Class 1, (EC 70mS/m to 300mS/m) – rating of 3;

Class 2, (EC 300mS/m to 1000mS/m) – rating of 2; and

Class 3 and 4, (EC>1000mS/m) – rating of 1.

## 6.6 Vulnerability

The groundwater vulnerability classes are based on the national groundwater vulnerability map information:

- Very Low, rating of 1;
- Low, rating of 2;
- Low to medium, rating of 3;
- Medium, rating of 4; and
- High, rating of 5;

## 6.7 Number of Existing Groundwater users within a 1km Radius of Medupi FGD Retrofit Project area

Number of reported existing groundwater users within a 1km radius of the site was grouped into 3 classes:

- > 10 rating of 3;
- 5 to 10, rating of 2; and
- < 5, rating of 1.

### 6.7.1 Medupi FGD Retrofit Project area - Risk Rating

The existing licensed disposal facility scores a risk rating of 16 and poses a moderate risk of impacting on the surrounding groundwater regime. Possible impacts on the groundwater need to be investigated further.

These ratings are consistent with the National vulnerability map of South Africa prepared by the WRC (Water Research Commission), using the DRASTIC methodology.

**Table 8: Site Selection Ranking and Rating**

| SITE SELECTION RANKING | SITE 13 |
|---|---|
| Aquifer Classification | Minor |
| | 2 |
| Aquifer System | Fractured |
| | 1 |
| Borehole Yield | 0.5 - 2.0l/s |
| | 2 |
| Local Geology Structures | Fault zone |
| | 4 |
| Groundwater Quality EC (mS/m) | Class 0 and 1 |
| | 3 |
| Aquifer Vulnerability | Low to Medium |
| | 3 |
| Number of reported existing groundwater users within a 1km radius | <5 |
| | 1 |
| SCORE | 16 |

# 7.0 IMPACT ASSESSMENT MEDUPI FGD PROJECT AREA

In order to address the amended scope of work for Medupi FGD (2017) the following SOW are included based on the Impact assessment methodology provided by Zitholele:

- Construction and operation of the FGD system within the Medupi Power Station Footprint;
- Construction and operation of the railway yard/siding and diesel storage facilities, and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF;
- A qualitative opinion on impact on groundwater, if any, if ash and gypsum is disposed together on the existing ADF considering the ADF will have an appropriate liner since both ash and gypsum is classified as type 3 wastes; and
- Provide a qualitative opinion whether groundwater could potentially be impacted with the construction of the FGD within the Medupi PS footprint. From the aerial view it is evident that the entire Medupi GD footprint area is disturbed during the construction activities at the power station.

The potential groundwater impacts that the **FGD system (**Figure 22**)** and the **operation of the railway yard/siding, diesel storage facilities** and **limestone and gypsum handling facilities between the Medupi Power Station and existing ADF**, poses to the groundwater regime are discussed as follows for the different phases:

- Existing impacts – these are current activities that potentially have an impact on the groundwater regime. These activities include Matimba Power Station and ADF, Medupi Power station and the existing licensed disposal facility, however Grootegeluk mine are excluded due to the Eenzaamheid fault serving as a barrier to interactions.
- Cumulative impacts - **include the existing activities plus the FGD system** and **the operation of the railway yard/siding, diesel storage facilities and limestone** and **gypsum handling facilities between the Medupi Power Station and existing ADF**; and
- Residual impacts- are the post-mitigation activities. This rating considers the cumulative impacts when proposed mitigation measures are effectively implemented.

The existing activities and the FGD system pose the following potential impacts on the groundwater:

- A change in the groundwater quality;
- A change in the volume of groundwater in storage or entering groundwater storage (recharge); or
- A change in the groundwater flow regime.

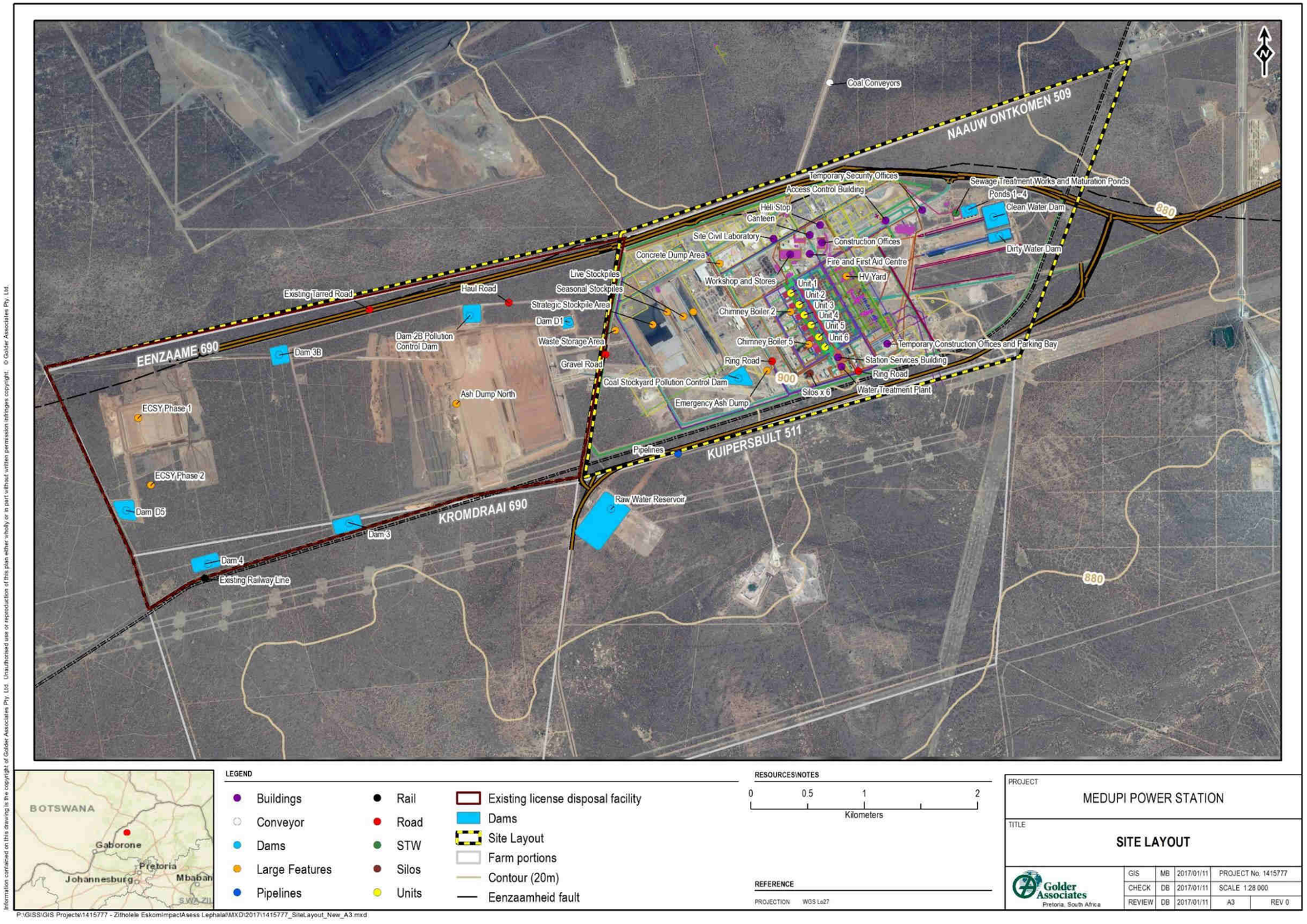




*Figure 22: Medupi Site Outlay*

## 7.1 Impact Assessment Methodology

The impacts will be ranked according to the based on the Impact Assessment Methodology provided by Zitholele as described below. Where possible, mitigation measures will be provided to manage impacts. In order to ensure uniformity, a standard impact assessment methodology will be utilised so that a wide range of impacts can be compared with each other. The impact assessment methodology makes provision for the assessment of impacts against the following criteria, as discussed below.

### 7.1.1 Nature of the impact

Each impact should be described in terms of the features and qualities of the impact. A detailed description of the impact will allow for contextualisation of the assessment.

### 7.1.2 Extent of the impact

Extent intends to assess the footprint of the impact. The larger the footprint, the higher the impact rating will be. Table 9 below provides the descriptors and criteria for assessment.

**Table 9: Criteria for the assessment of the extent of the impact**

| Extent Descriptor | Definition | Rating |
|---|---|---|
| Site | Impact footprint remains within the boundary of the site. | 1 |
| Local | Impact footprint extends beyond the boundary of the site to the adjacent surrounding areas. | 2 |
| Regional | Impact footprint includes the greater surrounds and may include an entire municipal or provincial jurisdiction. | 3 |
| National | The scale of the impact is applicable to the Republic of South Africa. | 4 |
| Global | The impact has global implications | 5 |

### 7.1.3 Duration of the impact

The duration of the impact is the period of time that the impact will manifest on the receiving environment. Importantly, the concept of reversibility is reflected in the duration rating. The longer the impact endures, the less likely it is to be reversible. See Table 10 for the criteria for rating duration of impacts.

**Table 10: Criteria for the rating of the duration of an impact**

| Duration Descriptor | Definition | Rating |
|---|---|---|
| Construction / Decommissioning phase only | The impact endures for only as long as the construction or the decommissioning period of the project activity. This implies that the impact is fully reversible. | 1 |
| Short term | The impact continues to manifest for a period of between 3 and 5 years beyond construction or decommissioning. The impact is still reversible. | 2 |
| Medium term | The impact continues between 6 and 15 years beyond the construction or decommissioning phase. The impact is still reversible with relevant and applicable mitigation and management actions. | 3 |
| Long term | The impact continues for a period in excess of 15 years beyond construction or decommissioning. The impact is only reversible with considerable effort in implementation of rigorous mitigation actions. | 4 |
| Permanent | The impact will continue indefinitely and is not reversible. | 5 |

### 7.1.4 Potential intensity of the impact

The concept of the potential intensity of an impact is the acknowledgement at the outset of the project of the potential significance of the impact on the receiving environment. For example, $SO_2$ emissions have the potential to result in significant adverse human health effects, and this potential intensity must be accommodated within the significance rating. The importance of the potential intensity must be emphasised within the rating methodology to indicate that, for an adverse impact to human health, even a limited extent and duration will still yield a significant impact.

Within potential intensity, the concept of irreplaceable loss is taken into account. Irreplaceable loss may relate to losses of entire faunal or floral species at an extent greater than regional, or the permanent loss of significant environmental resources. Potential intensity provides a measure for comparing significance across different specialist assessments. This is possible by aligning specialist ratings with the potential intensity rating provided here. This allows for better integration of specialist studies into the environmental impact assessment. See Table 11 and Table 12 below.

**Table 11: Criteria for impact rating of potential intensity of a negative impact**

| Potential Intensity Descriptor | Definition of negative impact | Rating |
|---|---|---|
| High | Significant impact to human health linked to mortality/loss of a species/endemic habitat. | 16 |
| Moderate-High | Significant impact to faunal or floral populations/loss of livelihoods/individual economic loss. | 8 |
| Moderate | Reduction in environmental quality/loss of habitat/loss of heritage/loss of welfare amenity | 4 |
| Moderate-Low | Nuisance impact | 2 |
| Low | Negative change with no associated consequences. | 1 |

**Table 12: Criteria for the impact rating of potential intensity of a positive impact**

| Potential Intensity Descriptor | Definition of positive impact | Rating |
|---|---|---|
| Moderate-High | Net improvement in human welfare | 8 |
| Moderate | Improved environmental quality/improved individual livelihoods. | 4 |
| Moderate-Low | Economic development | 2 |
| Low | Positive change with no other consequences. | 1 |

It must be noted that there is no HIGH rating for positive impacts under potential intensity, as it must be understood that no positive spinoff of an activity can possibly raise a similar significance rating to a negative impact that affects human health or causes the irreplaceable loss of a species.

### 7.1.5 Likelihood of the impact

This is the likelihood of the impact potential intensity manifesting. This is not the likelihood of the activity occurring. If an impact is unlikely to manifest then the likelihood rating will reduce the overall significance. Table 13 provides the rating methodology for likelihood.

The rating for likelihood is provided in fractions in order to provide an indication of percentage probability, although it is noted that mathematical connotation cannot be implied to numbers utilised for ratings.

**Table 13: Criteria for the rating of the likelihood of the impact occurring**

| Likelihood Descriptor | Definition | Rating |
|---|---|---|
| Improbable | The possibility of the impact occurring is negligible and only under exceptional circumstances. | 0.1 |
| Unlikely | The possibility of the impact occurring is low with a less than 10% chance of occurring. The impact has not occurred before. | 0.2 |
| Probable | The impact has a 10% to 40% chance of occurring. Only likely to happen once in every 3 years or more. | 0.5 |
| Highly Probable | It is most likely that the impact will occur and there is a 41% to 75% chance of occurrence. | 0.75 |
| Definite | More than a 75% chance of occurrence. The impact will occur regularly. | 1 |

### 7.1.6 Cumulative Impacts

Cumulative impact are reflected in the potential intensity of the rating system. In order to assess any impact on the environment, cumulative impacts must be considered in order to determine an accurate significance. Impacts cannot be assessed in isolation. An integrated approach requires that cumulative impacts be included in the assessment of individual impacts.

The nature of the impact should be described in such a way as to detail the potential cumulative impact of the activity.

### 7.1.7 Significance Assessment

The significance assessment assigns numbers to rate impacts in order to provide a more quantitative description of impacts for purposes of decision making. Significance is an expression of the risk of damage to the environment, should the proposed activity be authorised.

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus the total value of the impact is described as the function of significance, which takes cognisance of extent, duration, potential intensity and likelihood.

***Impact Significance*** = (extent + duration + potential intensity) x likelihood

Table 14 provides the resulting significance rating of the impact as defined by the equation as above.

**Table 14: Significance rating formulas**

| Score | Rating | Implications for Decision-making |
|---|---|---|
| < 3 | Low | Project can be authorised with low risk of environmental degradation |
| 3 - 9 | Moderate | Project can be authorised but with conditions and routine inspections. Mitigation measures must be implemented. |
| 10 - 20 | High | Project can be authorised but with strict conditions and high levels of compliance and enforcement. Monitoring and mitigation are essential. |
| 21 - 26 | Fatally Flawed | Project cannot be authorised |

## 7.2 Potential Impacts from the FGD System

### 7.2.1 Groundwater Quality

The predicted impacts from the FGD system on the ambient groundwater quality is:

- Of Moderate significance during pre-construction, construction and operational phases; and
- Low significance during the decommissioning phase.

The Impact from the FGD system on the ambient groundwater quality of the underlying weathered aquifer for the different phase are listed inTable 15 to Table 18.

**Table 15: FGD System Pre-Construction**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *1* | 2 | 4 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 2 | 4 | **0.5** | 4 - MOD |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

**Table 16: FGD System Construction**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *1* | 2 | 4 | **0.5** | 4 - MOD |
| | Cumulative (current and FGD) | *1* | 2 | 4 | **0.5** | 4 - MOD |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

**Table 17: FGD System Operational**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *2* | 3 | 4 | **0.75** | 7 - MOD |
| | Cumulative (current and FGD) | *2* | 3 | 4 | **0.75** | 7 - MOD |
| | Post Mitigation | *1* | 3 | 2 | **0.2** | 1 - LOW |

**Table 18: FGD System Decommissioning**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 3 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 2 | 1 | **0.1** | 0 - LOW |

### 7.2.2 Groundwater Volume and Flow Regime

The construction and operation of the FGD system, is expected to have a minor change in the volume of water entering groundwater storage (reduced recharge in comparison to status quo conditions) and with negligible changes expected in the groundwater flow regime.

The predicted impact of the FGD system on the groundwater volume and flow is:

- Of Low significance during pre-construction phase and Low to moderate during the construction and operational phases, if the operator limits any “on-site” pollution to an absolute minimum (within the dilution potential of annual recharge. The significance during the decommissioning phases are Low.

The Impact from the FGD system on the groundwater quantity/recharge and flow regime for the different phases are listed in Table 19 to Table 22.

**Table 19: FGD System Pre-Construction**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume/recharge | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 2 | 4 | **0.2** | 1 - LOW |
| | Residual/Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |
| Groundwater Flow | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative | *2* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

**Table 20: FGD System Construction**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume/recharge | Existing | *1* | 2 | 2 | **0.5** | 3 - MOD |
| | Cumulative (current and FGD) | *2* | 2 | 4 | **0.5** | 4 - MOD |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |
| Groundwater Flow | Existing | *1* | 2 | 2 | **0.75** | 4 - MOD |
| | Cumulative | *2* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

**Table 21: FGD System Operational**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume/recharge | Existing | *2* | 3 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 2 | 4 | **0.5** | 4 - MOD |
| | Post Mitigation | *2* | 2 | 2 | **0.1** | 1 - LOW |
| Groundwater Flow | Existing | *2* | 3 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 2 | 4 | **0.2** | 1 - LOW |
| | Post Mitigation | *2* | 2 | 2 | **0.1** | 1 - LOW |

**Table 22: FGD System Decommissioning**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 2 | 1 | **0.1** | 0 - LOW |
| Groundwater Flow/recharge | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and FGD) | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 2 | 1 | **0.1** | 0 - LOW |

## 7.3 Potential Impacts from the Railway Yard and Limestone and gypsum handling facilities between the Medupi Power Station and existing ADF

### 7.3.1 Groundwater Quality

The predicted impacts from the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF activities on the ambient groundwater quality is:

- Of Low significance during pre-construction and of moderate significance during the construction and operational phases; and
- Low of significance during the decommissioning phase.

The Impact from the railway yard and limestone and gypsum handling facilities on the ambient groundwater quality of the underlying weathered aquifer for the different phases are listed in Table 23 to Table 26.

**Table 23: Railway Yard and Handling Facilities Pre-Construction**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 4 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

**Table 24: Railway Yard and Handling Facilities Construction**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *1* | 2 | 2 | **0.5** | 3 - MOD |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 4 | **0.5** | 4 - MOD |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

**Table 25: Railway Yard and Handling Facilities Operational**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *2* | 3 | 4 | **0.75** | 7 - MOD |
| | Cumulative (current and railway yard and facilities) | *2* | 2 | 8 | **0.5** | 6 - MOD |
| | Post Mitigation | *1* | 3 | 2 | **0.2** | 1 - LOW |

**Table 26: Railway Yard and Handling Facilities Decommissioning**

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater quality | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 3 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 2 | 1 | **0.1** | 0 - LOW |

### 7.3.2 Groundwater Volume and Flow Regime

The predicted impact the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF activities on the groundwater volume and flow is:

- Of Low significance during pre-construction phase and of low to moderate significance during the construction phase. The significance during the operational and decommissioning phases are of Low significance.

The Impact from the railway yard and limestone and gypsum handling facilities on the groundwater quantity/recharge and flow regime for the different phases are listed in Table 27 to Table 30.

### Table 27: Railway Yard and Handling Facilities Pre-Construction

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume/recharge | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 4 | **0.2** | 1 - LOW |
| | Residual/Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |
| Groundwater Flow | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 4 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

### Table 28: Railway Yard and Handling Facilities Construction

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume/recharge | Existing | *1* | 2 | 2 | **0.5** | 3 - MOD |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 2 | **0.5** | 3 - MOD |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |
| Groundwater Flow | Existing | *1* | 2 | 2 | **0.75** | 4 - MOD |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 1 | 2 | **0.1** | 0 - LOW |

### Table 29: Railway Yard and Handling Facilities Operational

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume/recharge | Existing | *2* | 3 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 1 | 4 | **0.2** | 1 - LOW |
| | Post Mitigation | *2* | 2 | 2 | **0.1** | 1 - LOW |
| Groundwater Flow | Existing | *2* | 3 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 1 | 4 | **0.2** | 1 - LOW |
| | Post Mitigation | *2* | 2 | 2 | **0.1** | 1 - LOW |

### Table 30: Railway Yard and Handling Facilities Decommissioning

| Description of Impact | Impact type | Extent | Duration | Potential Intensity | Likelihood | Rating |
|---|---|---|---|---|---|---|
| Groundwater Volume | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 2 | 1 | **0.1** | 0 - LOW |
| Groundwater Flow/recharge | Existing | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Cumulative (current and railway yard and facilities) | *1* | 2 | 2 | **0.2** | 1 - LOW |
| | Post Mitigation | *1* | 2 | 1 | **0.1** | 0 - LOW |

## 7.4 Professional opinion on Trucking of Type 1 Waste to a Hazardous Disposal Facility

For the first five (5) years of the operational phase, sludge and salts will be stored at a temporary waste storage facility, after which it will be trucked to a licensed hazardous waste disposal site. During transportation of hazardous waste, the trucking contractor should adhere to all regulations and standards of both environmental and mining acts. Safe working procedures (SWP) for transportation of hazardous waste must be in place, to minimize the risk of contamination to the environment and groundwater should a spillage occur.

A hazardous spillage could contaminate the groundwater, and samples of any nearby boreholes should be analysed and monitored after a spillage incident. Storage of the Type 1 waste (hazardous waste) on site may result in risks to contamination the groundwater regime. This risk can be managed by ensuring that construction is done to good quality, after the facility is registered, and prepared in line with NEMWA Norms and Standards for Storage of Waste. Trucking of Type 1 waste to a licensed hazardous waste disposal site is effectively would effect a positive impact on site.

Possible impacts on the groundwater regime associated with trucking process of type 1 waste, to a licensed hazardous waste disposal site are based on a simplified groundwater risk assessment and are presented in Table 31. The risk rating is based on a possible risk/impact that activities from the trucking process of type 1 waste poses to the groundwater regime. Assessment is based on positive and negative outcome of impact/risk to the groundwater regime.

**Table 31: Groundwater Risk Assessment**

| Activity | Positive Impacts | Negative Impacts |
|---|---|---|
| Removal of hazardous waste from existing licensed waste disposal facility | Removal of contamination source | None |
| Transportation of hazardous waste to a licensed hazardous waste disposal site | Removal and transportation of hazardous waste | None |
| Spillage during transportation of hazardous waste | None | Contamination of groundwater and impacting on existing users in vicinity of spillage |
| Disposal of hazardous waste | Disposal of hazardous waste | None |

## 7.5 Qualitative Opinion on Impact on Groundwater, if Ash and Gypsum is Disposed together on the Existing ADF

The existing licensed disposal facility is designed for a 50 year life period and will have a liner that is designed according to the appropriate waste classification of the ash. The liner for the facility will be installed at appropriate frequencies, e.g. every two years. This is to reduce risk of damage to the liner due to exposure for long periods of time.

Considering that the ADF is proposed to have a Class C liner, in line with waste classification as per the NEMWA GNXX, since both ash and gypsum classified as Type 3 wastes will be disposed, the disposal of ash and gypsum together will probably not have a significant impact on the groundwater regime. This rehabilitation of WDF approach serves as a mitigation measure against groundwater contamination and poses a minimal risk of contamination on the groundwater.

A numerical groundwater model was constructed by Groundwater Complete (January 2017) to simulate possible pollution migration in the aquifer system underlying Medupi.

Two model scenarios were simulated, namely:

- A worst case scenario where the North dump and the entire surface area of the plant were assigned contaminated recharge (Figure 23), and
- A most probable scenario where the North dump and only the coal stockyard and sewage treatment plant (together with its recovery dams) were simulated as source areas (Figure 24).

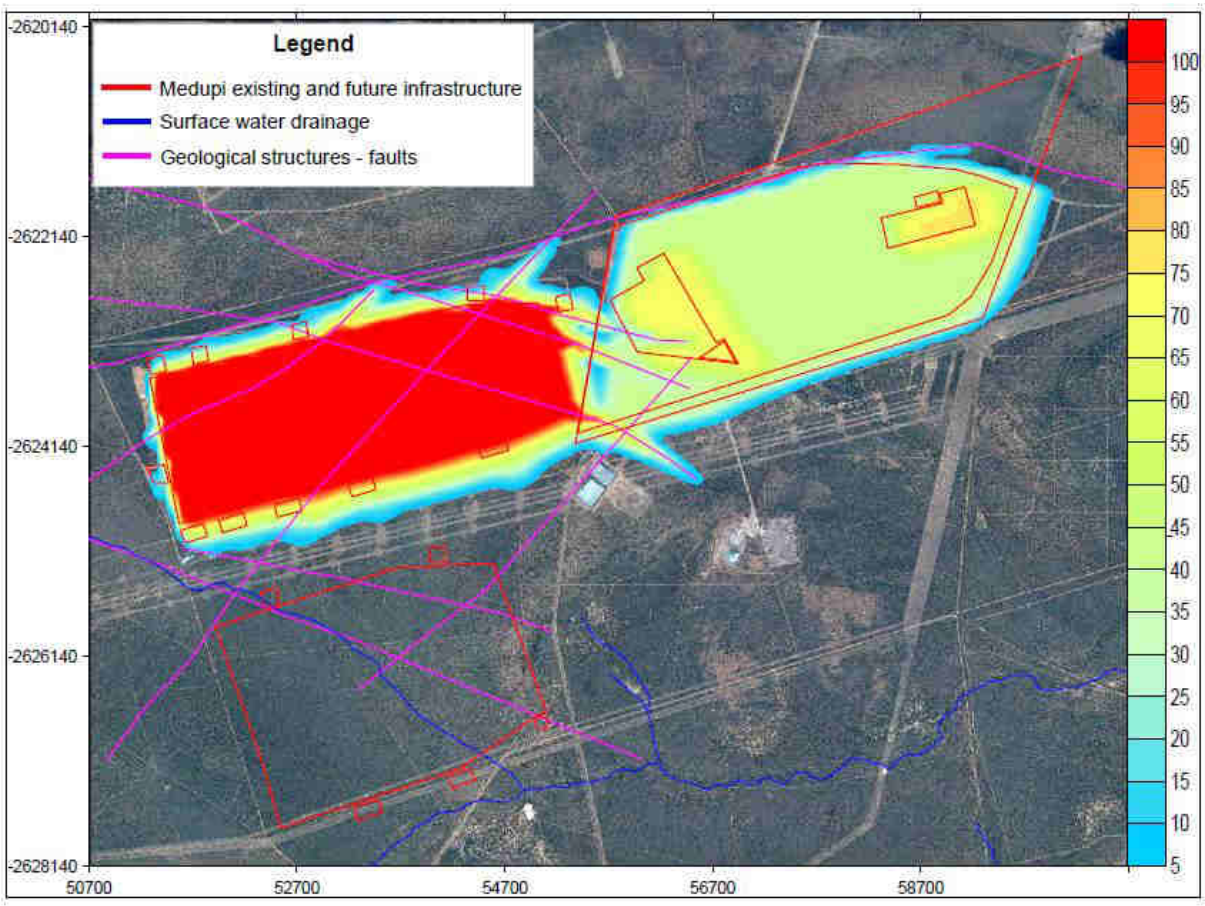


*Figure 23: Model simulated pollution plumes for Scenario 1 at 50 years post closure (%) (Adapted from Groundwater Complete – 2017)*

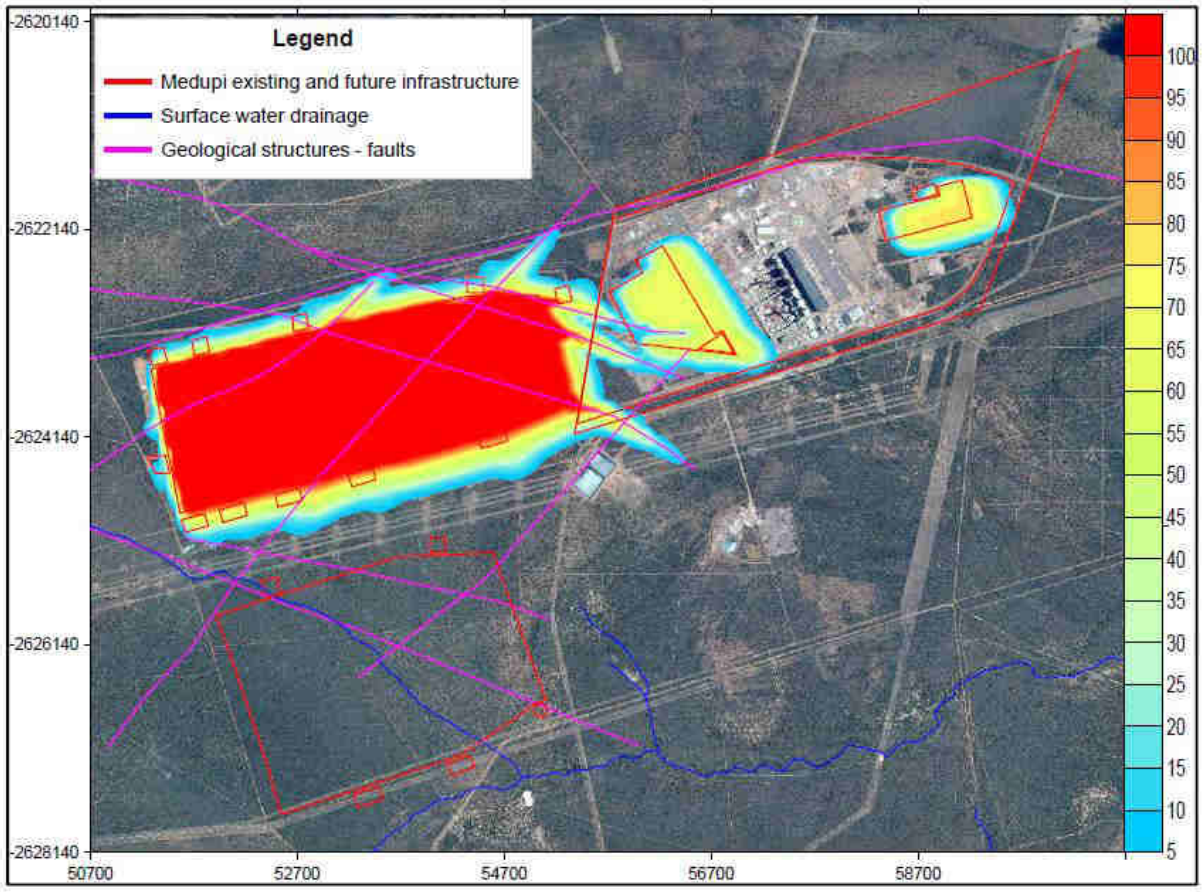


*Figure 24: Model simulated pollution plumes for Scenario 2 at 50 years post closure (%) (Adapted from Groundwater Complete – 2017)*

## 7.6 Qualitative Opinion whether Groundwater could potentially be impacted with the Construction of the FGD within the Medupi Power Station Footprint

During any construction phase involving disturbing of top soil by earth moving equipment and trucks, possible spillage could occur which could contaminate the groundwater. This contamination, however, will be point source only and within the site boundaries.

Safe working procedures (SWP) for construction work must be in place, to minimize the risk of contamination to the environment and groundwater should a spillage occur. Any accidental spillage should be cleaned up immediately to limit contamination and if intensity is high, the impact must be reversed with the applicable mitigation and management actions.

The potential impact whether groundwater could potentially be impacted with the Construction of the FGD within the Medupi Power Station Footprint is considered as a low to moderate significance.

# 8.0 MITIGATION MEASURES

The proposed mitigation measures that can be implemented at the Medupi FGD Project, should a leakage or contamination plume occur, are summarised below:

- The existing licenced disposal facility needs to be lined during the construction phase;
- The type 3 waste in a Class C barrier system and the Type 1 wastes in a Class A liner system;
- The existing licenced disposal facility needs to be rehabilitated at closure;

- Monthly groundwater monitoring of Eskom monitoring boreholes is recommended to form part of the mitigation and management of the Medupi FGD Project. This monitoring must be included in the monitoring network and will function as an early warning system for contaminant migration (if any);
- Frequent inspection and maintenance of liners; and
- Scavenger borehole system, to contain pollution on site must only be implemented if any contamination is detected at monitoring boreholes.

# 9.0 CONCLUSIONS

The following groundwater conclusions are made from the investigation and available data for the Medupi FGD Project:

- The existing licensed disposal facility is mainly underlain by Waterberg sediments comprising of sandstone, subordinate conglomerate, siltstone and shale;
- The initial regional groundwater conceptual model identifies two aquifer zones namely weathered, and fractured aquifer zones, but needs to be confirmed and updated, supported by future test pumping and borehole logs;
- The average groundwater level measured during the hydrocensus for the area of investigation is 30.4mbgl;
- Based on the hydrocensus water quality analyses , the background groundwater quality of the existing licensed disposal facility is Marginal (Class II) to Poor (Class III - IV) water Quality;
- Only boreholes GE06 and VER02 groundwater quality are representative of calcium magnesium bicarbonate type of water (Ca, Mg–($HCO_3$). This water type represents unpolluted groundwater (mainly from direct rainwater recharge) and are probably representative of the pristine background water quality;
- The following inorganic constituents as identified during the hydrocensus exceed the SANS 241 (2011) drinking water compliance standards EC, TDS, Na, Cl, N, Al, F, Fe and Mn;
- The groundwater vulnerability of the existing licensed disposal facility proposed is shown on the national groundwater vulnerability map as low to medium;
- According to simplified groundwater risk rating assessment, the existing licenced disposal facility have a risk rating of 16, and poses a moderate risk of impacting on the surrounding groundwater regime. Possible impacts on the groundwater need to be investigated further;
- Following a decision by ESKOM to utilize the existing licenced disposal facility, a qualitative impact assessment was conducted on this site. Gypsum and ash are to be disposed on the existing licenced disposal facility;
- Based on the qualitative impact assessment, the existing activities and the licensed disposal facility poses the following potential impacts on the groundwater system:
  - A change in the groundwater quality;
  - A change in the volume of groundwater in storage or entering groundwater storage (recharge); or
  - A change in the groundwater flow regime.
- The predicted impacts from the FGD system (2017 SOW) on the ambient groundwater quality is:
  - Of Moderate significance during pre-construction, construction and operational phases; and
  - Low significance during the decommissioning phase.
- The predicted impact of the FGD system on the groundwater volume and flow is:

  - Of Low significance during pre-construction phase and Low to moderate during the construction and operational phases. The significance during the decommissioning phases are Low.

- The predicted impacts from the railway yard and limestone and gypsum handling facilities (2017 SOW) between the Medupi Power Station and existing ADF activities on the ambient groundwater quality is:
  - Of Low significance during pre-construction and of Moderate significance during the construction and operational phases; and
  - Low of significance during the decommissioning phase.
- The predicted impact the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF activities on the groundwater volume and flow is:
  - Of Low significance during pre-construction phase and of Low to Moderate significance during the construction phase. The significance during the operational and decommissioning phases are of Low significance.

# 10.0 RECOMMENDATIONS

Following the groundwater baseline and IA investigation the following is recommended:

- Monthly monitoring of exiting Eskom monitoring boreholes groundwater levels and quality. Monitoring should be conducted to be consistent with the existing WUL (Licence no.: 01 /A1042/ABCEFGI/5213);
- Monitoring boreholes MBH08, MBHO9 and MBH07 which are dry or water level are too low to sample and need to be replaced to ensure monitoring coverage in these areas;
- Aquifer testing of new monitoring boreholes to determine hydraulic parameters and update initial groundwater conceptual model. The groundwater conceptual model with aquifer parameters provide the basic input into a groundwater numerical model;
- Groundwater sampling of newly drilled monitoring boreholes;
- The newly-drilled monitoring boreholes should be incorporated into the existing monitoring programme. The following monitoring tasks should be conducted to be consistent with the existing WUL Licence no.: 01 /A1042/ABCEFGI/5213;
- Bi-annually groundwater monitoring of existing groundwater user's boreholes in the area surrounding the existing licensed disposal facility (In radius of ~ 3.0 km).
- Development of a numerical groundwater flow & transport model (or update of existing models) and Impact Assessment. This model to include Medupi Power station (MPS) and the Medupi FGD Project;
- Use model predictions to predict the pollution plume from the Medupi FGD Project area and Medupi Power station;
- Update mitigation and management measures for the Medupi FGD Project on numerical model outcome and predictions.

# 11.0 REFERENCES

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1:250 000, Geological map series.

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1:4 000 000, Groundwater Resources map of RSA – Sheet 2 (WRC.DWAF 1995).

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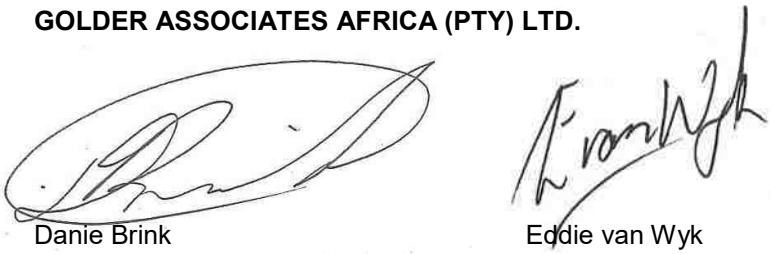

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# APPENDIX A

## Analytical Result Certificates of Hydrocensus Samples

# WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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SANAS Accredited Testing Laboratory
No. T0391

## CERTIFICATE OF ANALYSES
## GENERAL WATER QUALITY PARAMETERS

**Date received:** 2015 - 09 - 28 **Date completed:** 2015 - 10 – 09

**Project number: 159** **Report number: 54819** **Order number: 93428**

**Client name: Golder Associates** **Contact person: Mr. D. Brink**

**Address: P.O. Box 6001 Halfway House 1685** **e-mail: dbrink@golder.co.za**

**Telephone: 011 313 1058** **Facsimile: -** **Mobile: 083 379 2666**

| Analyses in mg/ℓ (Unless specified otherwise) | Method Identification | Sample Identification | | | | |
|---|---|---|---|---|---|---|
| | | KR05 | BU03 | KR01 | KR03 | BU02 |
| Sample Number | | 16952 | 16953 | 16954 | 16955 | 16956 |
| pH – Value at 25°C * | WLAB001 | 7.3 | 7.3 | 5.7 | 5.4 | 7.5 |
| Electrical Conductivity in mS/m at 25°C * | WLAB002 | 31.0 | 288 | 15.7 | 27.4 | 204 |
| Total Dissolved Solids at 180°C * | WLAB003 | 180 | 1 896 | 116 | 198 | 1 320 |
| Total Alkalinity as $CaCO_3$ * | WLAB007 | 160 | 292 | 8 | 8 | 288 |
| Chloride as Cl | WLAB046 | 9 | 664 | 25 | 36 | 518 |
| Sulphate as $SO_4$ | WLAB046 | 8 | 62 | 24 | 51 | 36 |
| Fluoride as F * | WLAB014 | 0.3 | 2.2 | 0.9 | 2.7 | 2.2 |
| Nitrate as N | WLAB046 | <0.2 | 66 | <0.2 | 2.0 | 16 |
| ICP-MS Scan * | WLAB050 | See Attached Report:54819 -A | | | | |
| % Balancing* | --- | 95.0 | 95.7 | 96.4 | 94.7 | 97.1 |

| Analyses in mg/ℓ (Unless specified otherwise) | Method Identification | Sample Identification | | | | |
|---|---|---|---|---|---|---|
| | | VER02 | BU01 | GE03 | GE01 | GE06 |
| Sample Number | | 16957 | 16958 | 16959 | 16960 | 16961 |
| pH – Value at 25°C * | WLAB001 | 7.4 | 7.5 | 7.8 | 7.1 | 7.0 |
| Electrical Conductivity in mS/m at 25°C * | WLAB002 | 112 | 178 | 124 | 12.2 | 39.6 |
| Total Dissolved Solids at 180°C * | WLAB003 | 652 | 1 058 | 670 | 84 | 248 |
| Total Alkalinity as $CaCO_3$ * | WLAB007 | 356 | 368 | 276 | 48 | 208 |
| Chloride as Cl | WLAB046 | 167 | 336 | 280 | 18 | 17 |
| Sulphate as $SO_4$ | WLAB046 | 40 | 71 | 41 | <5 | <5 |
| Fluoride as F * | WLAB014 | 1.3 | 2.3 | 0.7 | <0.2 | <0.2 |
| Nitrate as N | WLAB046 | 0.5 | <0.2 | <0.2 | <0.2 | 0.3 |
| ICP-MS Scan * | WLAB050 | See Attached Report:54819 –A | | | | |
| % Balancing* | --- | 96.0 | 97.4 | 89.5 | 98.1 | 96.4 |

*** = Not SANAS Accredited**

**Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.**

**A. van de Wetering**

Technical Signatory

# WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

**Project Number** : 159
**Client** : Golder Assosiates
**Report Number** : 54819-A

| Sample Origin | Sample ID | Ag (mg/L) | Al (mg/L) | As (mg/L) | Au (mg/L) | B (mg/L) | Ba (mg/L) | Be (mg/L) | Bi (mg/L) | Ca (mg/L) | Cd (mg/L) | Ce (mg/L) | Co (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KR05** | 16952 | <0.010 | 0.715 | <0.010 | <0.010 | 0.071 | 0.085 | <0.010 | <0.010 | 15 | <0.010 | <0.010 | <0.010 |
| **BU03** | 16953 | <0.010 | 0.100 | <0.010 | <0.010 | 0.166 | 0.326 | <0.010 | <0.010 | 186 | <0.010 | <0.010 | <0.010 |
| **KR01** | 16954 | <0.010 | 0.576 | <0.010 | <0.010 | 0.023 | 0.163 | <0.010 | <0.010 | 6 | <0.010 | <0.010 | <0.010 |
| **KR03** | 16955 | <0.010 | 2.21 | <0.010 | <0.010 | 0.024 | 0.297 | <0.010 | <0.010 | 11 | <0.010 | <0.010 | 0.010 |
| **BU02** | 16956 | <0.010 | 0.255 | 0.067 | <0.010 | 0.143 | 0.206 | <0.010 | <0.010 | 135 | <0.010 | <0.010 | <0.010 |
| **VER02** | 16957 | <0.010 | <0.100 | 0.016 | <0.010 | 0.141 | 0.210 | <0.010 | <0.010 | 77 | <0.010 | <0.010 | <0.010 |
| **BU01** | 16958 | <0.010 | 0.103 | 0.019 | <0.010 | 0.169 | 0.075 | <0.010 | <0.010 | 81 | <0.010 | <0.010 | <0.010 |
| **GE03** | 16959 | <0.010 | <0.100 | <0.010 | <0.010 | 0.157 | 0.114 | <0.010 | <0.010 | 23 | <0.010 | <0.010 | <0.010 |
| **GE01** | 16960 | <0.010 | 0.130 | <0.010 | <0.010 | 0.022 | 0.081 | <0.010 | <0.010 | 3 | <0.010 | <0.010 | <0.010 |
| **GE06** | 16961 | <0.010 | <0.100 | <0.010 | <0.010 | 0.019 | 0.515 | <0.010 | <0.010 | 32 | <0.010 | <0.010 | <0.010 |

| Sample Origin | Sample ID | Cr (mg/L) | Cs (mg/L) | Cu (mg/L) | Dy (mg/L) | Er (mg/L) | Eu (mg/L) | Fe (mg/L) | Ga (mg/L) | Gd (mg/L) | Ge (mg/L) | Hf (mg/L) | Hg (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **KR05** | 16952 | <0.010 | <0.010 | 0.020 | <0.010 | <0.010 | <0.010 | 2.14 | 0.014 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU03** | 16953 | <0.010 | <0.010 | 0.022 | <0.010 | <0.010 | <0.010 | 0.108 | 0.034 | <0.010 | <0.010 | <0.010 | <0.010 |
| **KR01** | 16954 | <0.010 | <0.010 | 0.031 | <0.010 | <0.010 | <0.010 | 7.06 | 0.029 | <0.010 | <0.010 | <0.010 | <0.010 |
| **KR03** | 16955 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.566 | 0.050 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU02** | 16956 | <0.010 | <0.010 | 0.147 | <0.010 | <0.010 | <0.010 | 6.59 | 0.024 | <0.010 | <0.010 | 0.025 | <0.010 |
| **VER02** | 16957 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 3.61 | 0.029 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU01** | 16958 | <0.010 | <0.010 | 0.125 | <0.010 | <0.010 | <0.010 | 1.00 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE03** | 16959 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.042 | 0.016 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE01** | 16960 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 4.82 | 0.015 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE06** | 16961 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.030 | 0.082 | <0.010 | <0.010 | <0.010 | <0.010 |

| Sample Origin | Sample ID | Ho (mg/L) | In (mg/L) | Ir (mg/L) | K (mg/L) | La (mg/L) | Li (mg/L) | Lu (mg/L) | Mg (mg/L) | Mn (mg/L) | Mo (mg/L) | Na (mg/L) | Nb (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| **KR05** | 16952 | <0.010 | <0.010 | <0.010 | 2.6 | <0.010 | 0.024 | <0.010 | <2 | 0.044 | <0.010 | 52 | <0.010 |
| **BU03** | 16953 | <0.010 | <0.010 | <0.010 | 23 | <0.010 | 0.045 | <0.010 | 95 | <0.025 | <0.010 | 238 | <0.010 |
| **KR01** | 16954 | <0.010 | <0.010 | <0.010 | 6.4 | <0.010 | <0.010 | <0.010 | 4 | 0.068 | <0.010 | 11 | <0.010 |
| **KR03** | 16955 | <0.010 | <0.010 | <0.010 | 7.0 | <0.010 | <0.010 | <0.010 | 5 | 0.138 | <0.010 | 23 | <0.010 |
| **BU02** | 16956 | <0.010 | <0.010 | <0.010 | 17.0 | <0.010 | 0.053 | <0.010 | 65 | 0.775 | <0.010 | 195 | <0.010 |
| **VER02** | 16957 | <0.010 | <0.010 | <0.010 | 15.3 | <0.010 | 0.050 | <0.010 | 34 | 0.324 | <0.010 | 108 | <0.010 |
| **BU01** | 16958 | <0.010 | <0.010 | <0.010 | 18.4 | <0.010 | 0.087 | <0.010 | 54 | 0.090 | <0.010 | 194 | <0.010 |
| **GE03** | 16959 | <0.010 | <0.010 | <0.010 | 6.4 | <0.010 | 0.169 | <0.010 | 17 | 0.122 | <0.010 | 200 | <0.010 |
| **GE01** | 16960 | <0.010 | <0.010 | <0.010 | 2.5 | <0.010 | 0.024 | <0.010 | 2 | 0.131 | <0.010 | 17 | <0.010 |
| **GE06** | 16961 | <0.010 | <0.010 | <0.010 | 2.9 | <0.010 | 0.017 | <0.010 | 26 | 0.065 | <0.010 | 12 | <0.010 |

| Sample Origin | Sample ID | Nd (mg/L) | Ni (mg/L) | Os (mg/L) | P (mg/L) | Pb (mg/L) | Pd (mg/L) | Pt (mg/L) | Rb (mg/L) | Rh (mg/L) | Ru (mg/L) | Sb (mg/L) | Sc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| **KR05** | 16952 | <0.010 | 0.021 | <0.010 | 0.584 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU03** | 16953 | <0.010 | 0.050 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.025 | <0.010 | <0.010 | <0.010 | <0.010 |
| **KR01** | 16954 | <0.010 | 0.074 | <0.010 | 0.111 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **KR03** | 16955 | <0.010 | 0.026 | <0.010 | 0.010 | <0.010 | <0.010 | <0.010 | 0.013 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU02** | 16956 | <0.010 | 0.085 | <0.010 | 0.042 | 0.501 | <0.010 | <0.010 | 0.028 | <0.010 | <0.010 | <0.010 | <0.010 |
| **VER02** | 16957 | <0.010 | 0.047 | <0.010 | 0.039 | <0.010 | <0.010 | <0.010 | 0.015 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU01** | 16958 | <0.010 | 0.035 | <0.010 | 0.050 | 0.026 | <0.010 | <0.010 | 0.022 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE03** | 16959 | <0.010 | <0.010 | <0.010 | 0.049 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE01** | 16960 | <0.010 | 0.048 | <0.010 | 0.033 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE06** | 16961 | <0.010 | 0.010 | <0.010 | 0.061 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |

| Sample Origin | Sample ID | Se (mg/L) | Si (mg/L) | Sm (mg/L) | Sn (mg/L) | Sr (mg/L) | Ta (mg/L) | Tb (mg/L) | Te (mg/L) | Th (mg/L) | Ti (mg/L) | Tl (mg/L) | Tm (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| **KR05** | 16952 | <0.010 | 10.1 | <0.010 | <0.010 | 0.288 | <0.010 | <0.010 | <0.010 | <0.010 | 0.026 | <0.010 | <0.010 |
| **BU03** | 16953 | 0.016 | 28 | <0.010 | <0.010 | 1.51 | <0.010 | <0.010 | <0.010 | <0.010 | 0.301 | <0.010 | <0.010 |
| **KR01** | 16954 | <0.010 | 13.7 | <0.010 | <0.010 | 0.054 | <0.010 | <0.010 | <0.010 | <0.010 | 0.010 | <0.010 | <0.010 |
| **KR03** | 16955 | <0.010 | 19.7 | <0.010 | <0.010 | 0.059 | <0.010 | <0.010 | <0.010 | <0.010 | 0.025 | <0.010 | <0.010 |
| **BU02** | 16956 | 0.011 | 23 | <0.010 | <0.010 | 1.08 | <0.010 | <0.010 | <0.010 | <0.010 | 0.199 | <0.010 | <0.010 |
| **VER02** | 16957 | <0.010 | 5.8 | <0.010 | <0.010 | 0.540 | <0.010 | <0.010 | <0.010 | <0.010 | 0.110 | <0.010 | <0.010 |
| **BU01** | 16958 | <0.010 | 11.8 | <0.010 | <0.010 | 0.700 | <0.010 | <0.010 | <0.010 | <0.010 | 0.121 | <0.010 | <0.010 |
| **GE03** | 16959 | <0.010 | 8.8 | <0.010 | <0.010 | 0.279 | <0.010 | <0.010 | <0.010 | <0.010 | 0.036 | <0.010 | <0.010 |
| **GE01** | 16960 | <0.010 | 11.4 | <0.010 | <0.010 | 0.060 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **GE06** | 16961 | <0.010 | 29 | <0.010 | <0.010 | 0.169 | <0.010 | <0.010 | <0.010 | <0.010 | 0.048 | <0.010 | <0.010 |

| Sample Origin | Sample ID | U (mg/L) | V (mg/L) | W (mg/L) | Y (mg/L) | Yb (mg/L) | Zn (mg/L) | Zr (mg/L) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **KR05** | 16952 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| **BU03** | 16953 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.093 | <0.010 |
| **KR01** | 16954 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.527 | <0.010 |
| **KR03** | 16955 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | 0.029 | <0.010 |
| **BU02** | 16956 | 0.012 | <0.010 | <0.010 | <0.010 | <0.010 | 0.113 | <0.010 |
| **VER02** | 16957 | 0.000 | <0.010 | <0.010 | <0.010 | <0.010 | 0.007 | <0.010 |
| **BU01** | 16958 | 0.007 | <0.010 | <0.010 | <0.010 | <0.010 | 1.354 | <0.010 |
| **GE03** | 16959 | 0.002 | <0.010 | <0.010 | <0.010 | <0.010 | 0.026 | <0.010 |
| **GE01** | 16960 | 0.000 | <0.010 | <0.010 | <0.010 | <0.010 | 0.469 | <0.010 |
| **GE06** | 16961 | 0.001 | <0.010 | <0.010 | <0.010 | <0.010 | 0.014 | <0.010 |

# APPENDIX B

## Document Limitations

## DOCUMENT LIMITATIONS

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v) Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

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