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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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APPENDICES

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;
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- 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.

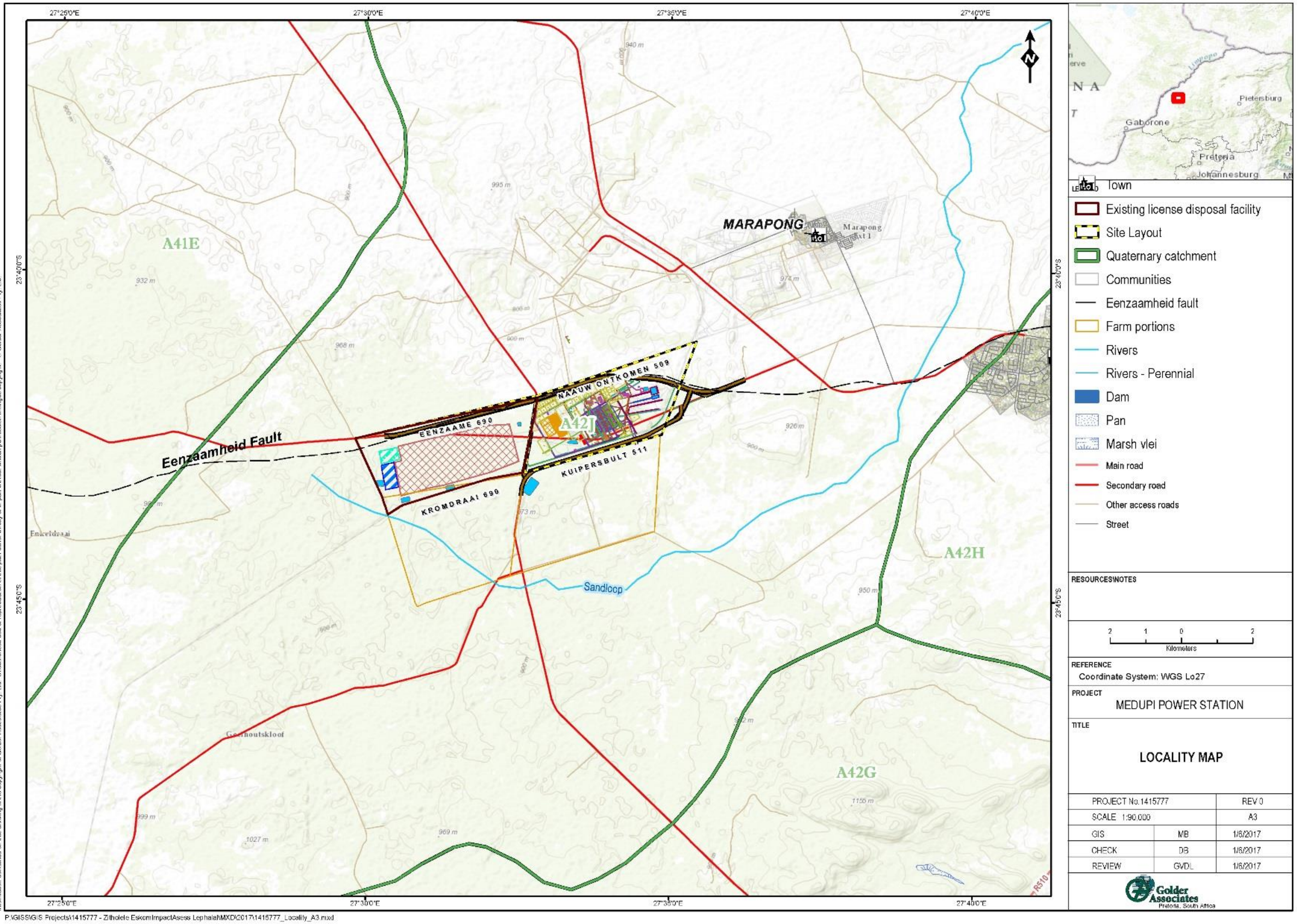

Figure 1: Locality Map

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).

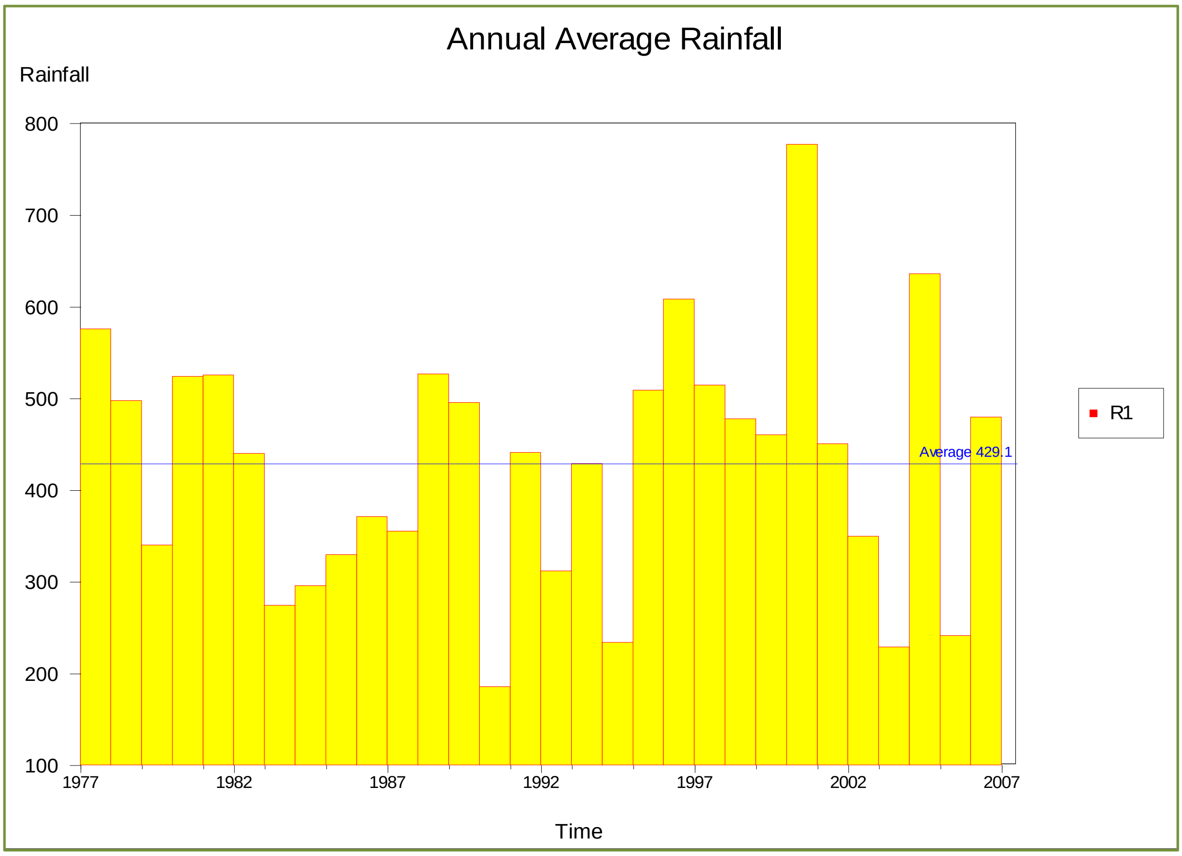

Figure 2: Annual Rainfall for the Medupi Area, Weather Bureau (IGS 2008)

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^{o} and 60^{o} 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.

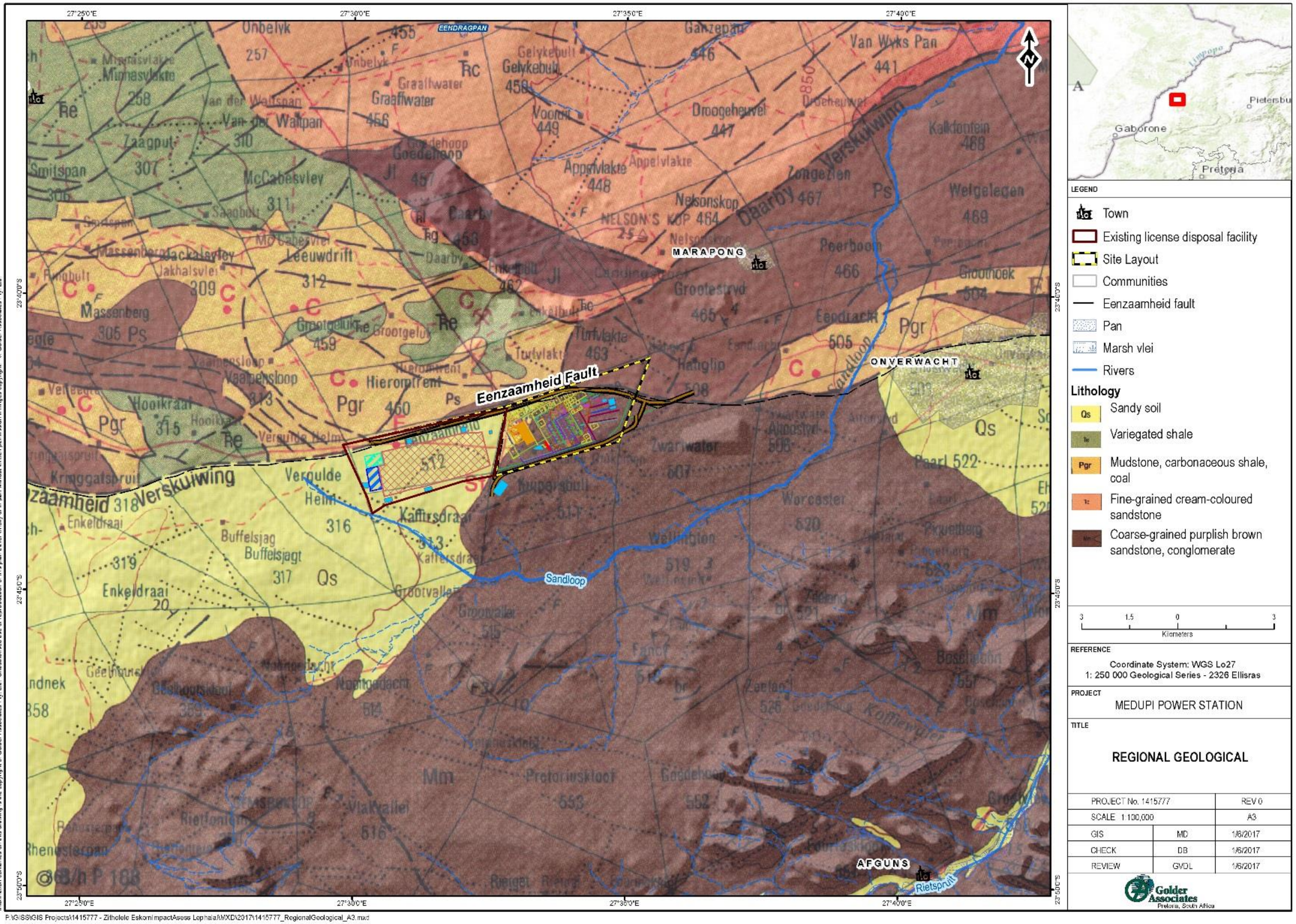

Figure 3: Regional Geology

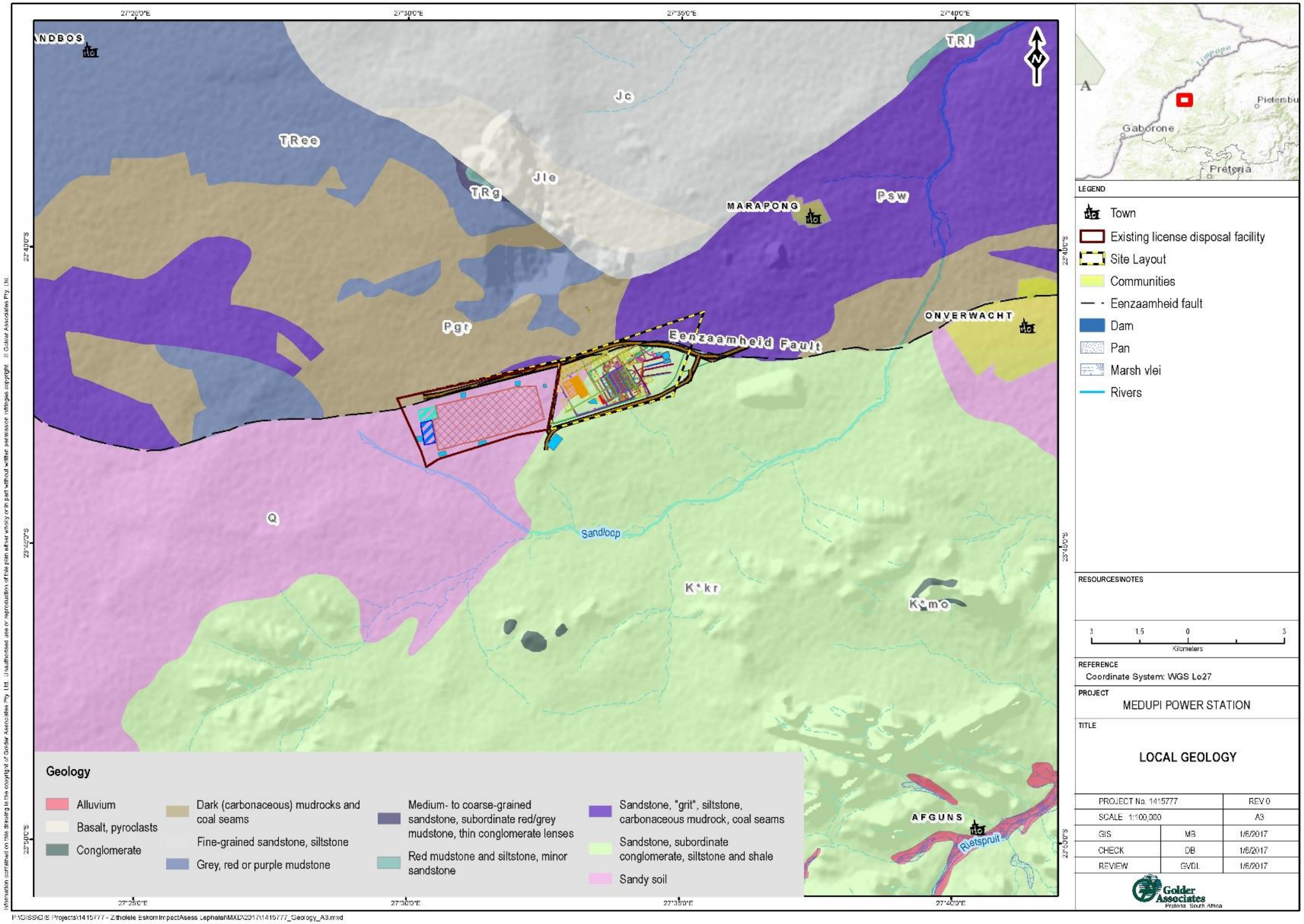

Figure 4: Local Geology

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.

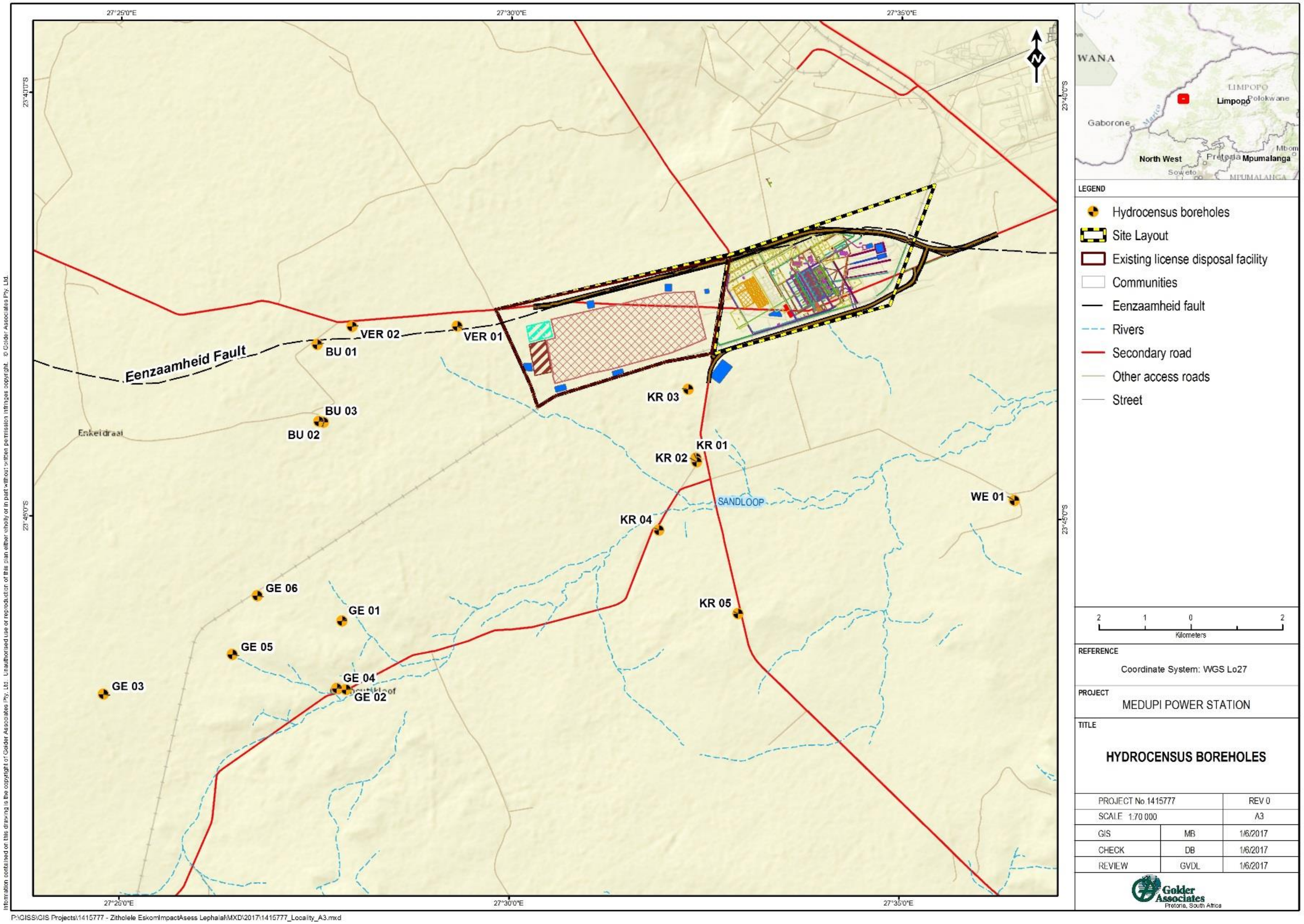

Figure 5: Hydrocensus Borehole Positions

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.

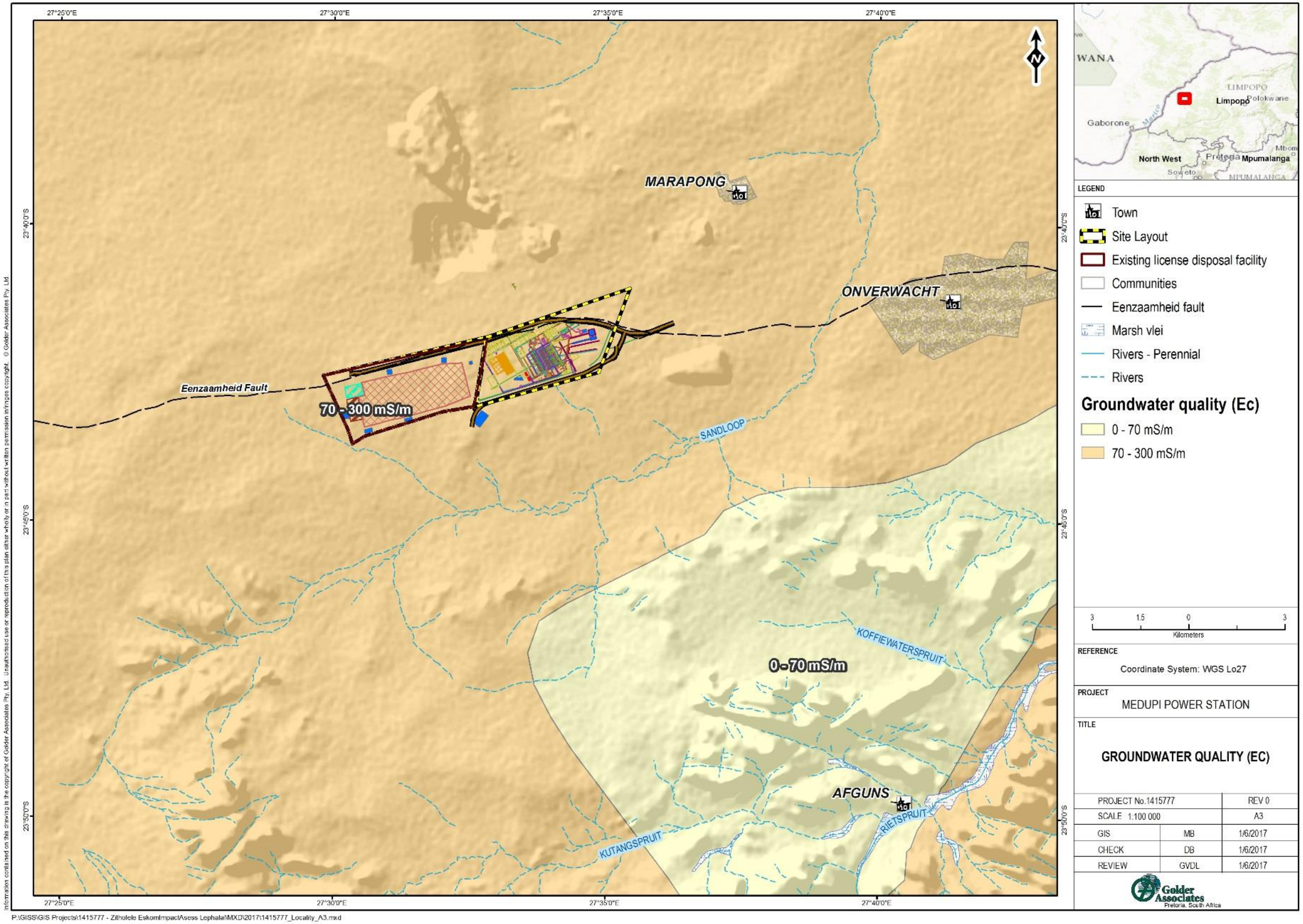

Figure 6: Hydrogeological Map Series Average Groundwater Electrical conductivity (EC) Values

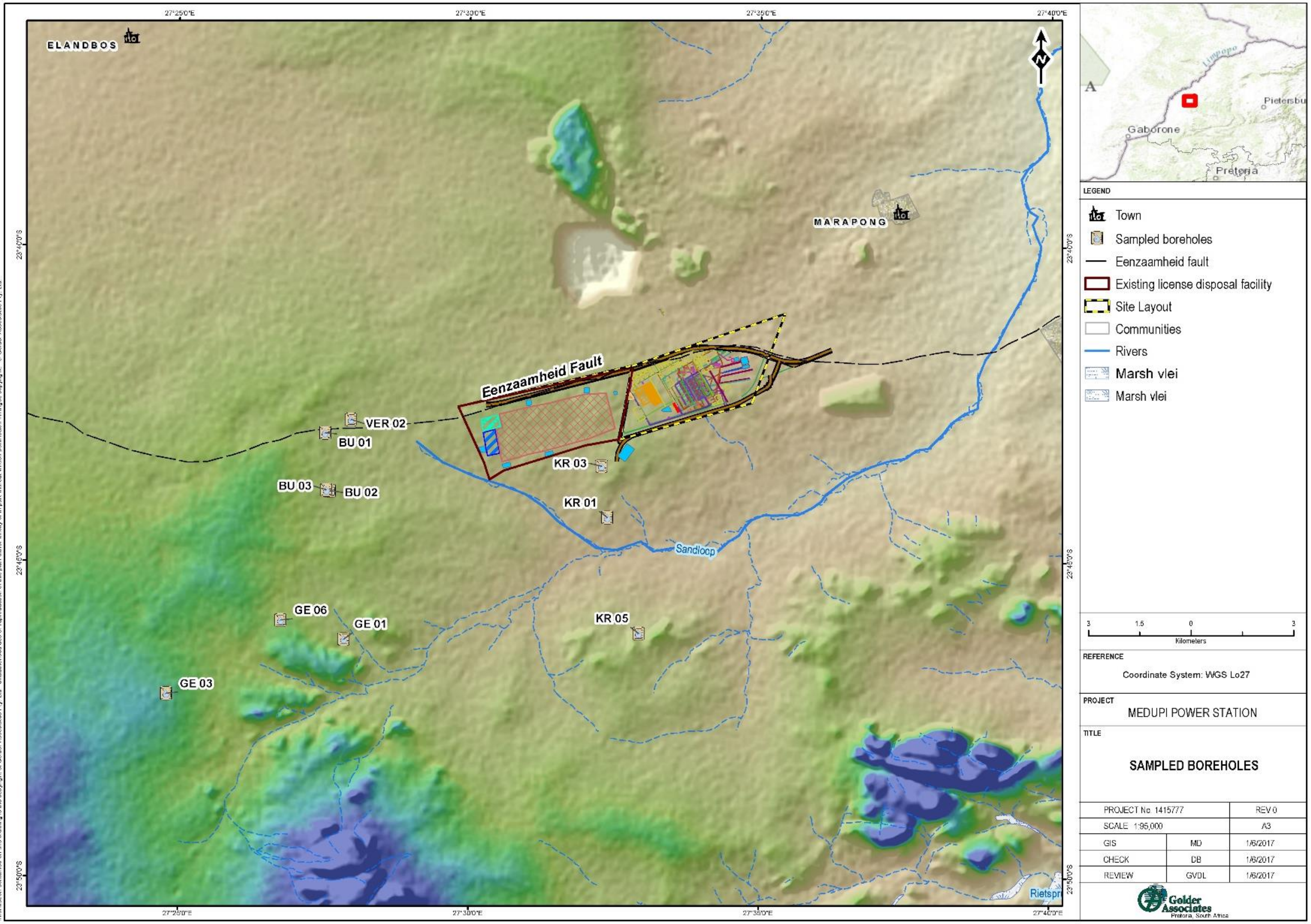

Figure 7: Sampled Boreholes

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.

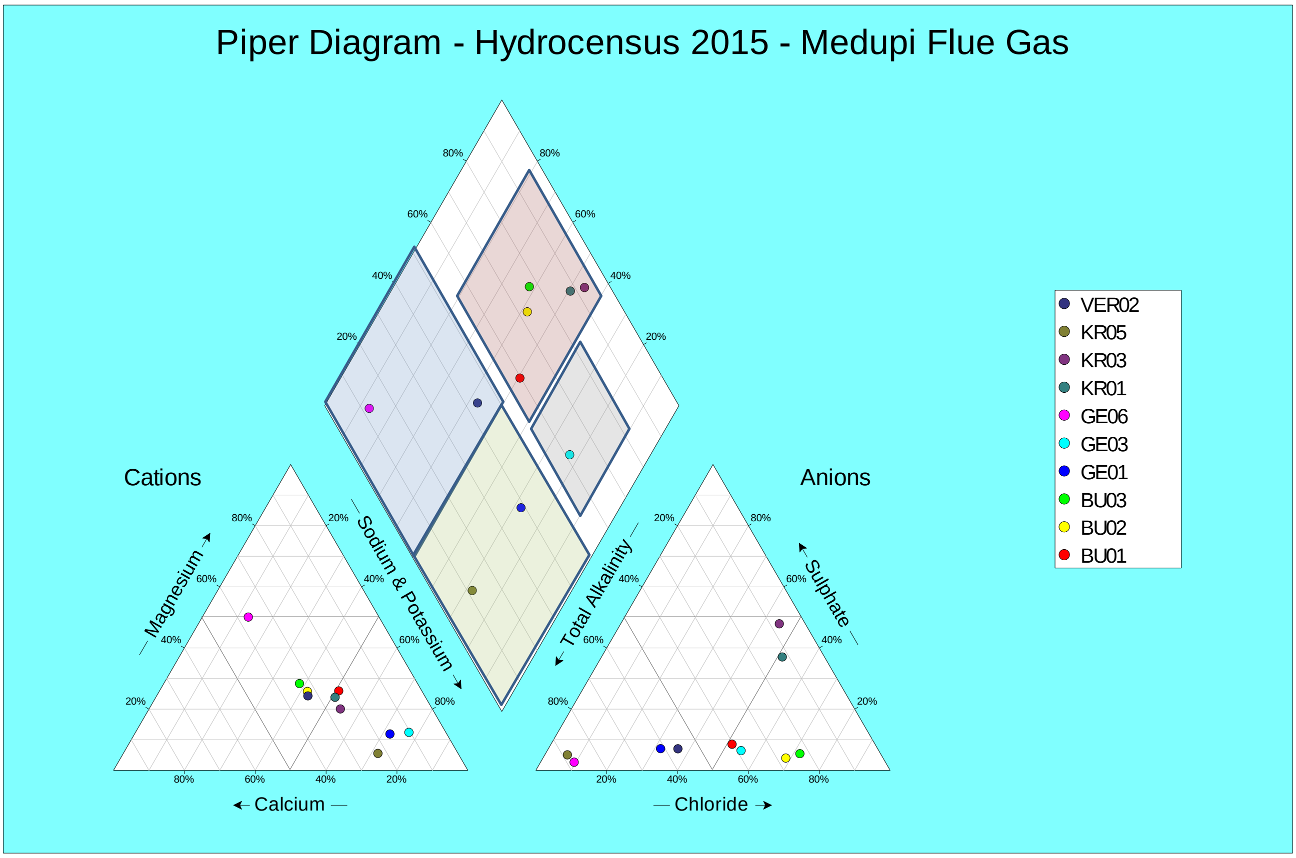

Figure 8: Piper Diagram Hydrocensus Boreholes

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.

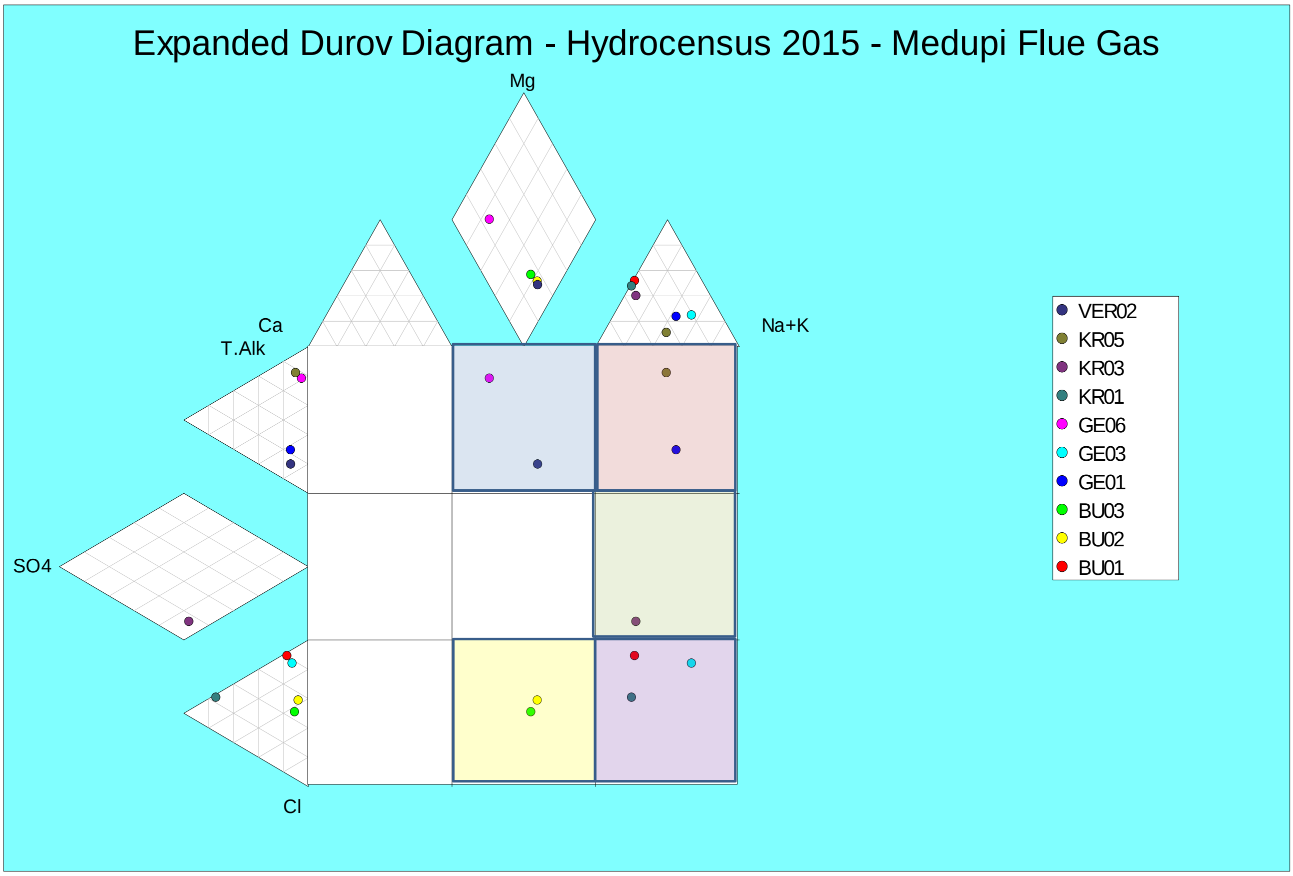

Figure 9: Expanded Durov Diagram Hydrocensus Boreholes

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).

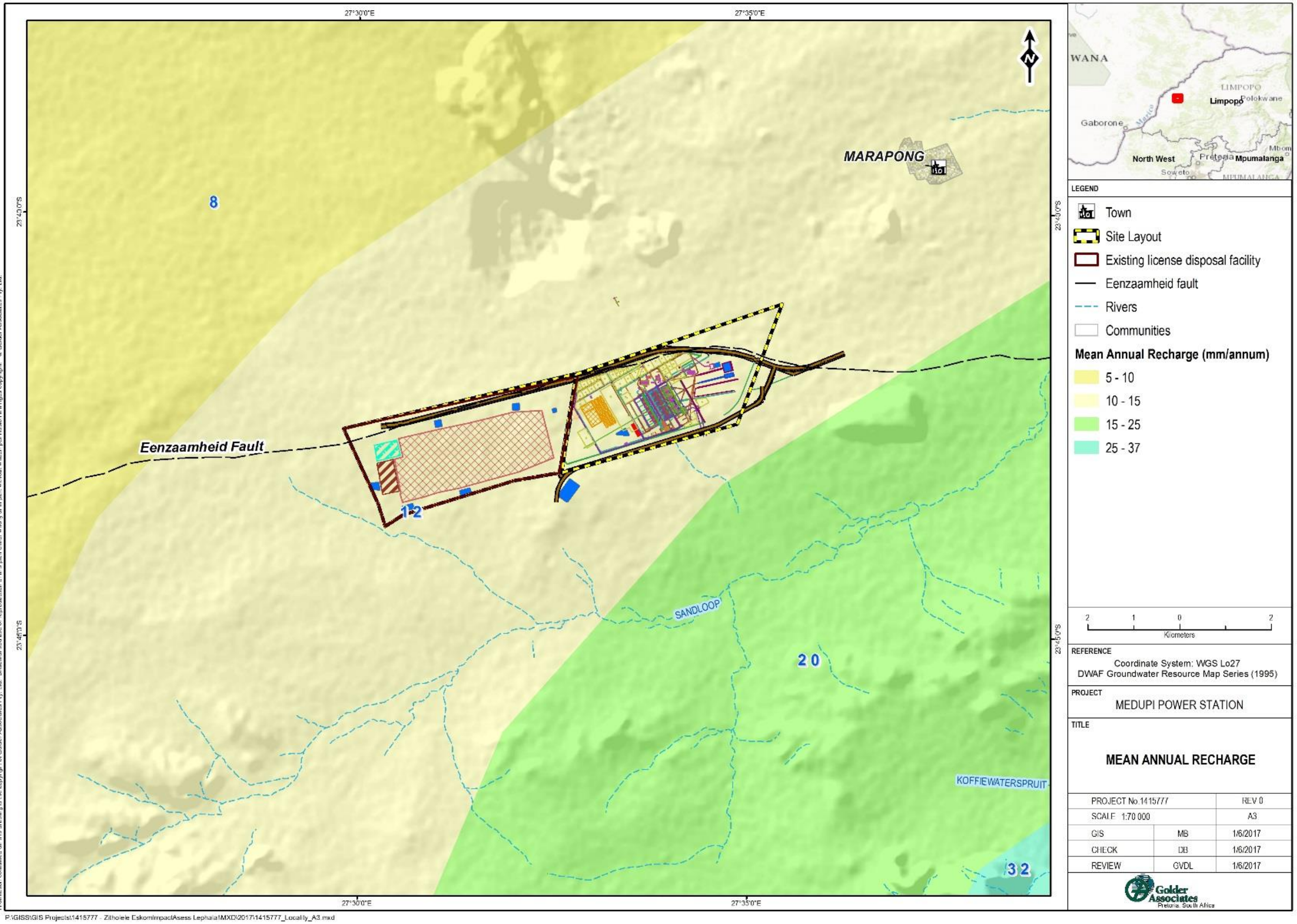

Figure 10: Groundwater Mean Annual Recharge (Vegter 1996)

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:

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

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.

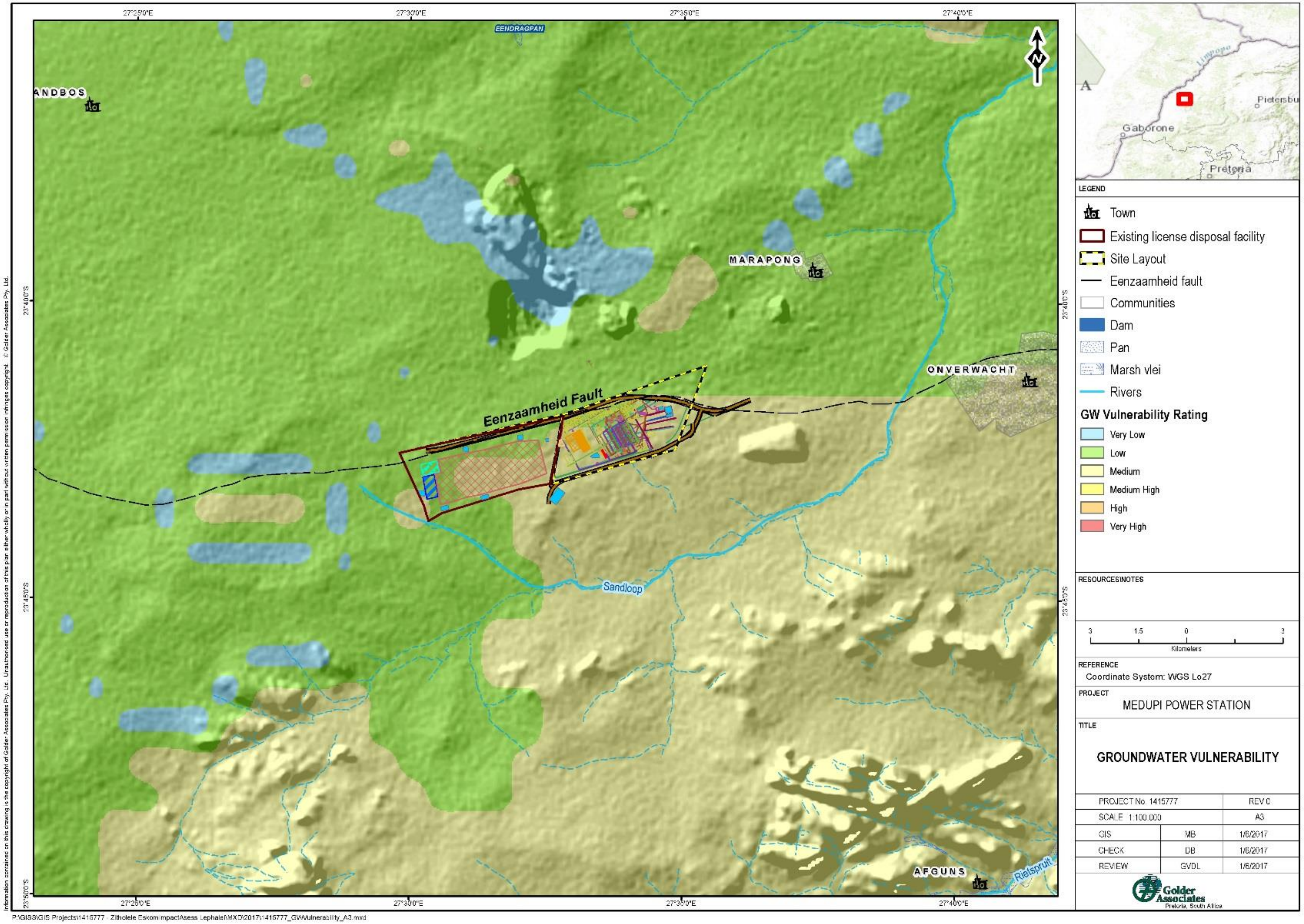

Figure 11: Groundwater Vulnerability Map

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 22m^2/d;
- Transmissivity for tested boreholes outside of the excavated area is < 8m^2/d; and
- The storage coefficient for the shallow aquifer is estimated to be between 4.4 x 10^{-5} and 2.2 x10^{-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.

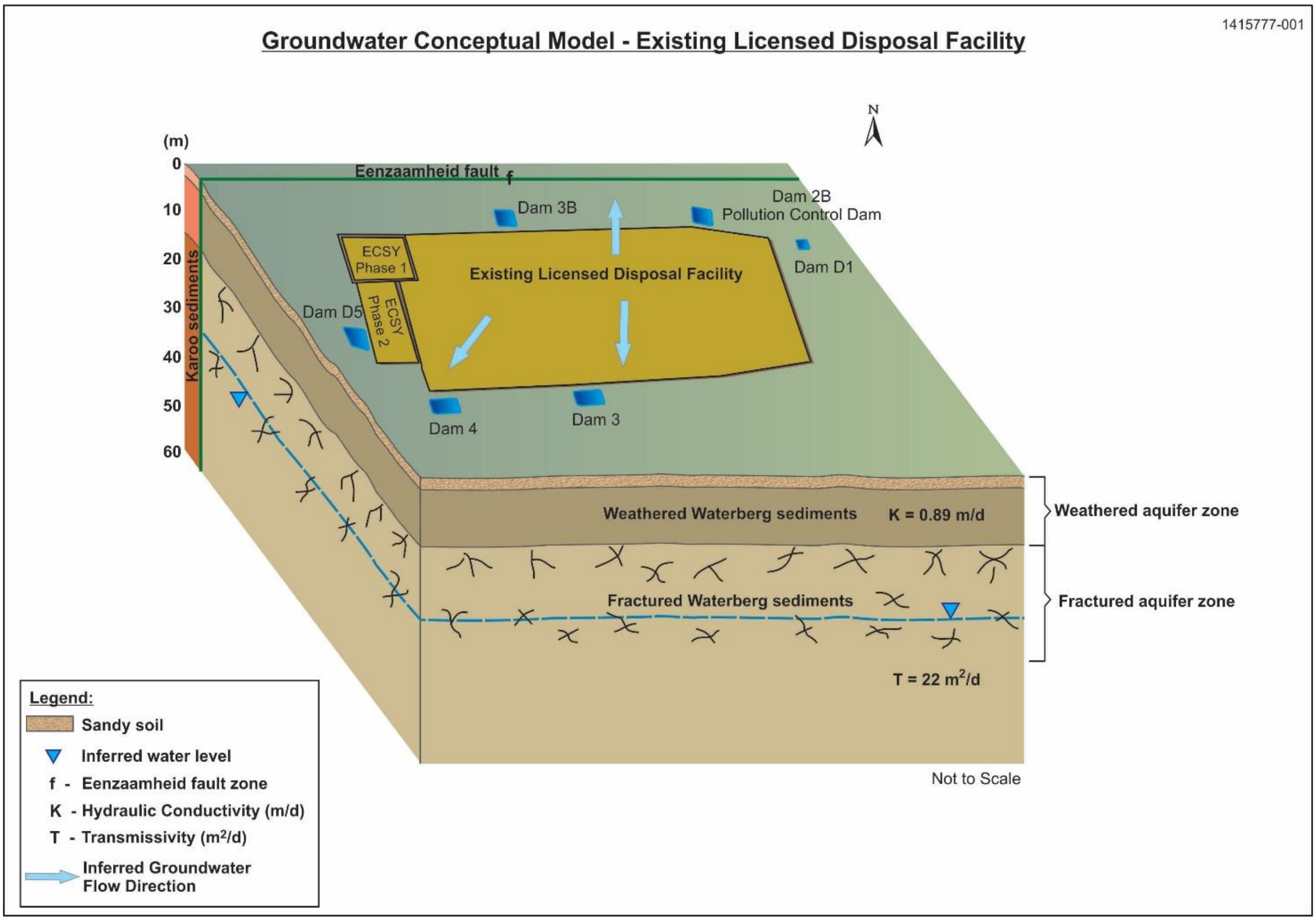

Figure 12: Initial Groundwater Conceptual Model for Medupi FGD Retrofit Project area and existing disposal facility

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).

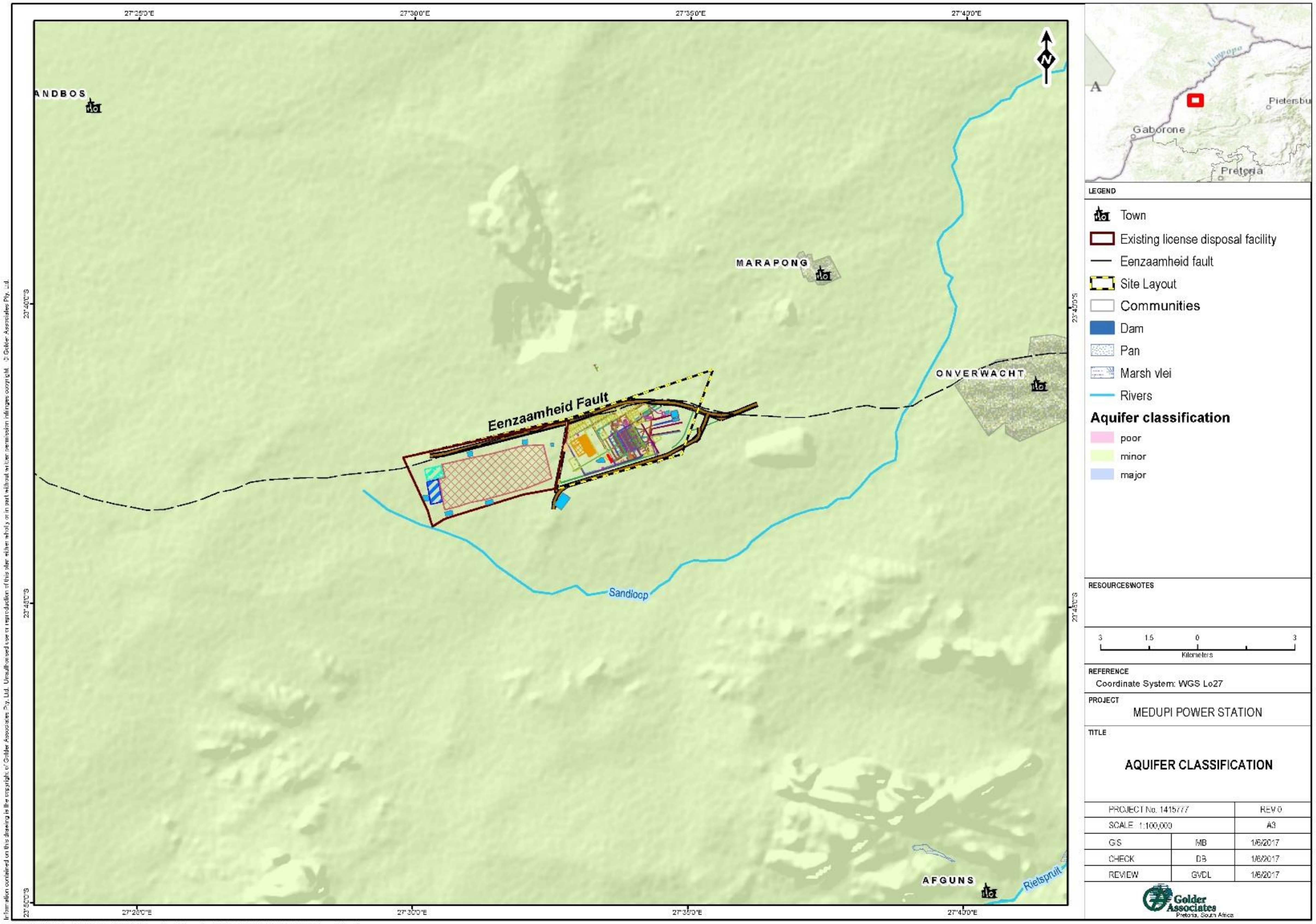

Figure 13: Aquifer Classification

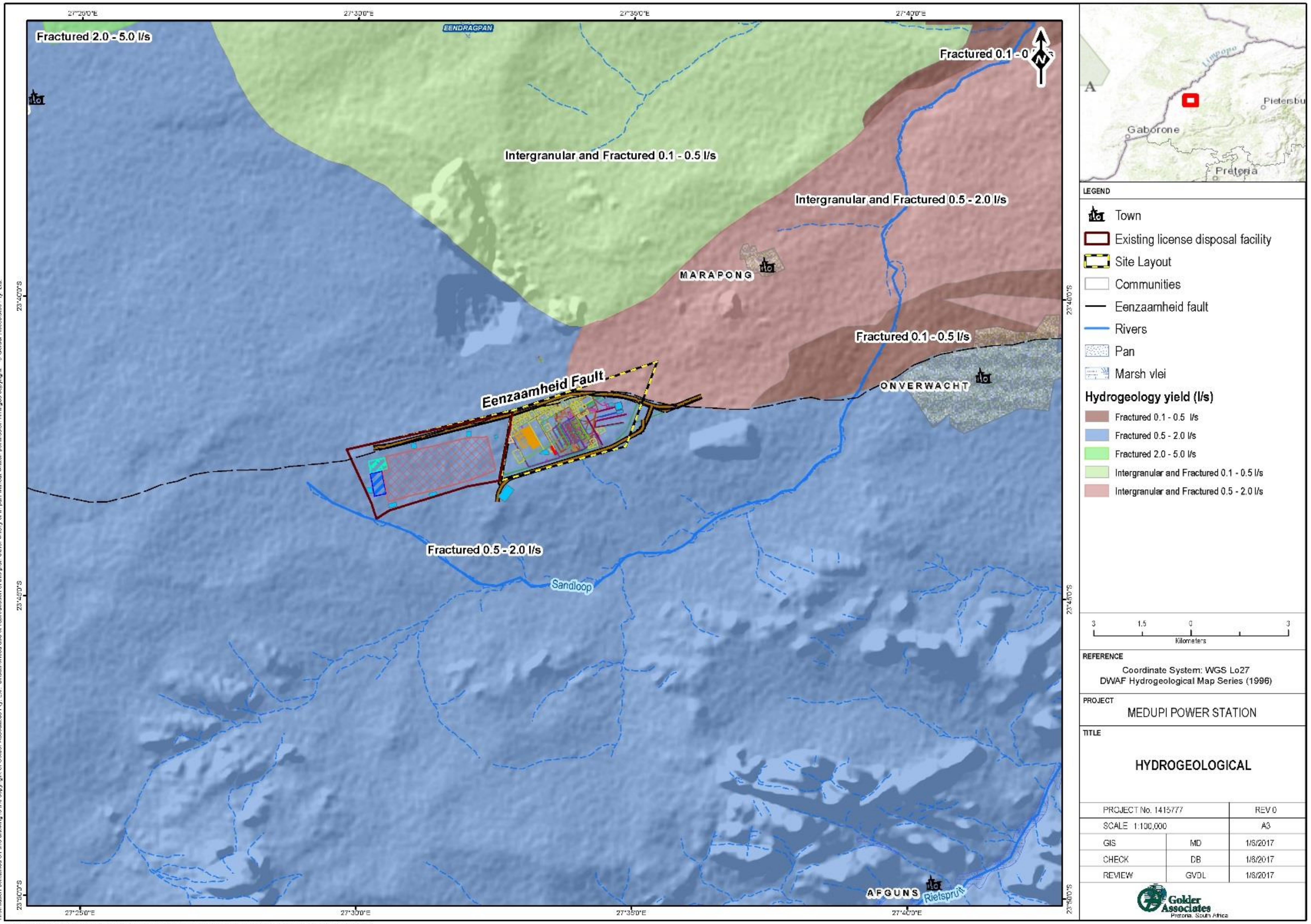

Figure 14: Hydrogeology Map

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.

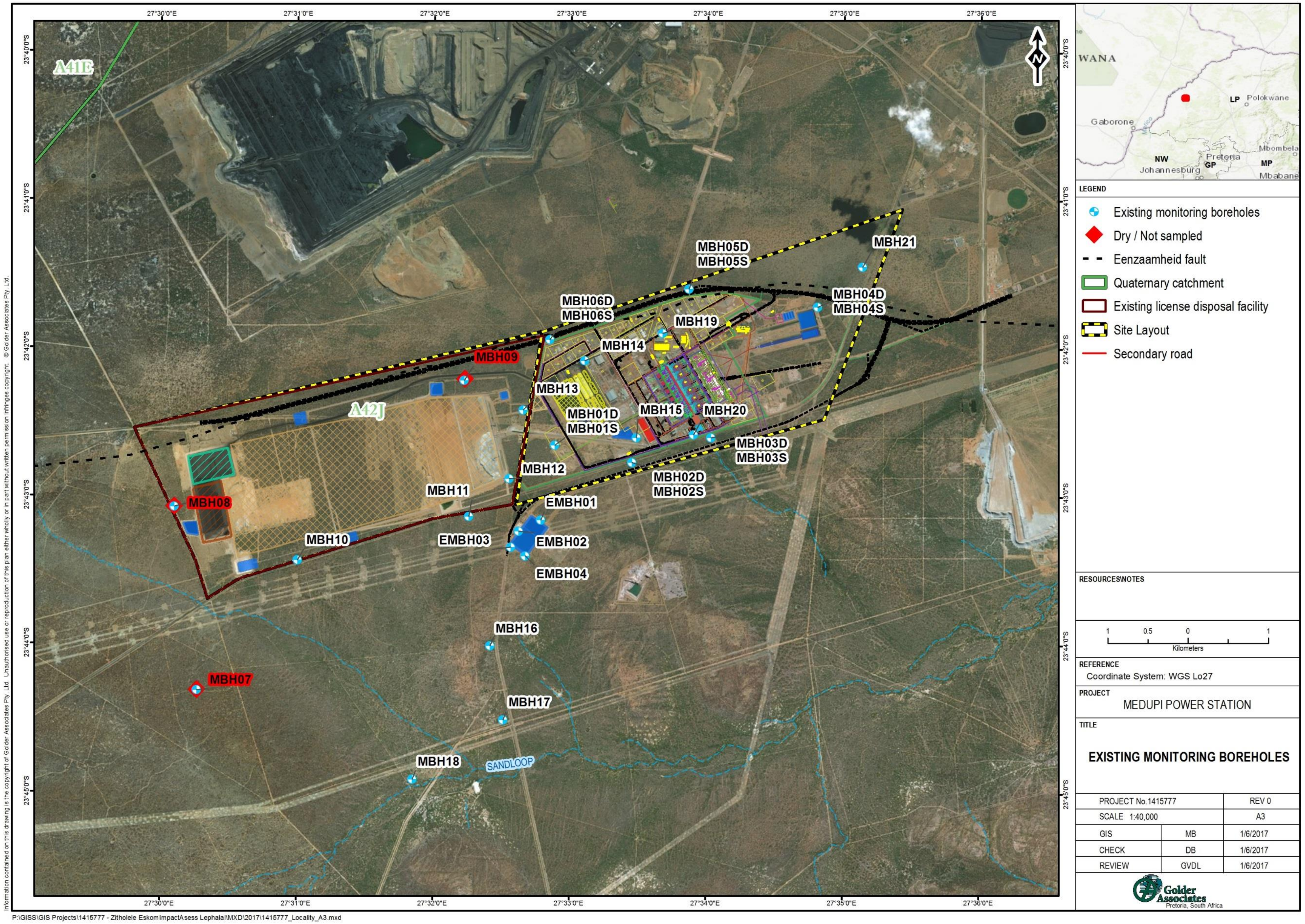

Figure 15: Exiting Groundwater Monitoring Boreholes

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	Physical Determinants			Chemical Determinants												Water Quality Class
Number	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.

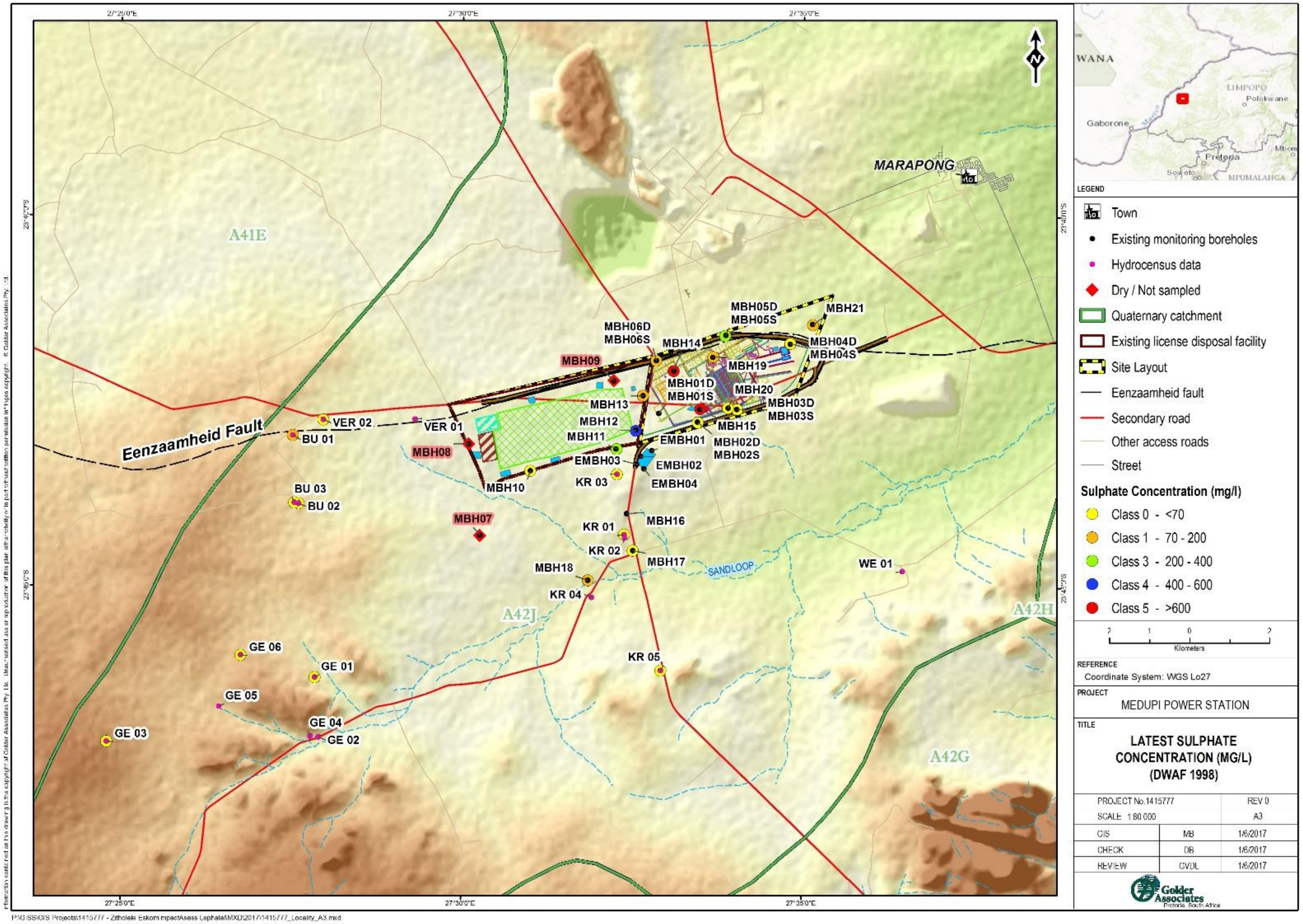

Figure 16: Latest Sulphate Concentrations (mg/l)

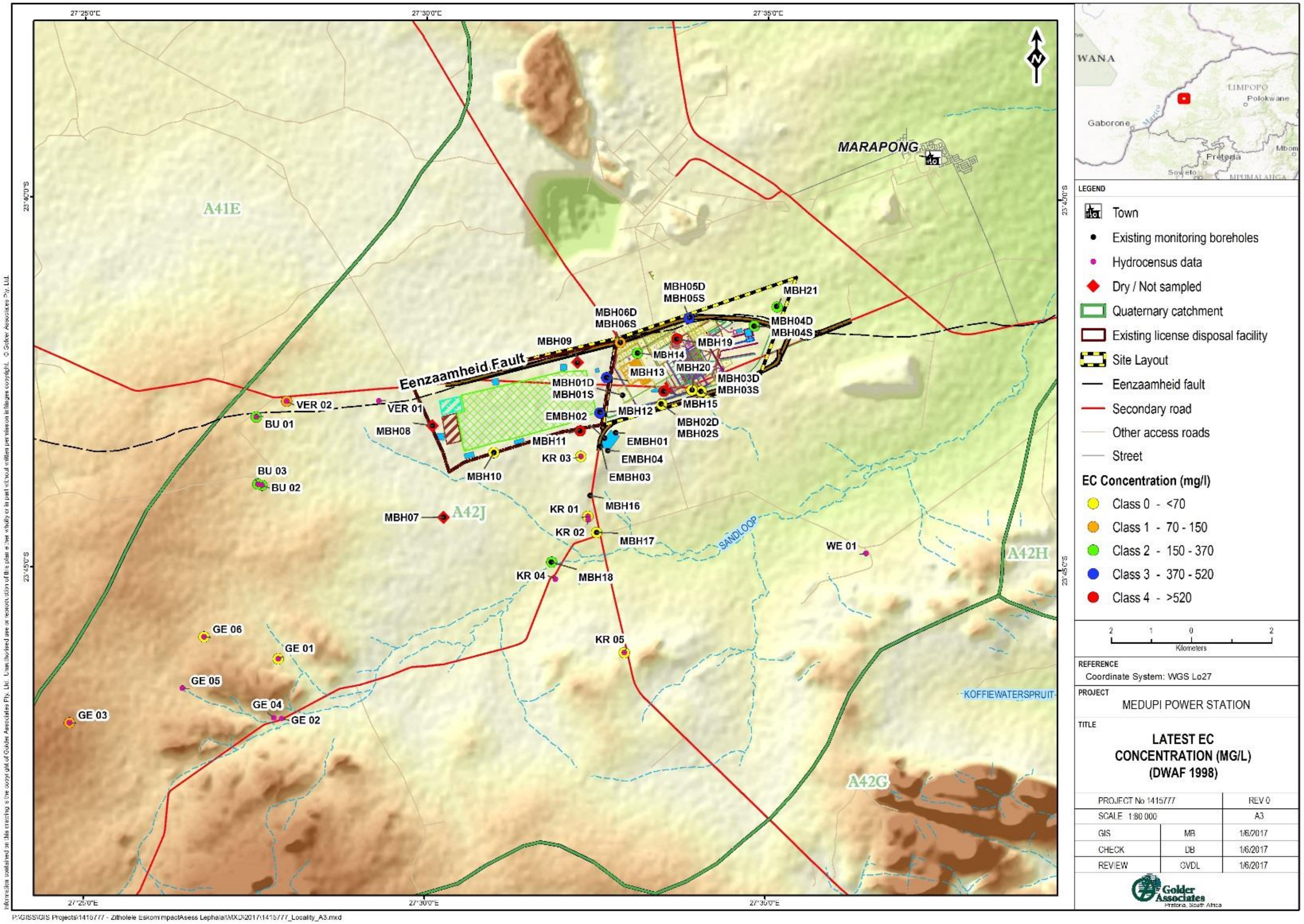

Figure 17: Latest EC Concentrations (mg/l)

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)

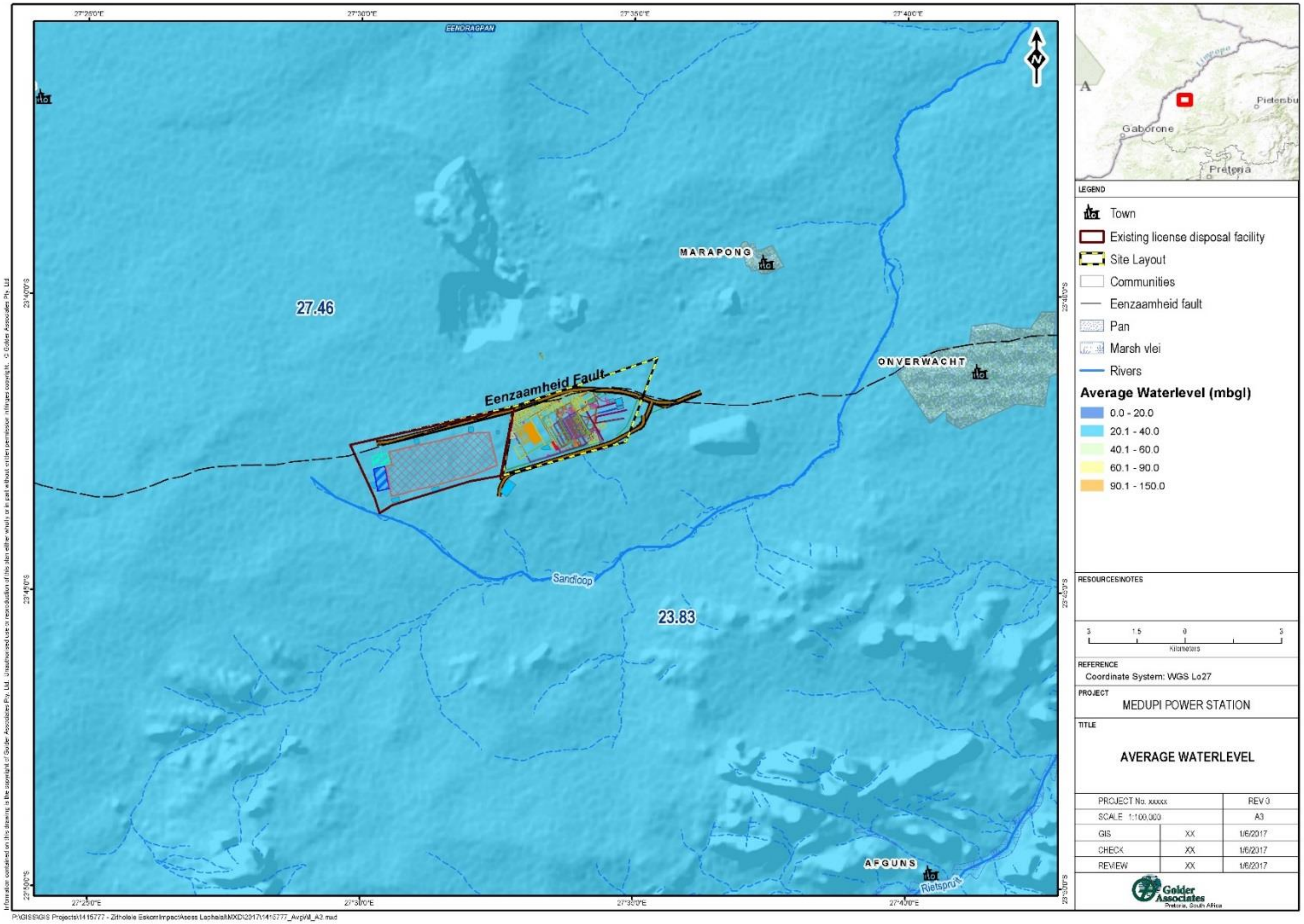

Figure 18: Average Ground Water Level (DWAF 1996)

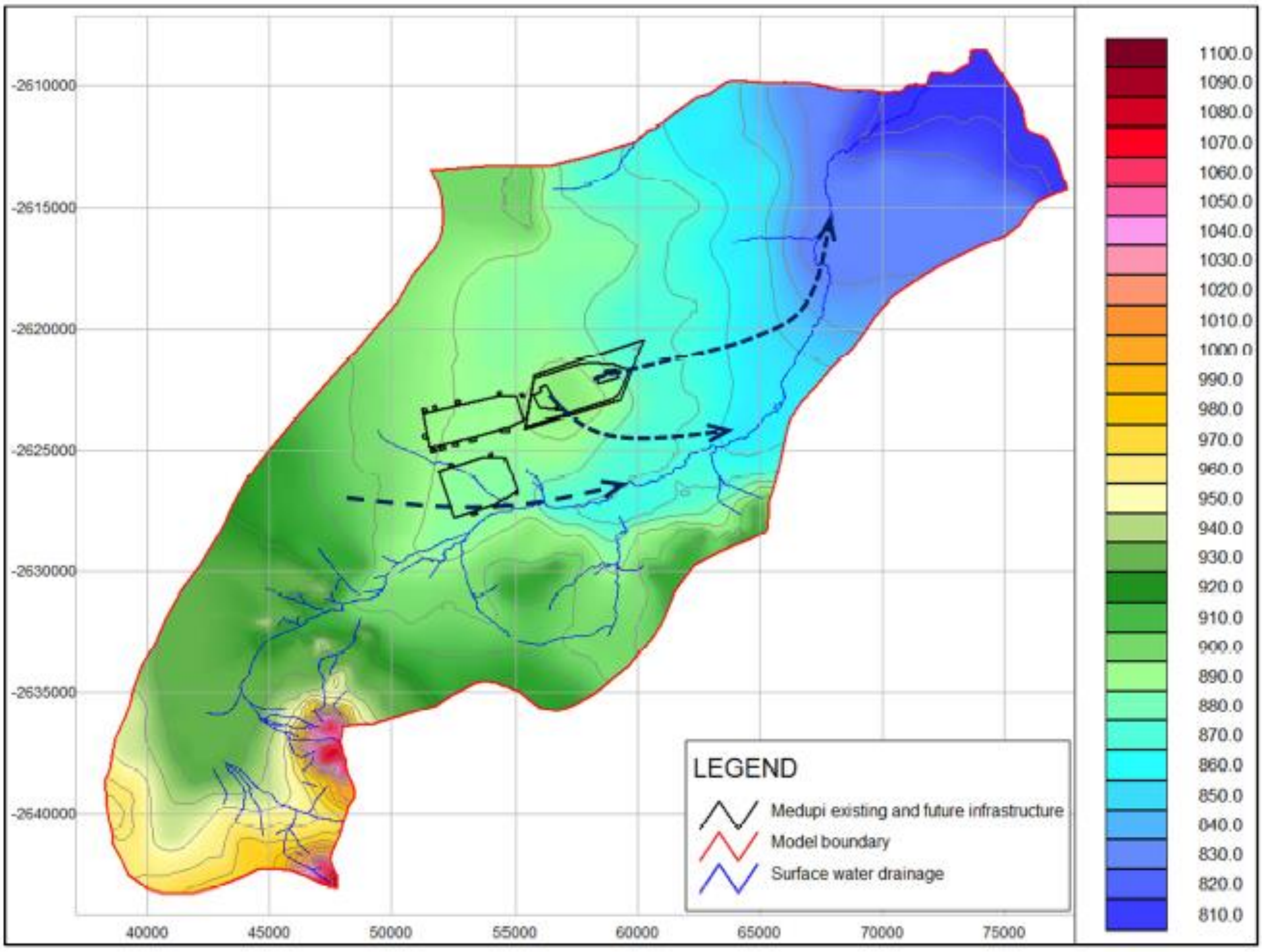

Figure 19: Groundwater Elevation Contour map (Adapted from Groundwater Complete - 2017).

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.

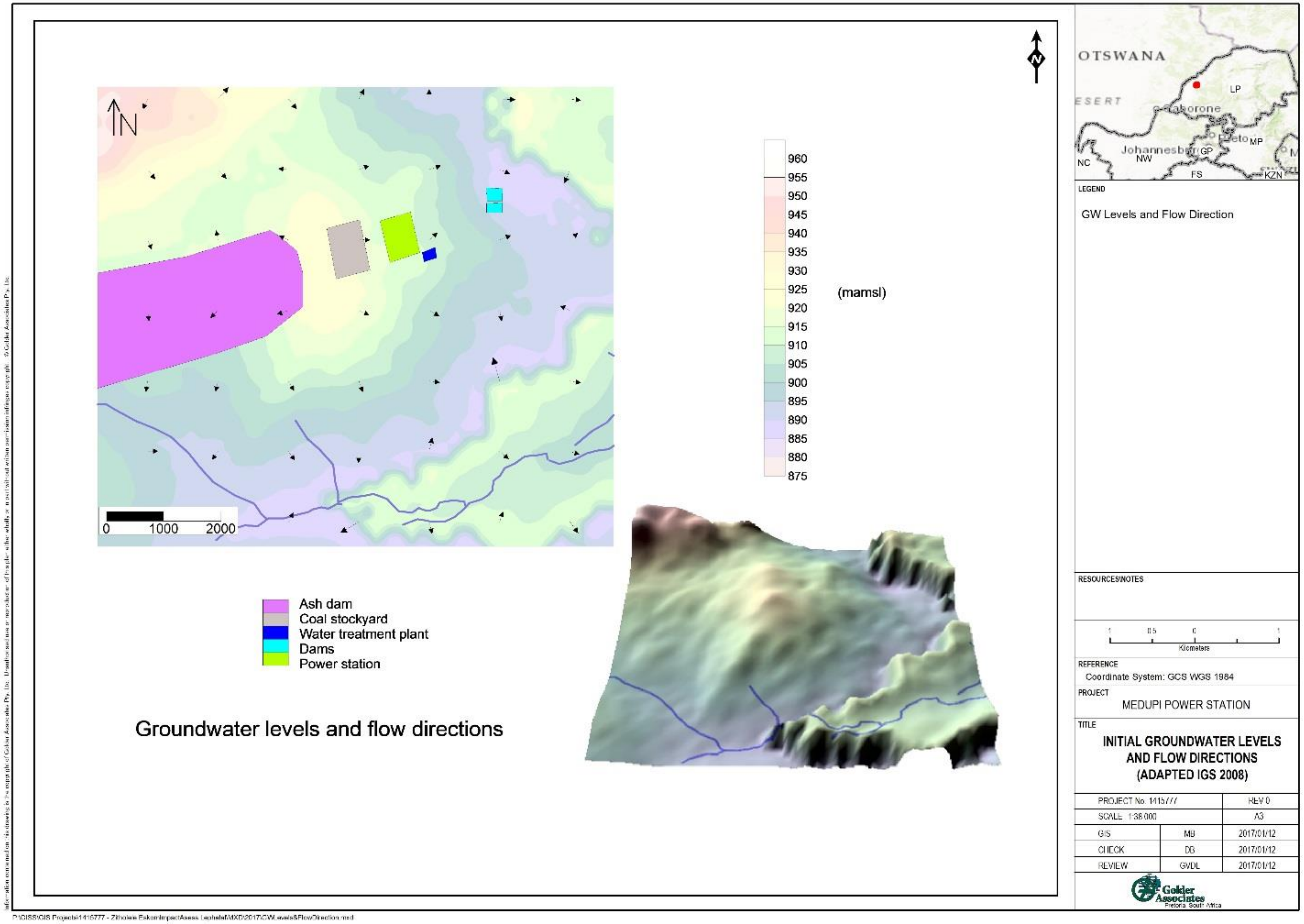

Figure 20: Initial Groundwater Levels and Flow Directions (Adapted IGS 2008)

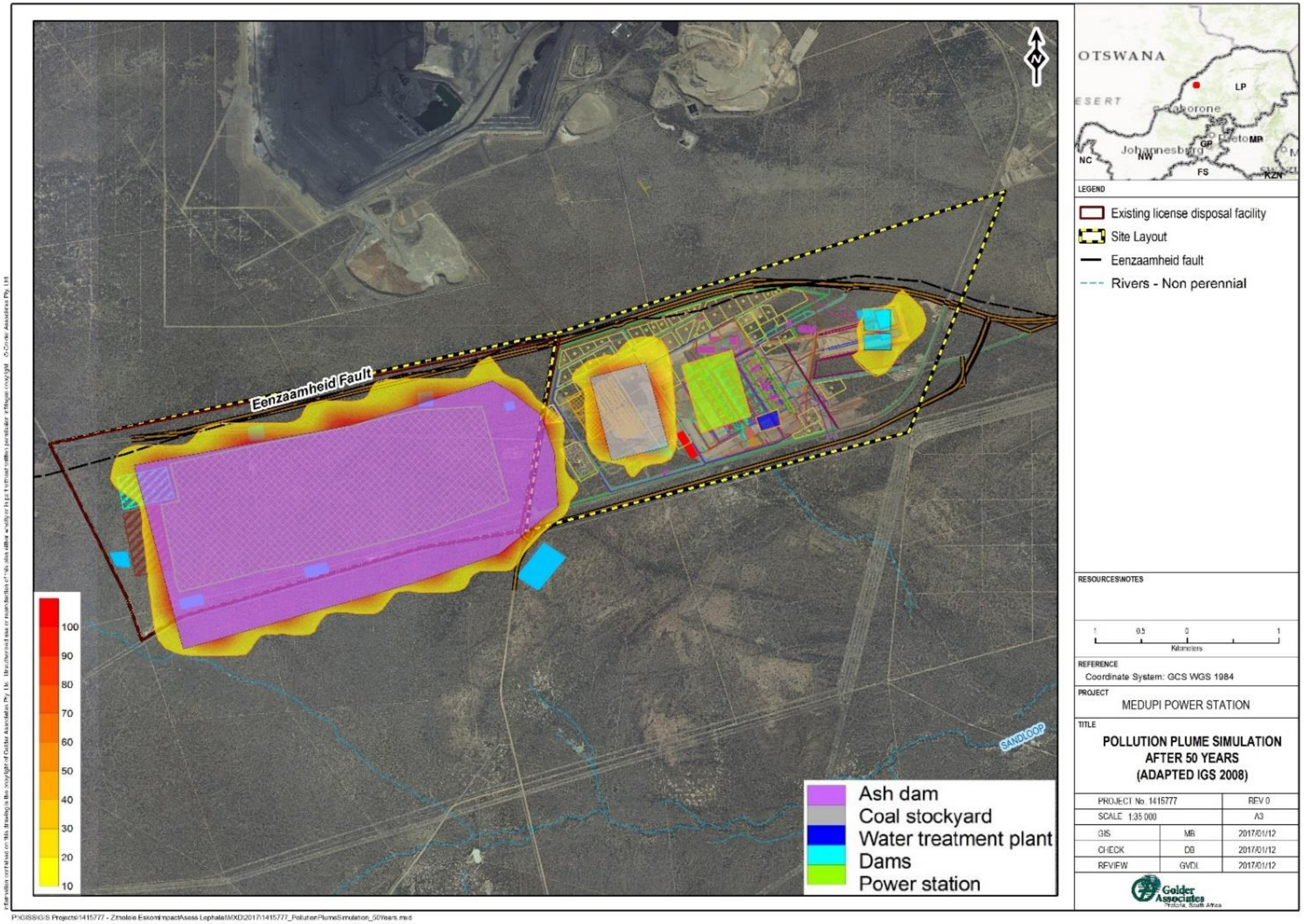

Figure 21: Pollution Plume Simulation after 50 years (Adapted IGS 2008)

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.

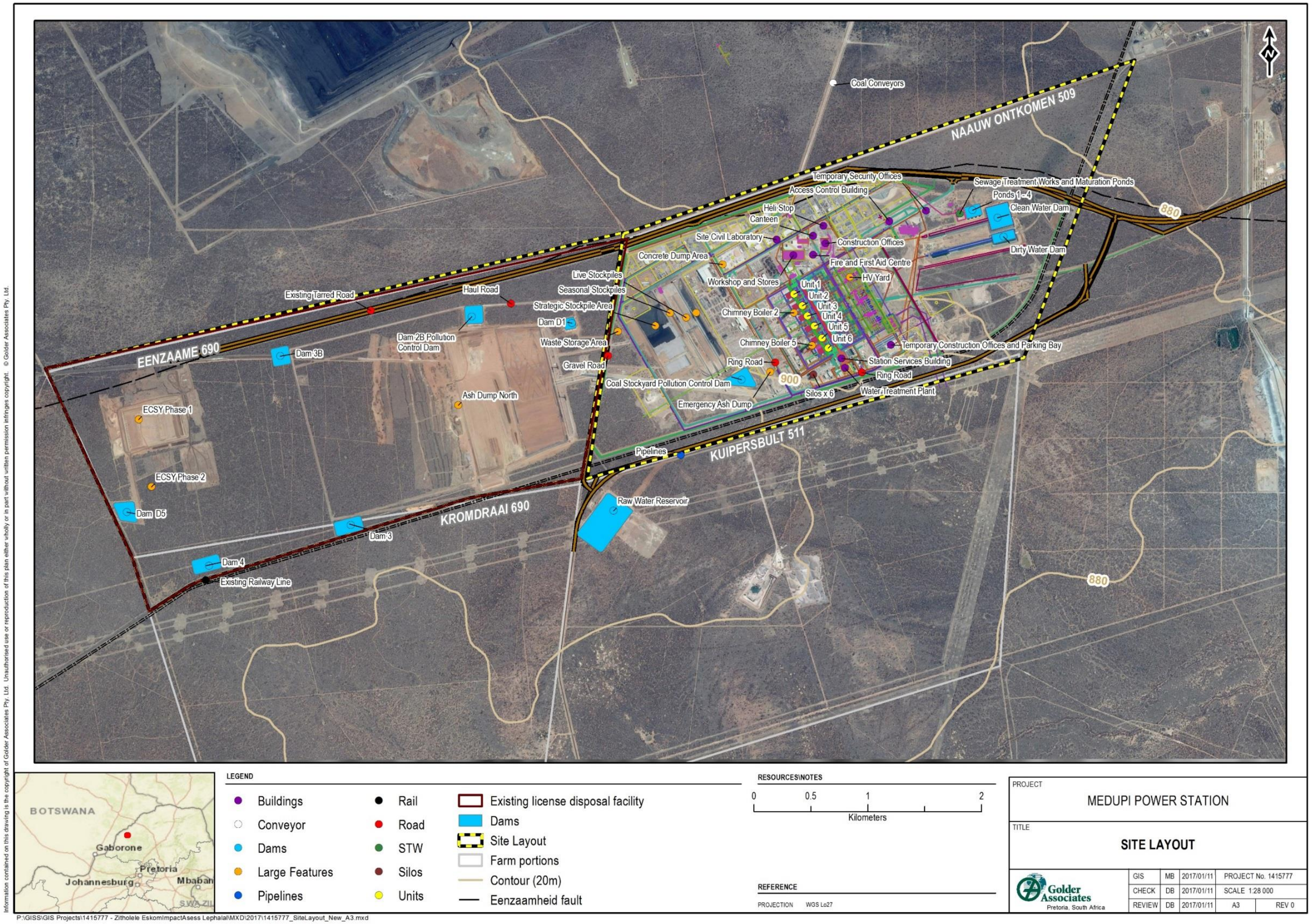

Figure 22: Medupi Site Outlay

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).

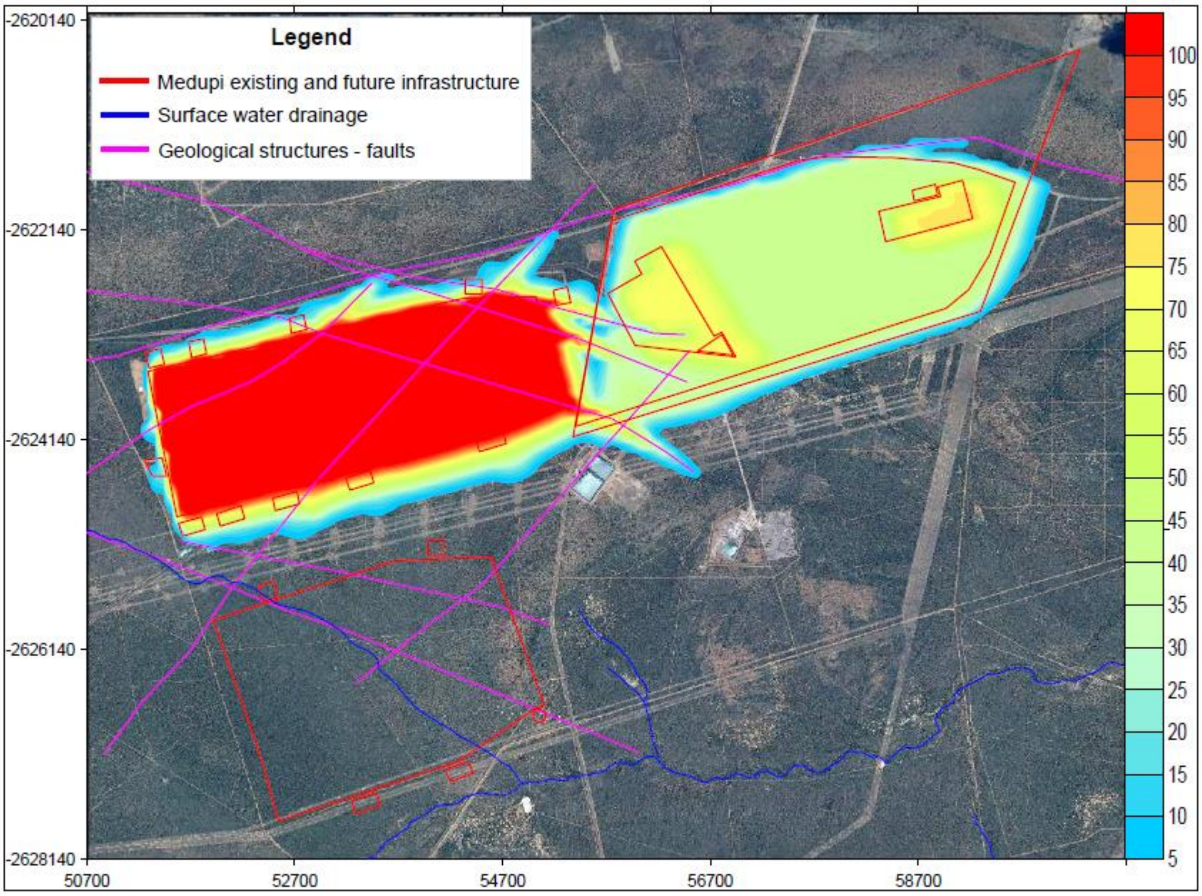

Figure 23: Model simulated pollution plumes for Scenario 1 at 50 years post closure (%) (Adapted from Groundwater Complete – 2017)

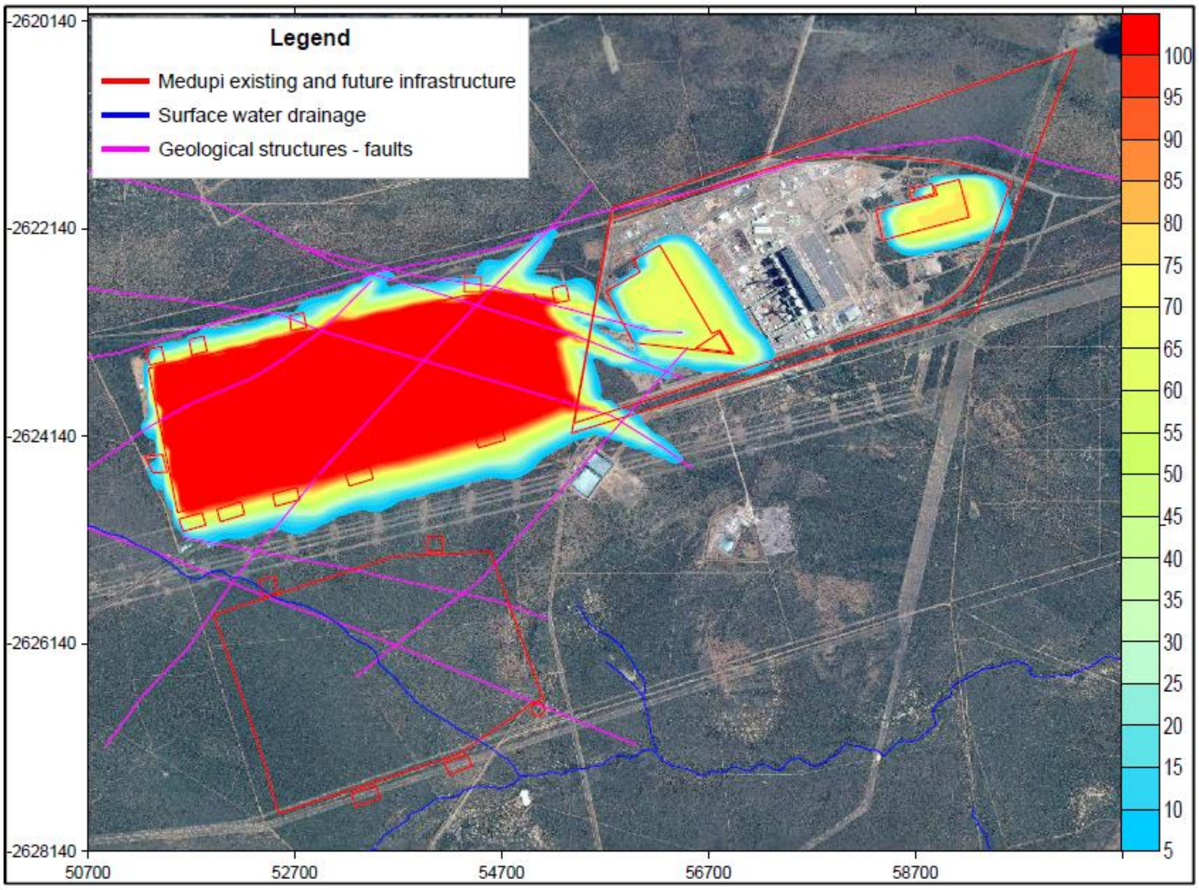

Figure 24: Model simulated pollution plumes for Scenario 2 at 50 years post closure (%) (Adapted from Groundwater Complete – 2017)

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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IGS 2008. Geohydrological Interpretation, Modelling and Impact Risk Assessment for Medupi Power Station. Report No: 2008/28/PDV.

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1: 500 000, Hydrogeological Map Series of RSA (1996).

Groundwater Complete 2017. Eskom Medupi Power Station. Report on Numerical Groundwater Modelling Results.

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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

WATERLAB

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

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ZITHOLELE CONSULTING (PTY) LTD

Surface Water Impact Assessment and Baseline Report for Medupi Power Station - FGD Project

REPORT

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Golder Associates

EXECUTIVE SUMMARY

Overview

Golder Associates Africa (Pty) Ltd was commissioned by Zitholele Consulting Services (Pty) Ltd (Zitholele) to prepare a surface water impact assessment for the Environmental Authorisation Process for the Medupi Power Station (Medupi) Flue Gas Desulphurisation (FGD) Retrofit Project for the following scope to support the Water Use Licence Application (WULA) required by the Department of Water and Sanitation (DWS):

1) Construction and operation of the FGD system within the Medupi Power Station Footprint (including the Zero Liquid Discharge Plant and temporary waste storage area);

2) Construction and operation of the railway yard and limestone and gypsum handling facilities between the Medupi Power Station plant and existing ADF; including two diesel storage facilities; and

3) Consideration of potential impacts from the disposal of ash and gypsum together on the existing ADF (that will necessitate a height change from 60m to 72m) for the amendment application of the existing Waste Management License.

The surface water impact assessment report will form one of the specialist investigations, and will be incorporated into the Integrated Environmental Assessment (EA1) and Water Use Licence Application for the proposed Medupi Power Station FGD retrofit project.

Methodology

The surface water impact assessment was carried out in three phases, namely:

- A desktop study to characterise the site, identify water sampling points and to conduct hydrological characterisation, catchment and water use description. The Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR) and Mean Annual Evaporation (MAE) were determined from available data. Storm rainfall depths were obtained from the closest rainfall station for the 1:2, 1:5, 1:10, 1:20, 1:50, 1:100 and 1:200 year recurrence intervals, using the Design Rainfall Estimation Programme (Smithers & Schulze, 2002);
- A site visit to assess the site characteristics and collect surface water quality samples (where possible). The proposed water quality sampling points were dry, therefore, no water quality data was collected;
- A floodline determination exercise was carried out for the non-perennial tributary of the Sandloop River which is located to the west of the existing ADF and drains in a south-easterly direction;
- Report compilation including the following;
  - Water quality baseline status benchmarked against the South African Water Quality Guidelines for Industry (Category 1 Industrial Processes);
  - Potential impacts identification, rating pre- and post-mitigation for a list of anticipated activities;
  - Recommendation of mitigation measures to minimise or reduce impacts on the surface water quality and quantity; and
  - Develop a water quality and quantity monitoring programme indicating monitoring points, frequency of monitoring, database management and reporting.

Existing Environment

Medupi Power Station is located about 15km west of the town Lephalale in Limpopo Province. The power station is situated on 883 hectares that historically operated as a game and livestock farm (Bohlweki, 2005) and it has a design lifespan of 50 years. Baseline hydrology can be summarised as follows:

- The study area is located within the Limpopo Water Management Area (WMA) and within quaternary catchment A42J;
- Based on South African Weather Services (SAWS) weather station number 0717595_W and the DWS's weather station A4E003, the MAP and MAE for the study area were determined to be 416.09mm and 2 572mm respectively;
- Non-perennial streams, mainly the Sandloop River, drain the study area. The general drainage of the area is in an easterly direction towards the Mokolo River. These non-perennial streams in the area were found to be seasonal and only likely to flow after rainfall events;
- The study area has gentle slopes of 0.5% to 5% in general with relatively steeper slopes to the south of the study area;
- A visual inspection of soils in carried out during the site visit in November 2016. The soils were found to be sandy and well drained; and
- The Medupi catchment is characterised by natural woodland and game and cattle farming.

Water Quality

In order to establish baseline water quality for the study area prior to the construction of the FGD and the expansion of the existing ADF, a water quality monitoring programme was established by Golder in 2015. Baseline water quality can be summarised as follows:

- Due to lack of flow, no water samples have been collected at the 5 monitoring points at this stage;
- Water quality data obtained from the Wetland Assessment (Natural Scientific Services, 2015) has been utilised for water quality analysis; but
- Golder has put forward a recommendation for continuous monthly water quality monitoring at the 5 proposed locations.
- Samples should be taken monthly or when water is present at the proposed locations. During the dry season, each monitoring site should be visited every two to three months to see if there is water that can be sampled; and
- The parameters to be analysed should include:
  - pH, Total Dissolved Solids, Electrical Conductivity, Alkalinity, Potassium, Calcium, Sodium, Chloride, Fluoride, Sulphate, Nitrate, Ammonium, Total Hardness, Metals: Arsenic, Beryllium, Cadmium, Barium, Chromium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Uranium, Vanadium and Zinc using ICP-MS), Orthophosphate, Total Suspended Solids, Oil and Grease

Water Management System

During the site visit conducted Golder, a water management system was identified. The water management system is aimed at mitigating the impact of the existing Medupi project on downstream water quality. However,

The existing water management system includes:

- A dirty water management system to ensure that polluted water the power station and its associated infrastructure, including the existing ADF, as well as sediment-laden runoff from disturbed areas is separated from clean area runoff and that it is collected in Pollution Control Dams (PCD); and
- A clean water management system to divert water undisturbed by the power station's operations around the disturbed project footprint.

Detailed storm water management design reports are available for the railway and ash dump. It is important that these are implemented to ensure adequate storm water control.

Water Balance

A numerical water balance model was developed for the existing operations at Medupi Power Station in order to assess the effectiveness of the power station water management system. However, a copy of this study has not been obtained at this stage and therefore no further reference can be made or conclusions drawn from it.

It is nonetheless recommended that a revision of this water balance study be carried out to include the FGD retrofit project as well as the proposed expansion of the existing ADF.

Flooding

The footprint of the proposed Ash Disposal Facility is 925.86 ha (9.26 km^2). The following summary can be made from the floodline study:

- The 1:100 year floodline encroaches on the ADF footprint;
- The south-western portion of the proposed ADF footprint, where a pollution control adam is located will be mostly affected by the 1 in 100 flood;
- The ADF project disturbance boundary is located within the Probable Maximum Flood (PMF); therefore
- To avoid flooding and contamination of the downstream environment through the transportation of pollutants from the ADF, the storm water management must be designed in such a way to mitigate pollution from the PCD to the river; and
- Water quality monitoring in the PCD located on the south west corner must be undertaken monthly or in accordance with the relevant water use authorisation, so that any potential impacts can be detected and mitigation planned.

Loss of Catchment Flows

- The existing Medupi site and ADF site have a combined area of approximately 1,874 ha (18. 7km^2) which equates to 1.03% of quaternary catchment A42J with a catchment area of 1,812km^2 (WRC, 2012);
- The Sandloop River tributary has an estimated catchment area of 4,467 ha (44.7km^2). The reduction in catchment area from the Medupi site and ADF site of approximately 1,874 ha (18.7km^2) equates to a 49.95% decrease in catchment area; and
- It is therefore anticipated that during the operational phase of the ADF, there will be a reduction in the total runoff reporting to the Sandloop River tributary, however limited reduction to the Mokolo system.

Mitigation and Management Measures

The following conclusions were drawn and recommendations made from the Medupi surface water impact assessment study:

- Natural on land surface water drainages are absent in the existing footprint of Medupi Power Station and will therefore not be impacted by the proposed Flue Gas Desulphurisation (FGD) Retrofit project.
- The 100-year floodline of the Sandloop River in the area of the ADF encroaches on the ADF footprint in the south western corner and this may have a detrimental effect in the event of a major flood event. Should the ADF operate within the 1:100 year floodline, the risk of pollutant transportation towards downstream water users during a flood event will be elevated. This will include flooding of the disposal facility and entrainment of waste materials and sediments downstream, making the management of the facility during significant storm events very difficult.

- If sound engineering flood control and prevention measures are not put in place, the contents of the ADF are likely to be washed away into the receiving environment in the event of a 1:100 flood. Statistically, the 1:100 year flood event refers to the mathematical probability of this flood magnitude occurring once over a 100-year period. However, in reality this flood magnitude may occur more than once in 100 years. With this in mind, the 20-year lifespan of the ash disposal facility should not be directly compared to the 1:100 flood event. ADF design and flood mitigation measures should be based on the 1:100 year flood event.

- Storm water that is generated within the Medupi Power Station, including the ADF, as a result of rainfall is a route by which pollutants may be mobilised and transported into the receiving downstream environment. The National Water Act (NWA) prohibits the discharge of any effluent (including contaminated storm water) into any water resources.

- To prevent possible pollution of the receiving surface water environment, dirty water containment structures should be designed, constructed, maintained and operated such that they do not spill over more than once in 50 years. A minimum freeboard of 0.8 m above full supply level (FSL) must also be maintained as per GN704 requirements (flow-based hydraulic sizing requirements). Water accumulated in the containment facility during the wet season should be used as a priority in the process water circuit to ensure that the capacity requirements are not compromised during periods of heavy and/or extended rainfall.

- It is recommended that an update to both the storm water management plan (SWMP) and the existing water balance be undertaken such that it caters for the proposed FGD and ADF infrastructure as well as be designed and operated in line with the DWS's GN704.

- During construction and times of major disturbances to land cover, it is recommended that sound engineering measures are put in place to protect the receiving surface water environment. It is also recommended that, where possible, construction and land cover disturbance is carried out during the dry season to avoid the washing away of materials by surface runoff (post-construction sediment and erosion control).

- If possible, it is recommended that a detention (dry) pond be constructed at or near the discharge point of the clean water drainage system before it enters the environment, or the clean water system be designed in such a manner to allow for longer residence times. This pond would be constructed for the purpose of flood control as well as storm water runoff treatment. This pond will function to settle suspended sediments and other solids typically present in storm water runoff. In the event of a major storm, the detention pond will slow down water flow and hold it for a short period of time before releasing it to the environment. Should the second option of designing the clean water system for a longer residence time be considered, then additional maintenance for periodic removal of collected sediment would be required.

- It is strongly recommended that the proposed water quality monitoring programme be strictly followed and sustained so that chemical constituent levels can be monitored and analysed over time. Pollution of surrounding surface water features should be avoided at all costs during the lifespan of the Medupi Power Station project. In the unfortunate occurrence of surface water resources pollution, swift and effective corrective measures should be implemented and the relevant authorities notified without delay.

- With respect to the transportation of sludge and salts from Medupi to a hazardous waste disposal site, it is recommended that a route selection study be carried out to determine the least potential water surface impacts, considering other factors such as the traffic impact assessment. From a surface water perspective, a route via a national road (highway) would be most appropriate as the likelihood of accidents and spillages due to poor road conditions will be minimised.

The impact assessment showed that most impacts were low after mitigation. If the impacts are properly mitigated and Best Management Practices followed at all times, the identified potential impacts can be reduced to negligible.

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General layout of the existing ADF and storm water management philosophy

1.0 INTRODUCTION

Golder associates Africa (Pty) Ltd (Golder) was appointed by Zitholele Consulting Services (Pty) Ltd (Zitholele) to assess the potential surface water impacts at Medupi Power Station (Medupi) in relation to the following scope:

1) 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;
2) Construction and operation of a 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;
3) The construction and operation of the wet FGD system that will reduce the SO_2 content in the flue gas emitted;
4) 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 storm water infrastructure and conservancy tanks for sewage;
5) 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 Waste Management License (WML) amendment application.
6) Pipeline for the transportation of wastewater from the gypsum dewatering plant and its treatment at the WWTP (Zero Liquid Discharge (ZLD) plant) that will be located close to the FGD infrastructure within the Medupi Power Station;
7) Construction and operation of the ZLD plant;
8) 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.
9) 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.
10) 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.

Medupi currently has a Water Use Licence (WUL) for its existing industrial footprint, including the existing ADF which will be constructed in three phases. Currently the power station is ashing on the four years ashing cell. This study focuses on the environmental authorisation process and Water Use Licence Application (WULA) for the Medupi Power Station Flue Gas Desulphurisation (FGD) as well as the proposed expansion of the existing ADF from 4 years to 20 years operational lifespan. The existing Medupi Power Station has been designed and constructed to be FGD retrofit ready, therefore the potential surface water impacts of the FGD process will occur on an already impacted footprint.

1.1 Project Description

Medupi Power Station (Medupi) is a coal-fired power station that forms part of the Eskom New Build Programme. This project focuses on the environmental authorisation process for the Medupi Power Station Flue Gas Desulphurisation (FGD) Retrofit. As part of the Environmental Impact Assessment (EIA) and Water Use Licence Application (WULA), it is required that a Surface Water Impact Assessment (SWIA) be conducted. This report provides the surface water impact assessment as well as baseline water quality and quantity for the existing licensed ADF and Medupi Power Station footprint in general. This surface water report that will form part of supporting documentation for the Environmental Impact Assessment (EIA), is based on desktop studies of available literature and aerial imagery.

From initial site investigations, it would seem that the key watercourse for floodline delineation and impact assessment would be the Sandloop River which generally drains the entire existing Medupi Power Station footprint.

The surface water impacts that could arise through transportation of sludge and salts from the Medupi Power Station to an appropriately licensed existing hazardous waste disposal facility is also a subject of discussion in this report. A qualitative specialist opinion is given in this regard.

1.2 Scope of Work

The detailed scope of work for the surface water impact assessment component included:

- Undertake any further site investigations/modelling as necessary;
- Identify watercourses within 500 m of the power station footprint and disposal facility footprint for flood line delineation and assessment;
- Assess the potential surface water impacts generated by the construction, operation, and decommissioning of the existing waste disposal facility for ash and gypsum disposal;
- Provide a specialist opinion on the significance of the surface water impacts for the proposed trucking of sludge and salts to an existing licensed Hazardous Waste Disposal Facility, outside of the Medupi Power Station study area;
- Attend one specialist integration meeting in Midrand, Waterfall City, to discuss the ratings and integrate the assessments for purposes of the EIA;
- Compile an Impact Assessment Report, with one round of review from Zitholele and Eskom;
- Attend the EIA Phase public meeting in Lephalale, Limpopo Province;
- The following tasks will be carried out in order to achieve the scope of work:
  - Compile a map showing the catchment areas, site infrastructure and the major surface water drainage lines;
  - Collect the available daily rainfall data from client records, South African Weather Services (SAWS) or Department of Water and Sanitation (DWS) and check for integrity. The rainfall data will be patched to produce a daily rainfall record for use in surface water modelling;
  - Rainfall statistics such as monthly averages, number of rain days per month, distribution of annual totals and the 2, 5, 10, 20, 50, 100 and 200 year recurrence interval 24 hour storm depths will be determined;
  - Collect and review the available climate data to produce monthly potential evaporation and temperature statistics based on regional and local climatic data;
  - Conduct a two day site visit entailing site familiarization and measurement of all river crossings including bridges, culverts, pedestrian pathways, railway crossings, pipelines, etc.;
  - Map and describe the surface water resources in the study area;
  - Propose and implement a water quality programme for the drainages that could be impacted on by the existing operations and proposed sites at Medupi;

- Calculate the 1:50 and 1:100 year peak using the Rational Method and also determine the 1:50 and 1:100 year floodline based on the current development levels and taking into account all current infrastructure using HEC-RAS,
- Use the IA Rating System as provided by Zitholele Consulting to quantify the surface water impact; and
- Compile an Impact Assessment Report which identifies potential impacts on surface water and provides significance ratings for the impacts, as well as proposed mitigation actions.

1.3 Study Area

Medupi Power Station is situated in the Matlabas catchment which is a predominantly flat area of the Limpopo Water Management Area (WMA). Medupi is approximately 19 km west of the town of Lephalale and approximately 42 km south of the Limpopo River. The catchment is still largely undeveloped with limited water resources and water uses. The Medupi site is situated in the Steenbokpan area which lies in the A42J quaternary catchment. The sites investigated are located west of Medupi Power Station. Figure 1 shows the study area in relation to the surface water resources.

This study area is located to the south of the Lephalale coalfield and numerous mining developments are foreseen, predominantly to the north of the Eenzaamheid Fault line. The area is a semi-arid region which has economic activity centred on livestock farming, irrigation and industrial development including coal mining and power generation. The Matlabas catchment is a dry catchment with non-perennial flow and therefore limited sustainable yield from surface water (Department of Water Affairs, 2013). Figure 1 shows the locality map along with the climate stations in the area.

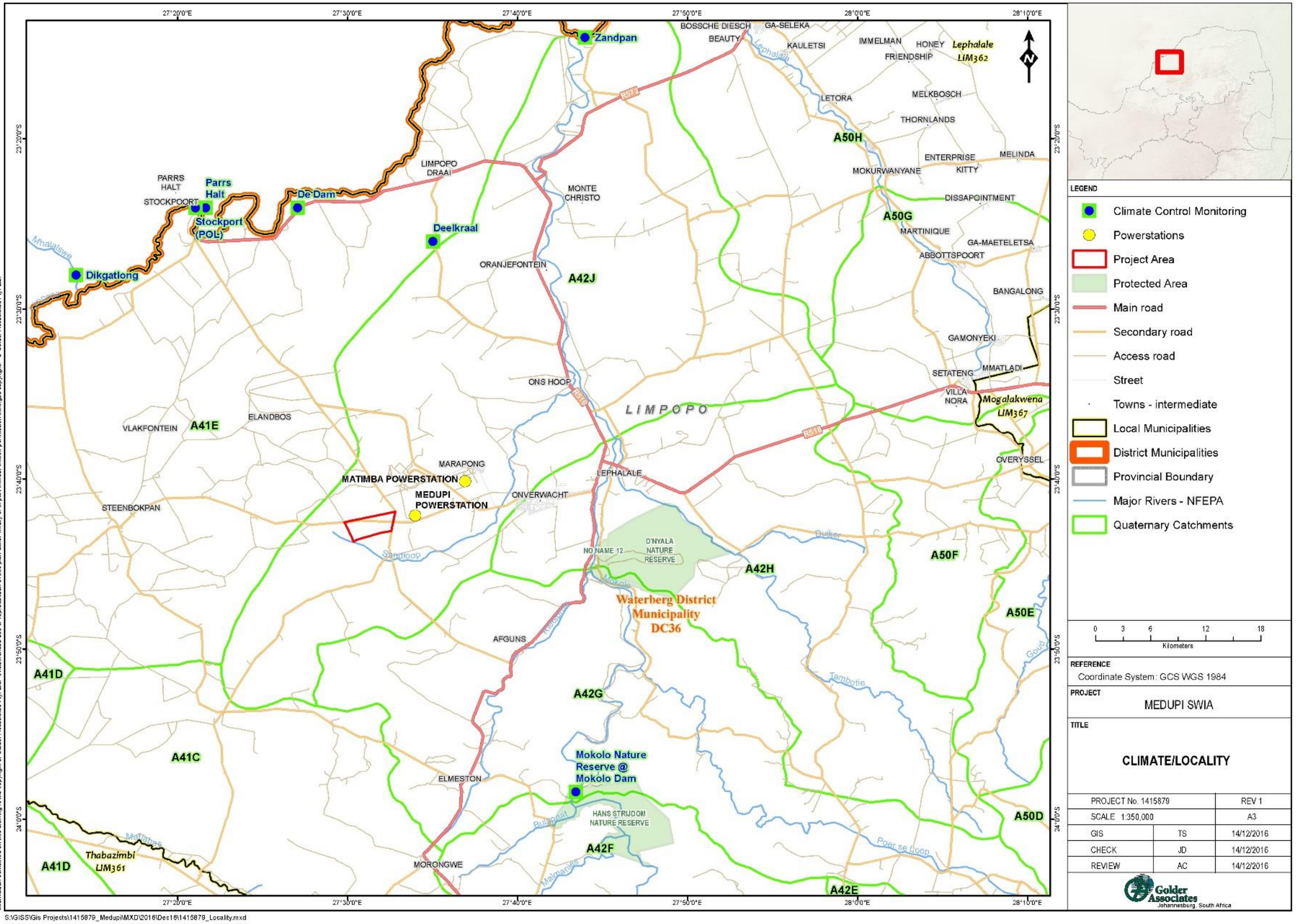

Figure 1: Locality and climate map for the Medupi area

1.4 Project Team

The Golder surface water team comprised of the following members:

Table 1: Surface water project team

Name	Project role	Qualifications	Years of experience
Lee Boyd	Project manager / Water Resource Scientist	MSc, SFWISA (Pr. Sci. Nat)	25 years
Zinhle Sithole	Junior Hydrologist	BSc (Hons) Hydrology	3 years
Johan Jordaan	Project Reviewer	BEng (Civil Engineering) (Pr. Eng.)	20 years
Trevor Coleman	Technical Advisor / Senior Water Resources Engineer	MSc Engineering (Pr. Eng.)	35 years

1.5 Related Studies

The studies which are to be read in conjunction with this assessment include the following:

- Zitholele Technical Memorandum: Medupi PS FGD Retrofit Project, Project scope and description – December 2017;
- Integrated Environmental Authorisation Process for the Medupi Power Station Flue Gas desulphurisation (FGD) Retrofit Project, Final Scoping Report (Zitholele, 2015);
- A Wetland Assessment for the Ash Disposal Facility at Medupi Power Station – Lephalale, Limpopo (Natural Scientific Services, 2016);
- Knight Piésold, Conceptual Design of Stormwater Management, Sewage Infrastructure and Access Roads between Boiler Edge Slab and Road No.3 (Ring Road West) and Design of the New Gypsum Offtake Infrastructure Slab, associated Drainage, and Access Roads, October 2017.

1.6 Report Structure

This report comprises ten sections:

- Section 1 is the introduction and background to the project;
- Section 2 provides an overview of the regulatory framework related to the project;
- Section 3 describes the existing environment with respect to surface water resources;
- Section 4 outlines the existing surface water management system at Medupi Power Station;
- Sections 5 provides a high level overview of the existing site water balance;
- Section 6 presents the floodline determination study for the Sandloop River tributary;
- Section 7 describes the potential impacts of the FGD retrofit project and ADF on surface water resources;
- Section 8 provides a specialist opinion on the transportation of sludge and salts from Medupi to an off-site licensed hazardous waste disposal facility;
- Section 9 outlines the proposed mitigation and management measures of the project; and
- Section 10 presents a summary of the conclusions and recommendations of the surface water impact assessment.

2.0 REGULATORY FRAMEWORK

2.1 Regulatory Documents

This part of the document is intended to detail environmental legislation that may have bearing on the existing Medupi Power Station project as well as the proposed expansion of the Ash Disposal Facility. The following national legislation, plans, policies and regulations are relevant to this project in terms of surface water management.

2.1.1 Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996)

The Constitution of the Republic of South Africa, 1996 (hereafter referred to as "the Constitution") is the Supreme Law in South Africa. The Bill of Rights is included in Chapter 2 of the Constitution. The Environmental Right as set out in Section 24 of the Constitution and states that – Everyone has the right –

- to an environment that is not harmful to their health or well-being; and
- To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –

i) Prevent pollution and ecological degradation;

ii) Promote conservation; and

iii) Secure ecologically sustainable development and use of natural resources, while

iv) Promoting justifiable economic and social development.

The National Environmental Management Act, 1998 (Act No. 107 of 1998) is the primary statute which gives effect to Section 24 of the Constitution. The Environmental Right contained in Section 24 of the Constitution also places responsibility on the Environmental Assessment Practitioner (EAP), the Applicant and the Competent Authority to ensure that this right is not infringed upon. The Sector Guidelines for Environmental Impact Assessment (2010) (Government Notice 654) describes a number of responsibilities which are placed on the EAP, Applicant and Competent Authority to ensure conformance with the statutory Environmental Right.

2.1.2 National Water Act, 1998 (Act No. 36 of 1996)

The specialist surface water assessment complies with South African legislation for environmental authorisations, most specifically the National Water Act (NWA), 1998 (Act No. 36 of 1998). The activities associated with the proposed Medupi Power Station FGD retrofit project and Ash Disposal Facility trigger some of the Water Uses that are defined in Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (NWA). Accordingly these Water Uses may not be undertaken without being granted a Water Use License from the DWS. In accordance with Sections 40 and 41 of the NWA (1998), a Water Use License Application Process will be carried out. The resultant documents from the WULA process will include completed WULA Forms as well as a Technical Report. These documents will be submitted to DWS for review and decision making. Although a joint PPP is followed for the WULA within the EIA Phase, these two EA processes constitute separate applications and submissions are made to the respective Competent Authorities.

2.1.3 National Environmental Management Act, 1998 (Act No. 107 of 1998)

The Environmental Management can be defined as the management of human interaction with the environment. Fuggle and Rabie (Strydom & King; 2009) defines Environmental Management as the regulation of the effects of peoples' activities, products and services on the environment. Although South Africa has a comprehensive array of environmental legislation and policies in place, these must be aligned with the provisions of the NEMA (1998), in particular the National Environmental Management Principles stipulated in Chapter 1 of the NEMA (1998). The Environmental Management Principles are centred around providing explicit guidance for co-operative and environmental governance on all matters relating to decision-making which will affect the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of state, and to provide for matters connected therewith.

2.2 Water Use Licence

The National Water Act (Act 36 of 1998) (NWA) identifies 11 consumptive and non-consumptive water uses which must be authorised under a tiered authorisation system. This authorisation system includes scheduled uses, general authorisations and water use licences. It allows for the "Reserve[1]" and provides for public consultation processes in the establishment of strategies and decision-making and guarantees the right to appeal against such decisions.

Sections 40 and 42 of the NWA provides for the responsible authority to request an assessment of the likely effect of the proposed license on the resource quality, and that such assessment is subject to the EIA regulations as promulgated under Section 26 of the Environmental Conservation Act, 1989 (Act 73 of 1989) (ECA).

In terms of Section 21 of the NWA which relates to the consumption of water, as well as activities which may affect water quality and the condition of the resource itself, the following water uses need to be authorised:

- Section 21(a) –Taking water from a water resource;
- Section 21(b) –Storing water;
- Section 21(c) – Impeding or diverting the flow of water in a watercourse;
- Section 21(d) – Engaging in a stream flow reduction activity;
- Section 21(e) – Engaging in a controlled activity;
- Section 21(f) – Discharging waste or water containing waste into a water resource through a pipe, canal, sewer or other conduit;
- Section 21(g) –Disposing of waste in a manner which may detrimentally impact on a water resource;
- Section 21(h) – Disposing in any manner of water which contains waste from, or which has been heated in any industrial or power generation process;
- Section 21(i) – Altering the bed, banks, course or characteristics of a watercourse;
- Section 21(j) – Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
- Section 21(k) – Using water for recreational purposes.

Medupi has an existing IWUL. The water uses related to this project will be identified and an application made to the DWS. The surface impact assessment will also consider these aspects.

2.3 Water Resources Classification

The classification of significant water resources in the Crocodile (West), Marico, Matlabas and Mokolo catchments in accordance with the Water Resource Classification System (WRCS) was undertaken in 2011/ 2012 and finalised in 2013 (Department of Water Affairs, 2013). Classification of water resources aims to ensure that a balance is reached between the need to protect and sustain water resources on the one hand and the need to develop and use them on the other. The WRCS places the following principles at the forefront of implementation:

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[1] ``Reserve'' means the quantity and quality of water required -

(a) to satisfy basic human needs

(b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource;

- Maximising economic returns from the use of water resources;
- Allocating and benefits of utilising the water resources fairly; and
- Promoting the sustainable use of water resources to meet social and economic goals without detrimentally impacting on the ecological integrity of the water resource.

Each quaternary catchment is classified as a Class I, II or III, defined as:

- Class I - Minimally used: Water resource is one which is minimally used and the overall condition of that water resource is minimally altered from its pre-development condition;
- Class II - Moderately used: Water resource is one which is moderately used and the overall condition of that water resource is moderately altered from its pre-development condition; and
- Class III - Heavily used: Water resource is one which is heavily used and the overall condition of that water resource is significantly altered from its pre-development condition.

The recommended Class for quaternary catchment A42J is a Class II (Department of Water Affairs, 2013). In this respect mitigation implemented must be such that it will protect the water resources so that an ecological category of B/C is maintained. Ecological category refers to the assigned ecological condition by the Minster to a water resource that reflects the ecological condition of that water resource in terms of the deviation of its biophysical components from a pre-development condition. These ecological categories are in the order of A, B, C, and D with intermediate A/B, B/C, and C/D, where A is a well maintained ecological system and D is a poorly maintained system.

2.4 Best Management Practices

The Department of Water and Sanitation's (DWS) Best Practice guidelines (Department of Water Affairs and Forestry, 2006) and GN 704 of the National Water Act (National Water Act, 1999) will be used as a guiding principle. This section is extracted from the DWS's Guideline Document for the Implementation of Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources, Operation Guideline No. M6.1 of May 2000, Second Edition.

The Minister of Water and Sanitation (then known as Department of Water Affairs and Forestry, DWAF) promulgated regulations in respect of use of water for mining and related activities aimed at the protection of water resources on June 1999. These regulations are aimed at both at the mining industry (including industries with related activities, as defined) and the DWS who has to enforce the regulations. The final regulations were published in Government Notice No. 704 on 4 June 1999 (*Government Gazette* No. 20119) and approved by the National Assembly on 14 October 1999. The Minister of Water and Sanitation is responsible for the protection, conservation, management and control of water resources of South Africa on a sustainable basis. The requirements prescribed in terms of the regulations must be seen as minimum requirements to fulfil this goal.

During the development of the regulations a decision was made that industrial activities will not be included in the definition of "activity". However the differentiation between a mining and an industrial activity is not always that clear. When any doubt exists whether a specific activity directly or indirectly related to mining should comply with GN704 or not, the issue should be evaluated on a site-specific basis and a decision made on that basis. An example of the above differentiation is made below:

Eskom: Coal-fired power stations

The phrase "…whether situated at the mine or not…" allows for the following sections of the definition to be applicable to power station activities:

- Mineral storage yards, transport facilities and loading zones; and
- Storing, stockpiling, accumulating, dumping, disposing or transportation of residue.

A decision was made by DWS that coal-fired power stations are not included in the definition of “activity” as coal-fired power stations are regarded an industrial activity, and not a mining activity. Coal-fired power stations and its directly related activities are therefore excluded from these regulations. It is however important to note that, should a power station, for instance, make use of the workings of any underground or opencast mine excavation for the disposal of any residue defined in the regulations, the specific activity is considered a *related activity* and is thus not exempted from these regulations.

However, whenever making this differentiation between mining and industrial activities, the following must be kept in mind and the industrial activities excluded from the definition of “activity” must be advised accordingly:

- DWS is in the process of developing similar regulations on the use of water for industrial activities. These regulations will address the same concerns as that of GN704, and will most likely have similar requirements. It is therefore proposed that the industrial activities, especially new activities, address and manage their water-related issues according to these regulations;
- Section 19 of the National Water Act stipulates that all reasonable steps must be taken to prevent pollution from occurring, continuing or recurring from any activity or process which causes, has caused, or is likely to cause pollution of a water resource. The industrial activities excluded from the definition of “activity” are therefore not exempted from preventing or rectifying any pollution caused by their activities.

Stormwater Management Plan (SWMP)

The SWMP described in this section is developed to meet the requirements of GN704 of the National Water Act by;

- Diverting all clean water and, prevent any further runoff from entering mining or industrial areas;
- Directing any unpolluted water to a clean water system away from possible contamination;
- Design, construct, maintain and operate any clean water system at the mine or related activity so that it is not likely to spill into any dirty water system more than once in 50 years;
- Collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system.
- Design, construct, maintain and operate any dirty water system at the mine or related activity so that it is not likely to spill into any clean water system more than once in 50 years; and
- Design, construct, maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level.

One of the most important best management practice principles relating to water management is the separation of unpolluted (clean) and polluted (dirty) water and in order to achieve this effectively, the person in control of a mining or related activity should develop and implement a storm water management plan for their premises. GN704 was published to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. There are important definitions in the regulation, which require understanding, and these are discussed below.

- **Clean water system:** This includes any dam, other form of impoundment, canal, works pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted water.
- **Dam:** This includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. polluted water).
- **Dirty area:** This refers to any area at a mine which causes, has caused or is likely to cause pollution of a water resource (i.e. polluted water).

- **Dirty water system:** This includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste.

The four main principle conditions of GN704 applicable to the Medupi Power Station project are:

- *Condition 4* which defines the area in which mine workings or associated structures may be located with reference to a watercourse and associated flooding. The 50 year floodline and 100 year floodline are used for defining suitable locations for mine workings and associated structures respectively. Where the floodline is less than 100 meters away from the watercourse, then a minimum watercourse buffer distance of 100 meters is required for both the workings and associated structures.
- *Condition 5* which indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure.
- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these systems do not spill over into each other more than once in 50 years.
- *Condition 7* which describes the measures that must be taken to protect water resources. All dirty water or substances which cause or are likely to cause pollution of a water resource either through natural flow or by seepage are to be mitigated.

3.0 EXISTING SURFACE WATER ENVIRONMENT

3.1 Regional Drainage Network

As shown in Figure 1, the study area is located within the A42J Quaternary catchment to the south of the Lephalale coalfield where numerous mining developments are foreseen predominantly to the north of the Eenzaamheid Fault line. There are no perennial streams originating within the area itself. The closest perennial river is the Mokolo into which the non-perennial Sandloop River drains. The Mokolo flows through A42J to the Limpopo River.

Medupi is situated in the Mokolo catchment, with the non-perennial Sandloop River flowing around the site in an easterly to north easterly direction to confluence with the Mokolo River approximately 16 kilometres downstream of the town of Lephalale.

This is a predominantly flat area of the Limpopo Water Management Area (WMA). Medupi is approximately 19 km west of the town of Lephalale and the Mokolo River and approximately 42 km south of the Limpopo River. Except for those areas where mining and power generation has commenced the catchment is still largely natural with limited cultivated areas. The water resources are also limited. Game farming is a common land use in the area. The town of Lephalale has seen considerable growth in the past decade.

3.1.1 Water Resource Classification and Resource Quality Objectives

The classification of significant water resources in the Crocodile (West), Marico, Matlabas and Mokolo catchments in accordance with the Water Resource Classification System (WRCS) was undertaken in 2011/ 2012 and finalised in 2013 (Department of Water Affairs, 2013). Classification of water resources aims to ensure that a balance is reached between the need to protect and sustain water resources on the one hand and the need to develop and use them on the other. The WRCS places the following principles at the forefront of implementation:

- Maximising economic returns from the use of water resources;
- Allocating and benefits of utilising the water resources fairly; and
- Promoting the sustainable use of water resources to meet social and economic goals without detrimentally impacting on the ecological integrity of the water resource.

Each quaternary catchment is classified as a Class I, II or III, defined as:

- Class I - Minimally used: Water resource is one which is minimally used and the overall condition of that water resource is minimally altered from its pre-development condition;
- Class II - Moderately used: Water resource is one which is moderately used and the overall condition of that water resource is moderately altered from its pre-development condition; and
- Class III - Heavily used: Water resource is one which is heavily used and the overall condition of that water resource is significantly altered from its pre-development condition.

The recommended Class for quaternary catchment A42J is a Class II (Department of Water Affairs, 2013). In this respect mitigation implemented must be such that it will protect the water resources so that an ecological category of B/C is maintained. Ecological category refers to the assigned ecological condition by the Minster to a water resource that reflects the ecological condition of that water resource in terms of the deviation of its biophysical components from a pre-development condition. These ecological categories are in the order of A, B, C, and D with intermediate A/B, B/C, and C/D, where A is a well maintained ecological system and D is a poorly maintained system.

The determination of Resource Quality Objectives (RQO) for the area was undertaken in 2016/ 2017 and will be gazetted during the first quarter of 2018 (DWS, 2017, Report number: DM/WMA01/00/CON/RQO/0516). The proposed RQOs and numerical limits are set out in Table 2.

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Table 2: RQOs and numerical limits for quaternary catchment A42J

Component	Sub-component	RQO	Indicator	Numerical Limit	Context/Rationale for RQO/numerical limit
Quality	Nutrients	Instream concentration of nutrients must be maintained to sustain aquatic ecosystem health and ensure the prescribed ecological category is met.	Orthophosphate (PO_4^-) as Phosphorus	≤ 0.05 milligrams/litre (mg/l) (50^{th} percentile)	Present ecological state maintained. Require baseline data.
			Nitrate (NO_3^-) & Nitrite (NO_2^-) as Nitrogen	≤ 0.1 milligrams/litre (50^{th} percentile	Present ecological state maintained. Require baseline data.
	Salts	Instream concentration of salinity must be maintained to protect present ecological state and the aquatic ecosystem health.	Electrical Conductivity	≤ 55 milliSiemens/metre (mS/m)(95^{th} percentile)	Maintain present water quality.
	System Variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5^{th} percentile) and 8.5 (95^{th} percentile)	Aquatic ecosystem as the driver. Present ate
		A baseline assessment to determine the present state instream turbidity is required. Limits must be defined to control the impacts of slate mining on the resource.	Turbidity	A 10% variation from background concentration is allowed. Limits must be determined.	No baseline data available. Monitoring required to determine present state.
	Toxics	The concentrations of toxicants must pose no risk to aquatic organisms and to human health.	Atrazine	≤0.078 milligrams/litre (mg/l)	Human health is the driver. Aquatic ecosystem is the driver. Ecological specification. Ecological Reserve manual (2008). No monitoring data.
			Imidacloprid	≤ 0.000038 milligrams/litre (mg/l)	Human health considerations. Environment Protection Authority of New Zealand – Environmental Exposure Limit
			Aluminium (Al)	≤ 0.062 milligrams/litre (mg/l)(95th percentile)	Strictest of Ecological specifications for all metals except manganese. Manganese – domestic
			Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
			Iron (Fe)	≤ 0.1 milligrams/litre (mg/l)	

				(95th percentile)	user requirements. Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
			Lead (Pb) hard	≤ 0.0057 milligrams/litre (mg/l) (95th percentile)	
			Copper (Cu) hard	≤ 0.0048 milligrams/litre (mg/l) (95th percentile)	
			Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	
			Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
			Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	
Habitat	Instream	Habitat diversity should be maintained in a B ecological category.	Index of Habitat Integrity, Rapid Habitat Assessment Method and Model (RHAMM)	Instream Habitat Integrity EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state.
	Riparian habitat	Riparian vegetation should be maintained within B ecological category.	Index of Habitat Integrity, Vegetation Response Assessment Index	VEGRAI EC = B ≥ 82%	Maintenance of ecological integrity. Present ecological state

3.2 Local Network Drainage Medupi Power Station

Medupi Power Station is situated in the Limpopo Plain climate zone (Kleynhans et al. 2005). This climate zone is characterized by plains and lowlands, with low to moderate relief. The vegetation consists mostly of Bushveld and Mopane Veld.

The study area is situated in the Steenbokpan area which lies in the A42J quaternary catchment. The ADF site is located to the west of Medupi Power Station. The general layout of the site in which the proposed activities will take place is shown in the google image in Figure 2 in relation to the Sandloop River.

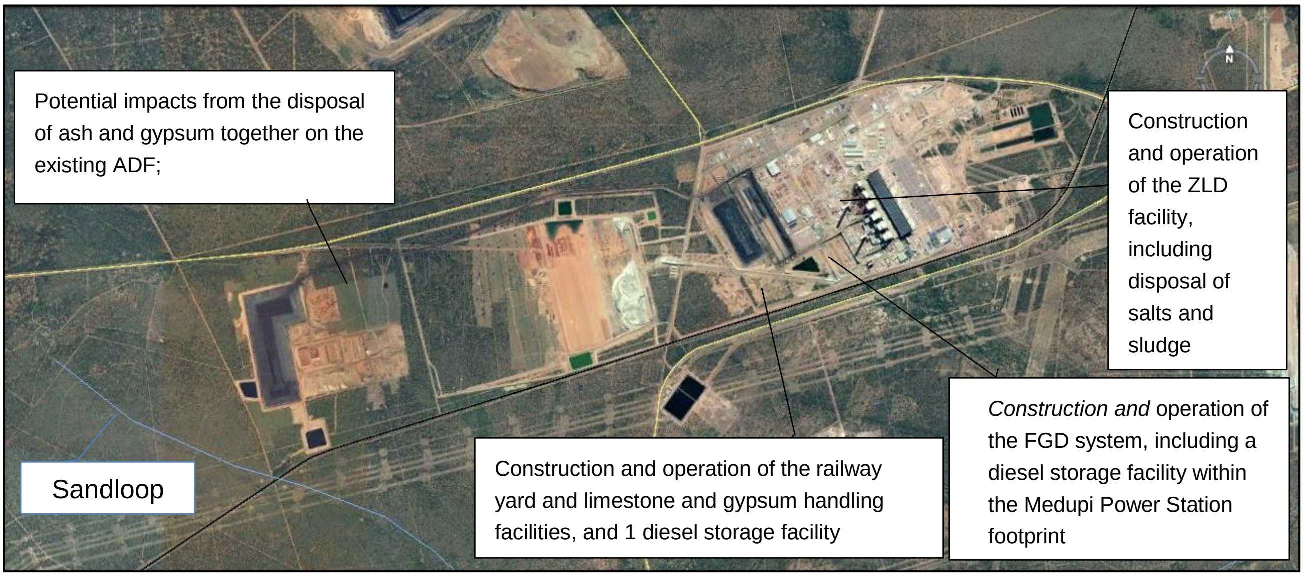


Figure 2: Area in which activities are to be undertaken

The tributary of the Sandloop River drains from the northwest to the southeast of the existing ADF footprint. The possible impacts to surface water would therefore be the potential reduction in catchment runoff and impacts from contaminants from the ADF and associated pollution control dams. The Sandloop River drains close to licensed disposal facility, and it is for this reason that a floodline delineation exercise was required to determine the effect of the 1:100 year flood on the ADF.

3.3 Rainfall and Evaporation

3.3.1 Rainfall

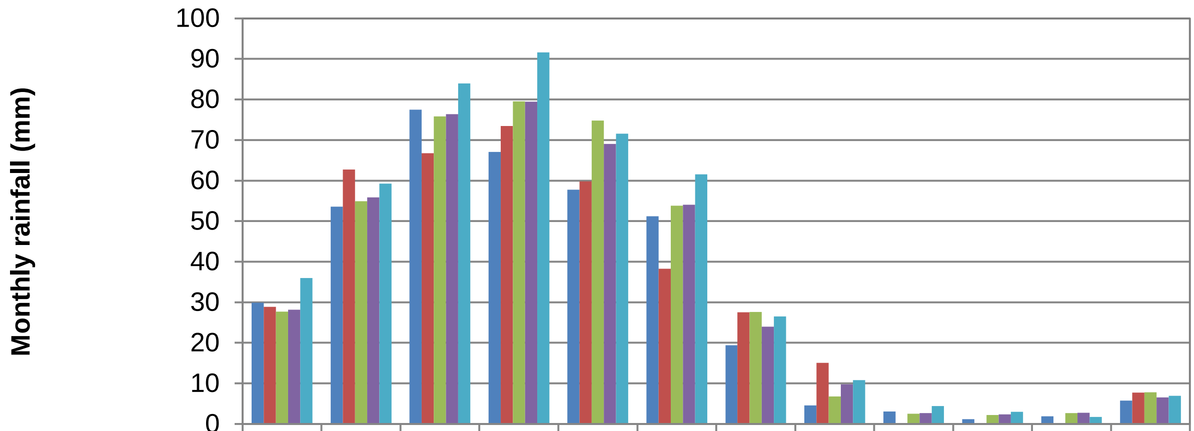
Rainfall data in the area around Medupi Power Station was sourced from the Daily Rainfall extraction utility (Kunz, 2004). The rainfall stations are presented in Table 3 and can be seen in Figure 1.

Table 3: Rainfall Stations in the Lephalale Area around the Medupi Power Station

Station	Name	Altitude (masl)	From	To	No. of Years	Distance to Medupi (km)	MAP (mm)
0717834_W	De Dam	825	1903	2000	97 (73.1% patched)	35.416	372.65
0717624_P	Parrs Halt	824	1903	2000	97 (61.9% patched)	39.994	380.63
0717595_W	Stockport (POL)	824	1903	2000	97 (35.4% patched)	39.441	416.09
0718147_W	Deelkraal	865	1908	2000	93 (86.9% patched)	29.791	410.82
0717418_P	Dikgatlong	834	1903	2000	97 (63%	42.811	457.30

					patched)		

Figure 3 shows the monthly rainfall distribution for the five rainfall stations in the Lephalale area over a period of approximately 100 years. It can be seen that the monthly rainfall is fairly uniform. The South African Weather Services (SAWS) station Stockport (POL) number 0717595_W was chosen as the station used in the study due to it being the average among the stations available and is the most reliable in terms of the number of years of observed data. Figure 4 shows the cumulative plots for the five rainfall stations. This is done to check if there are any anomalies in the recorded data and compare the data record lengths of each station.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
De Dam	29.91	53.53	77.52	67.08	57.73	51.21	19.37	4.52	3.06	1.14	1.85	5.72
Parrs Halt	28.90	62.73	66.79	73.47	59.79	38.28	27.53	15.05	0.08	0.22	0.06	7.74
Stockport (POL)	27.67	54.88	75.84	79.52	74.77	53.80	27.64	6.77	2.50	2.21	2.69	7.82
Deelkraal	28.15	55.82	76.38	79.42	69.05	54.02	24.01	9.74	2.64	2.32	2.76	6.51
Dikgatlong	36.00	59.24	83.96	91.60	71.56	61.57	26.52	10.79	4.40	3.01	1.69	6.96

Figure 3: Monthly rainfall distribution for rainfall stations in the Lephalale area

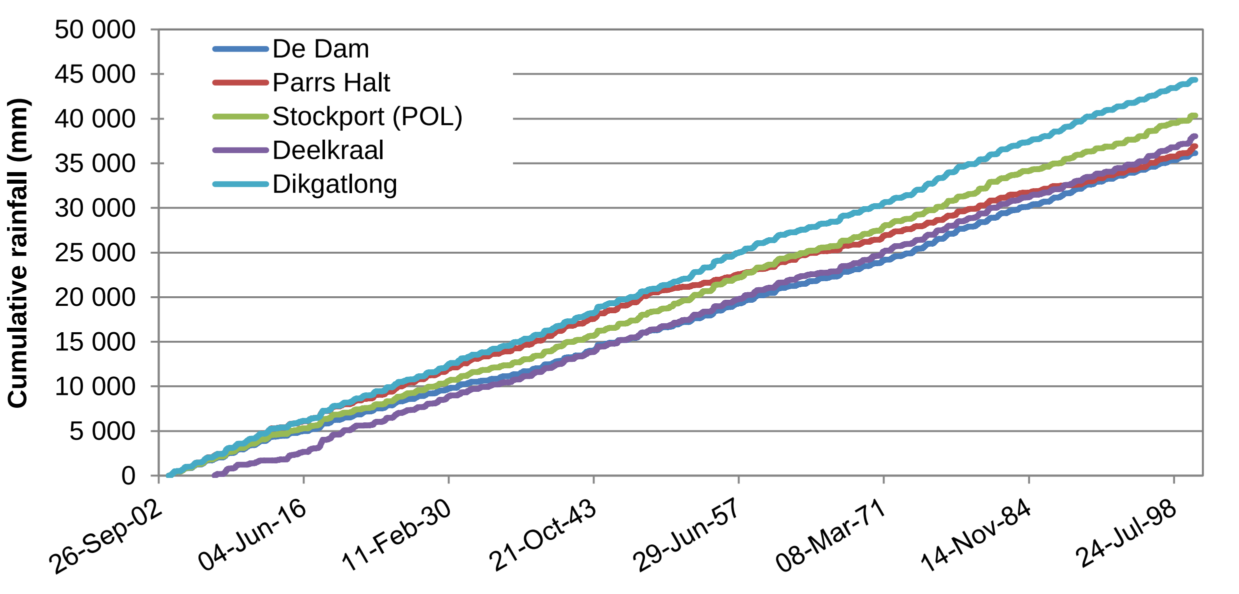


Figure 4: Cumulative rainfall for rainfall stations in the Lephalale area

Figure 5, Figure 6 and Figure 7 show the daily rainfall, monthly boxplot and the annual rainfall for the Stockport (POL) Rainfall Station respectively.

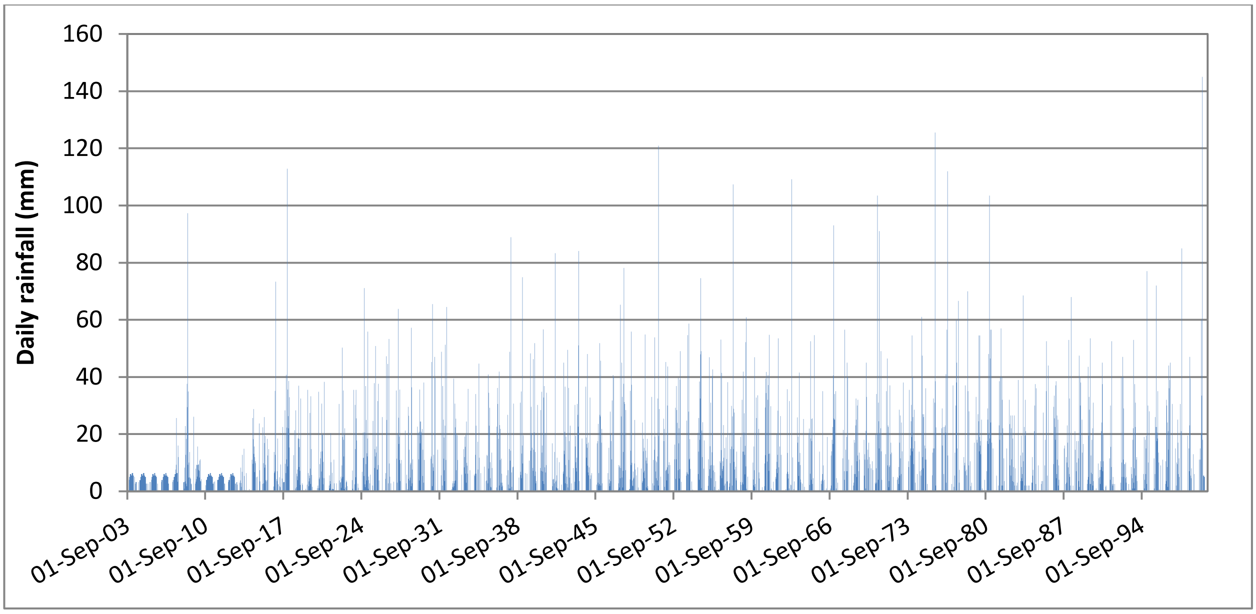


Figure 5: Daily rainfall for Stockport (POL) Rainfall Station (0717595 W)

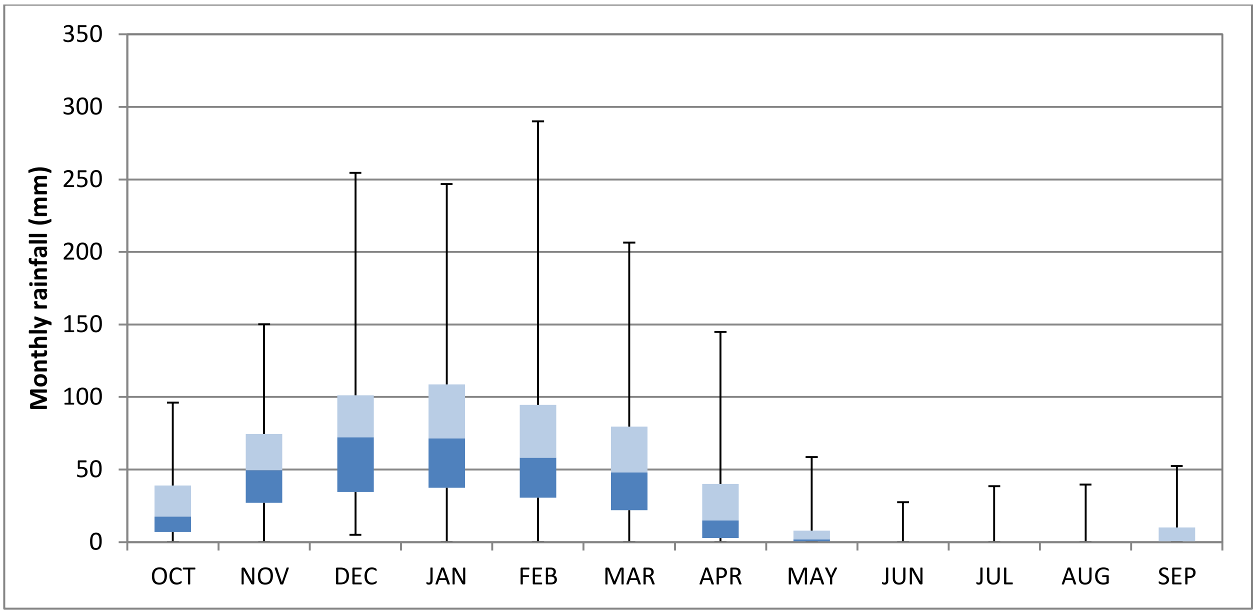


Figure 6: Monthly rainfall boxplot for Stockport (POL) Rainfall Station (0717595 W)

The boxplot in Figure 6 identifies the minimum, first quartile, median, third quartile, and maximum value in the monthly data set. It also highlights the amount of data, as a percentage, that falls below and above the 25%, 50%, and 75% mark.

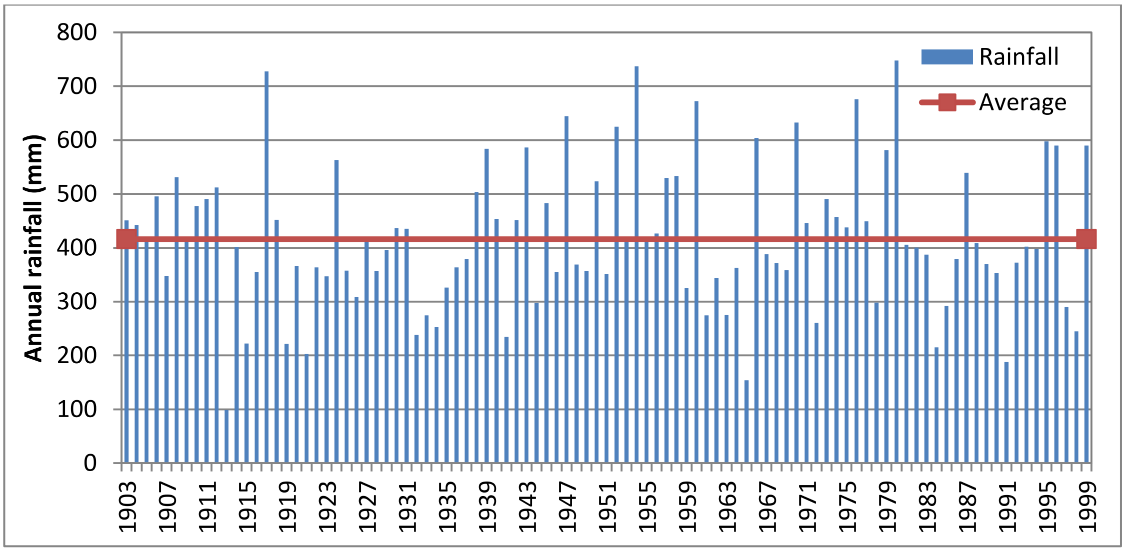


Figure 7: Annual rainfall measured at Stockport (POL) Rainfall Station (0717595 W)

The mean annual rainfall for Stockport (POL) is 416.09 mm. The lowest rainfall year was 1913 with 98.6 mm and the highest rainfall year was 1980 with 747.9 mm.

The 5, 50 and 95 percentiles of the annual rainfall totals for the rainfall station are presented in Table 4. Figure 8 shows the cumulative distribution function of the annual rainfall totals measured at the Stockport (POL) station.

Table 4: 5, 50 and 95 Percentile of the Annual Rainfall Totals

Station number	Station name	5th percentile	50th percentile	95th percentile
0717595 W	Stockport (POL)	209.21	421.70	636.55

Table 4 shows for Stockport (POL) there was:

- Less than 209 mm/annum rainfall for 5 % of the time;
- Less than 422 mm/annum rainfall for 50 % of the time; and
- Less than 637 mm/annum rainfall for 95 % of the time.

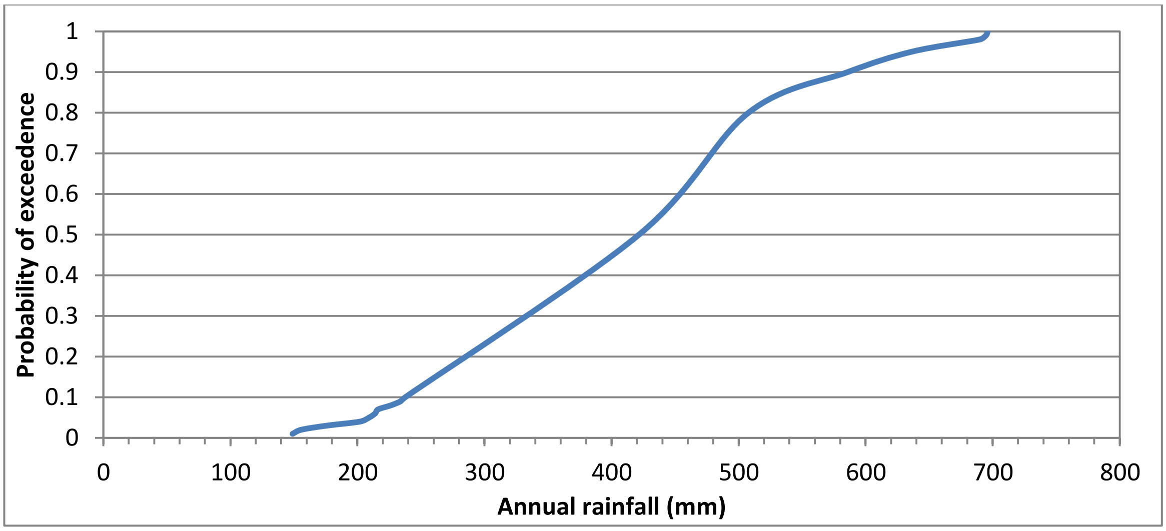


Figure 8: Annual probability curve for the Stockport (POL) Rainfall Station (0717595 W)

At the Stockport (POL) station 75 events measured more than 50 mm/day and rainfall events with more than 100 mm/day were recorded 9 times during the data period. Table 5 shows all the highest recorded rainfall events at the Stockport (POL) station.

Table 5: High Rainfall Events

Maximum recorded daily rainfall (mm)	Date of maximum rainfall
112.9	29 December 1917
120.9	22 April 1951
107.4	6 January 1958
109.2	7 April 1963
103.5	19 December 1970
125.5	11 February 1976
112	26 March 1977
103.5	6 January 1981
145	8 February 2000

The 24-hour storm rainfall gridded data for the 1:2, 1:5, 1:10, 1:20, 1:50, 1:100 and 1:200-year recurrence interval was abstracted from the database using the Design Rainfall Estimation Programme (Smithers & Schulze, 2002) from the closest rainfall station and are given in Table 6. South African Weather Services (SAWS) Rainfall station 0717595_W (Stockport POL) was used for this study. The selection of station 0717595_W was based on the fact that this is the closest station to the study area with a reliable record. The rainfall distribution on site is classified as a type 3 design rainfall distribution.

Table 6: 24 Hour Rainfall Depths for Different Recurrence Intervals (mm/day)

Recurrence interval (years)	1 in 2	1 in 5	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200
24-hour rainfall depth (mm)	61.7	87.1	105.3	123.9	149.7	170.3	192.0

3.3.2 Potential Evaporation

The Monthly evaporation data was available for two DWS stations namely A4E003 (23°50'34.52"S and 27°47'58.90"E some 30km South East of site), Zandpan and A4E007 Mokolo Nature Reserve @ Mokolo Dam (23°58'32.49"S and 27°43'28.89"E some 35km South East of site). The mean annual evaporation (MAE) for station A4E003 is 2 572 mm and is 2 014 mm for station A4E007. Monthly mean, minimum and maximum evaporation depths are shown in Figure 9.

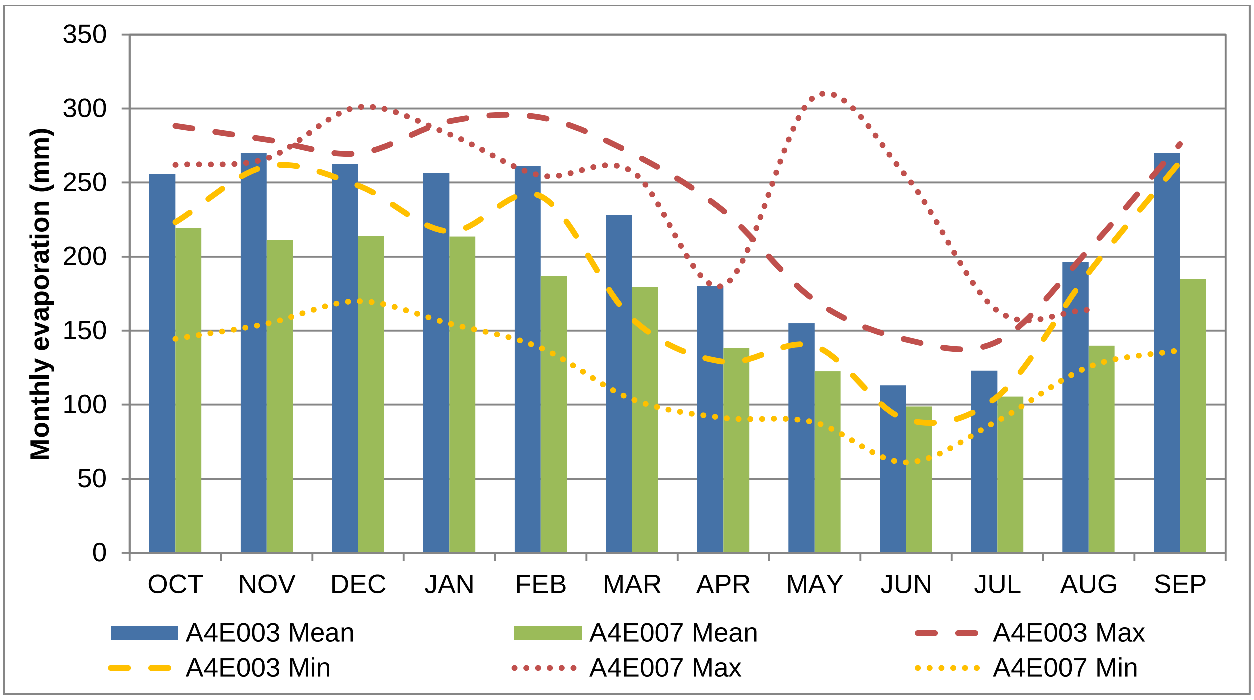


Figure 9: Monthly mean, minimum, maximum evaporation for stations A4E003 and A4E007

Figure 9 shows that the highest evaporation occurs in the summer months from September to March. This is verified in Table 7 which shows the average monthly evaporation for the two stations.

Table 7: Average monthly evaporation values for stations A4E003 and A4E007

Month	A4E003	A4E007
Oct	255.75	219.38
Nov	270.00	211.21
Dec	262.47	213.81
Jan	256.27	213.56
Feb	261.40	186.99
Mar	228.37	179.34
Apr	180.00	138.32
May	155.00	122.51
Jun	113.00	98.83
Jul	122.97	105.45
Aug	196.33	139.85
Sep	270.00	184.88
Total	**2 572**	**2 014**

3.4 Water quality and quantity

It is recommended that the water quality and water volumes on site be monitored on the surface watercourses around Medupi Power Station. The major constituents of concern would emanate from the ADF.

Fly ash contains trace concentrations of metals and other substances that are known to be detrimental to health in sufficient quantities. Potentially toxic trace elements in coal include arsenic, beryllium, cadmium, barium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, uranium, vanadium, and zinc.

Natural gypsum and FGD gypsum have the same chemical composition: calcium sulfate dihydrate (CaSO4·2H2O). FGD gypsum production and sales encourages power producers to capture "waste" for reuse, rather than merely storing it. However, certain impurities occasionally occur with natural as well as synthetic gypsum. The impurities are generally inert and harmless and typically consist of clay, anhydrite, or limestone in natural gypsum and fly ash in synthetic gypsum, which is likely to be the case here. Each individual source must be analyzed separately to assess its particular suitability which may vary depending on purity.

Based on the potential contaminants of concern the recommended water quality programme is as follows:

- The existing (NSS) as well as proposed (Golder) water quality monitoring points are shown in Figure 10;
- The existing water quality and water volumes monitoring points are listed in Table 8 and the laboratory analysis results for samples collected at these points in November 2015 are listed in Table 10;

For this study, three monitoring points in the Sandloop River and two points on the unnamed tributary were identified and sampled. The properties of the proposed water quality monitoring locations are listed in Table 9.

- The three monitoring locations in the Sandloop River were identified to establish a baseline water quality and flow along the main watercourse;
- The remaining two monitoring sites are located on the unnamed tributary of the Sandloop River that runs to south west of the existing licensed disposal facility. The monitoring points include one upstream of the disposal facility and one downstream of the disposal facility before the confluence with the Sandloop River;
- Samples should be taken monthly or when water is present at the proposed locations. During the dry season, each monitoring site should be visited every two to three months to see if there is water that can be sampled; and
- The parameters to be analysed should include:
  - pH, Total Dissolved Solids, Electrical Conductivity, Alkalinity, Potassium, Calcium, Sodium, Chloride, Fluoride, Sulphate, Nitrate, Ammonium, Total Hardness, Metals: Arsenic, Beryllium, Cadmium, Barium, Chromium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Uranium, Vanadium and Zinc using ICP-MS), Orthophosphate, Total Suspended Solids, Oil and Grease

Water quality data were collected at the existing monitoring points in November 2015 by Natural Scientific Services (NSS). However, no water quality or flow data were collected during the site visit undertaken by Golder on 7th to 8th November 2016 because the proposed points were dry. Since one set of water quality results exists, limited analysis of the laboratory results can be carried out and no trends could be established.

Table 8: Existing surface water quality and quantity monitoring sites at Medupi

Golder Site Name	River/ Location	Latitude	Longitude	Motivation for point location
MD1	Sandloop tributary (major)	23°43'22.38"S	27°29'24.49"E	Provide water quality on major tributary upstream of Eskom operation.
MD2	Sandloop tributary	23°43'54.09"S	27°30'51.95"E	Provide water quality and quantity after tributary passes Site 13 (existing ADF).
MD3	Site 2 (proposed)	23°44'50.52"S	27°30'16.55"E	Provide water quality at proposed Site 2.
MD4	Site 12 (proposed)	23°43'38.15"S	27°31'42.38"E	Provide water quality at proposed Site 12.
MD5	Sandloop tributary (minor)	23°44'20.34"S	27°32'55.28"E	Provide water quality on minor tributary downstream of Eskom operation.
MD6	Sandloop River	23°44'45.55"S	27°34'19.61"E	Establish water quality on the Sandloop River.

Table 9: Proposed surface water quality and quantity monitoring sites at Medupi

Golder Site Name	River/ Location	Latitude	Longitude	Motivation for point location
WQ1	Sandloop River (upstream)	27°26'34.96"E	23°47'42.65"S	Establish baseline water quality data furthest upstream Sandloop River.
WQ2	Sandloop tributary (major, upstream)	27°29'19.53"E	23°43'19.53"S	Provide water quality on major tributary upstream of Site 13 (ADF).
WQ3	Sandloop River (central)	27°30'36.07"E	23°45'38.27"S	Establish baseline water quality and flow data in the Sandloop River across Eskom operation.
WQ4	Sandloop tributary (major, downstream)	27°32'10.80"E	23°44'42.77"S	Provide water quality and flow on major tributary downstream of Site 13 (ADF).
WQ5	Sandloop River (downstream)	27°34'10.40"E	23°44'38.95"S	Establish baseline water quality data furthest downstream Sandloop River.

Table 10 shows the results for water quality samples collected at MD1 to MD6 (existing monitoring points) in November 2015. These results are compared against the proposed RQOs (Table 2) for the Sandloop.

Table 10: Water quality data from Waterlab (Pty) Ltd for the grab sample taken in November 2015 against the water quality component of the RQOs proposed for the Sandloop

Sample ID	Units	RQO or WQG#	MD1	MD2	MD3	MD4	MD5	MD6
			28/11/2015	28/11/2015	28/11/2015	28/11/2015	28/11/2015	28/11/2015
pH @ 25°c	-	6.5 – 8.5	7.20	7.10	7.00	7.10	7.00	6.90
Electrical Conductivity	mS/m	≤ 55	12.70	29.70	7.20	9.40	24.00	15.20
Total Dissolved Solids @ 180°C	mg/L	≤ 260*	109.00	218.00	56.00	54.00	129.00	89.00
Total Alkalinity	mg/L $CaCO_3$	-	28.00	32.00	16.00	20.00	20.00	20.00
Total Hardness	mg/L $CaCO_3$	≤ 100	40.00	80.00	17.00	27.00	43.00	36.00
Chloride as Cl	mg/L	≤ 100	8.00	7.00	6.00	4.00	17.00	13.00

Sample ID	Units	RQO or WQG#	MD1	MD2	MD3	MD4	MD5	MD6
Sulphate as SO_4	mg/L	≤ 400	43.00	93.00	23.00	16.00	46.00	32.00
Nitrate as NO_3	mg/L	≤ 0.1	<0.1	0.10	0.10	0.10	0.10	0.10
Nitrate as NO_2	mg/L	-	0.06	<0.05	<0.05	<0.05	0.20	<0.05
Ortho Phosphate as P	mg/L	≤ 0.05	1.00	<0.1	0.40	<0.10	<0.10	<0.10
Ammonia NH_3	mg/L	≤ 0.007	2.80	0.20	1.60	0.30	0.10	0.30
Sodium Na	mg/L	≤ 70	2.00	17.00	1.00	4.00	20.00	7.00
Potassium as K	mg/L	≤ 50	18.80	14.20	9.20	8.60	19.40	12.30
Calcium as Ca	mg/L	≤ 32	8.00	19.00	4.00	6.00	9.00	8.00
Magnesium as Mg	mg/L	≤ 30	4.00	8.00	1.00	3.00	5.00	4.00

* calculated from EC*6.5; #South African Water Quality Guideline for ecosystems/ domestic use/ irrigation (strictest)

A summary of the water quality results (as per Table 10) indicates that the only concern was noted for ammonia, the likely source being from livestock.

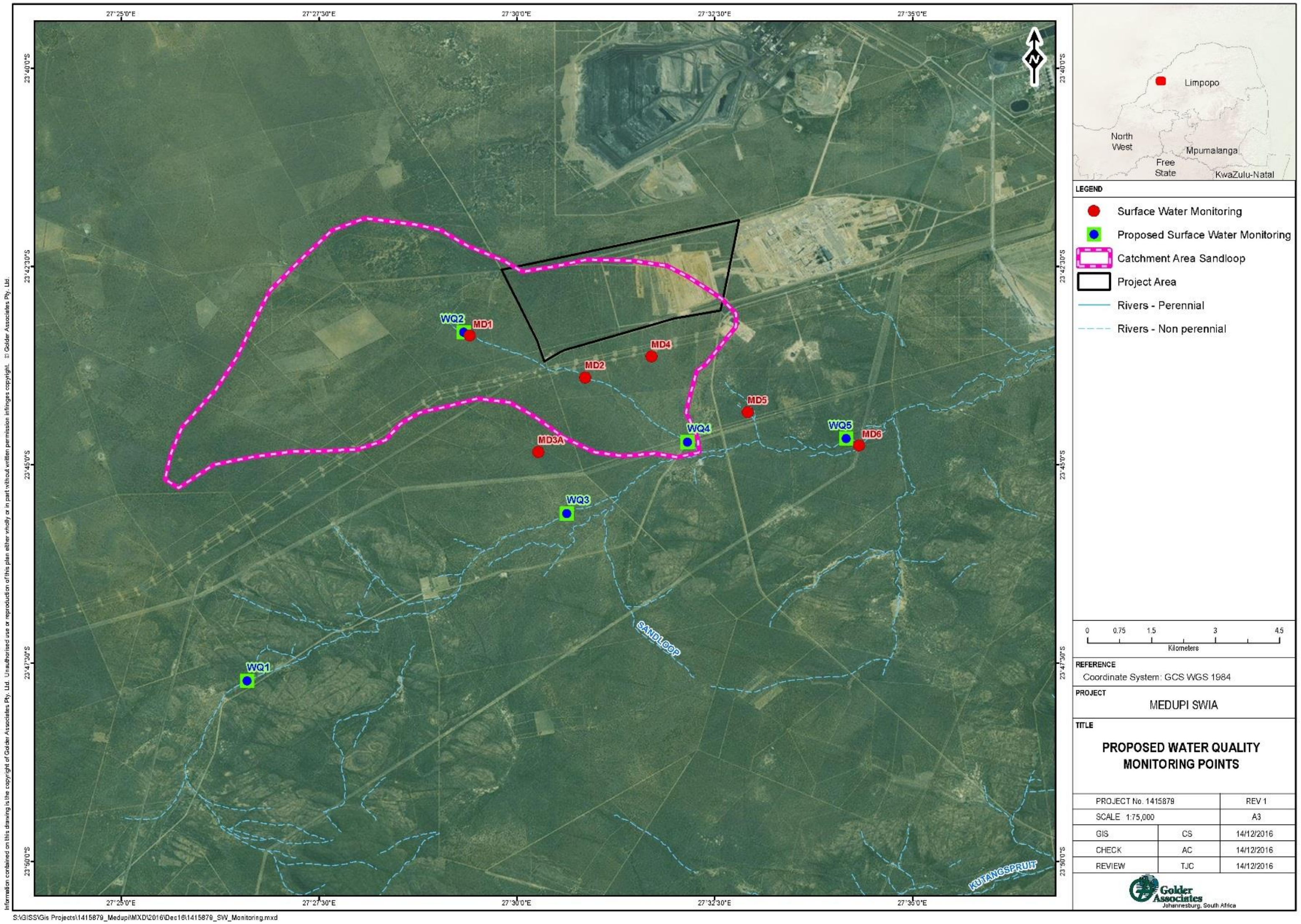


Figure 10: Medupi Power Station study area with existing and proposed water quality monitoring points

4.0 EXISTING STORM WATER MANAGEMENT SYSTEM (SWMS)

4.1.1 Overview

During the site visit conducted by Golder, a storm water management system was identified. The storm, water management system is aimed at mitigating the impact of the existing Medupi project on downstream water quality.

A General layout of the existing ADF and storm water management philosophy is provided in Appendix B. The existing water management system at Medupi includes:

- A dirty water management system to ensure that polluted water the power station and its associated infrastructure, including the existing ADF, as well as sediment-laden runoff from disturbed areas is separated from clean area runoff and that it is collected in Pollution Control Dams (PCD); and
- A clean water management system to divert water undisturbed by the power station's operations around the disturbed project footprint.

Additional facilities proposed and phased in over several years include three additional pollution control dams on the southern side of the ADF. All undeveloped, natural veld areas are clean and assumed to be free draining.

4.1.2 Water Conveyance and Storage

The following paragraphs describe a typical storm water management system (SWMS) as prescribed by Regulation 704 (GN704) and Best Management Practices (BMP's) and information gathered from the client during the site visit.

Clean and Dirty Water Areas

For the existing footprint at Medupi, clean and dirty catchments are delineated for the surface works using the site infrastructure layout plan and most recent aerial imagery. All flows from polluted surfaces are contained in dirty water systems. Only the surface areas which are anticipated to be impacted by the either clean or dirty water infrastructure as presented by the infrastructure layout plan and aerial imagery have been estimated. In all other areas around the power plant the natural pathways will be followed, ultimately routing surface water into the nearby watercourses. As such, these areas should not contain any infrastructure or workings which would be defined as dirty, unless additional mitigation has been included.

Clean Water Diversions

The Storm Water Management Plan (SWMP) includes typical upstream clean water diversions consisting of berms and cut-off trenches. Clean water diversion berms and cut-off trenches are designed to divert upstream clean water around dirty water generating areas (i.e. intercepting clean water runoff and diverting this water around mining activities). These diversions should be sized to cater for the 1:50 year flood event (with dimensions finalised during the detailed design phase of the project).

Dirty Water Containment

As per the clean water diversions, dirty water containment systems are designed to ensure dirty water generated within the footprint of Medupi is contained on site. These systems contain a channel and a storage component. Lining of the dirty water diversions is included to prevent seepage of any pollutants into the soil profile and subsequent percolation into groundwater. These diversions are typically sized to cater for a minimum of the 1:50 year flood event. Dirty water areas should be managed as a closed and separate system that is regulated by a collection point or Pollution Control Dam (CPD).

4.1.3 Findings of SWMS

The following can be concluded from the existing storm water management system at Medupi:

- No surface watercourses exist within the Medupi Power Station footprint;

- Surface access water generated from polluted areas during rainfall events within the power station's dirty footprint is contained on site by means of a dirty water management system that comprises a series of lined drains and pollution control dams (PCD's), which will be further developed as necessary (Appendix B); and

- Likewise, runoff resulting from unpolluted areas is channelled back into the environment via a series of open storm water channels.

Figure 11 and Figure 12 show a lined dirty water containment channel alongside the ADF at Medupi while Figure 13 shows an unlined clean water diversion channel on the periphery of the power station.

Figure 11: Concrete-lined dirty water containment drain alongside ADF at Medupi

Figure 12: Concrete-lined dirty water containment channel draining into PCD at Medupi

Figure 13: Unlined clean water diversion channel at Medupi

Knight Piésold undertook an assessment of the storm water management system in October 2017. The following regulations were considered:

- GN704: National Water Act, 1998 (Act No. 36 of 1998) Regulations on use of water for mining and related activities aimed at the protection of water resources; and
- Liner Regulations: Liner containment barrier systems. National Environmental Management Act (Act 59 of 2008). NEMWA Regulations R634, R635 and R636.

The results of the assessment indicate that the post-development flood peaks (after construction of the FGD area) are less than the pre-development flood peaks. It is noted in the report that this was due to the conservative approach adopted in the pre-development scenario as more development of the catchment was foreseen. This was done to allow for substantial development within the terrace area without having to increase the storm water system capacity once the final infrastructure layout is developed. The results indicated that approximately 35% of the total conveyance capacity is utilized. Two alternatives were considered for storm water management post-development of the FGD area and are described in the design report (Knight Piésold, 2017).

The recommendations from the report are that based on the re-designation of the catchments areas from clean to dirty (see Figure 14 and Figure 15), 20% of the total dirty water catchment areas will now be added to the dirty water system. It is therefore anticipated that the existing Dirty Water Dam (102 00 m^3 capacity) will have insufficient capacity to store the new dirty water runoff volumes (Figure 16). Additional dirty water storage will be required. This was not been sized as it was not part of the scope. The Dirty Water Dam capacity would have to be validated using a water balance so as to take into account the demands on the Dam. The 9% reduction in clean water areas indicates that the Clean Water Dam (133 400 m^3 capacity) will have sufficient capacity to cope with the proposed FGD infrastructure.

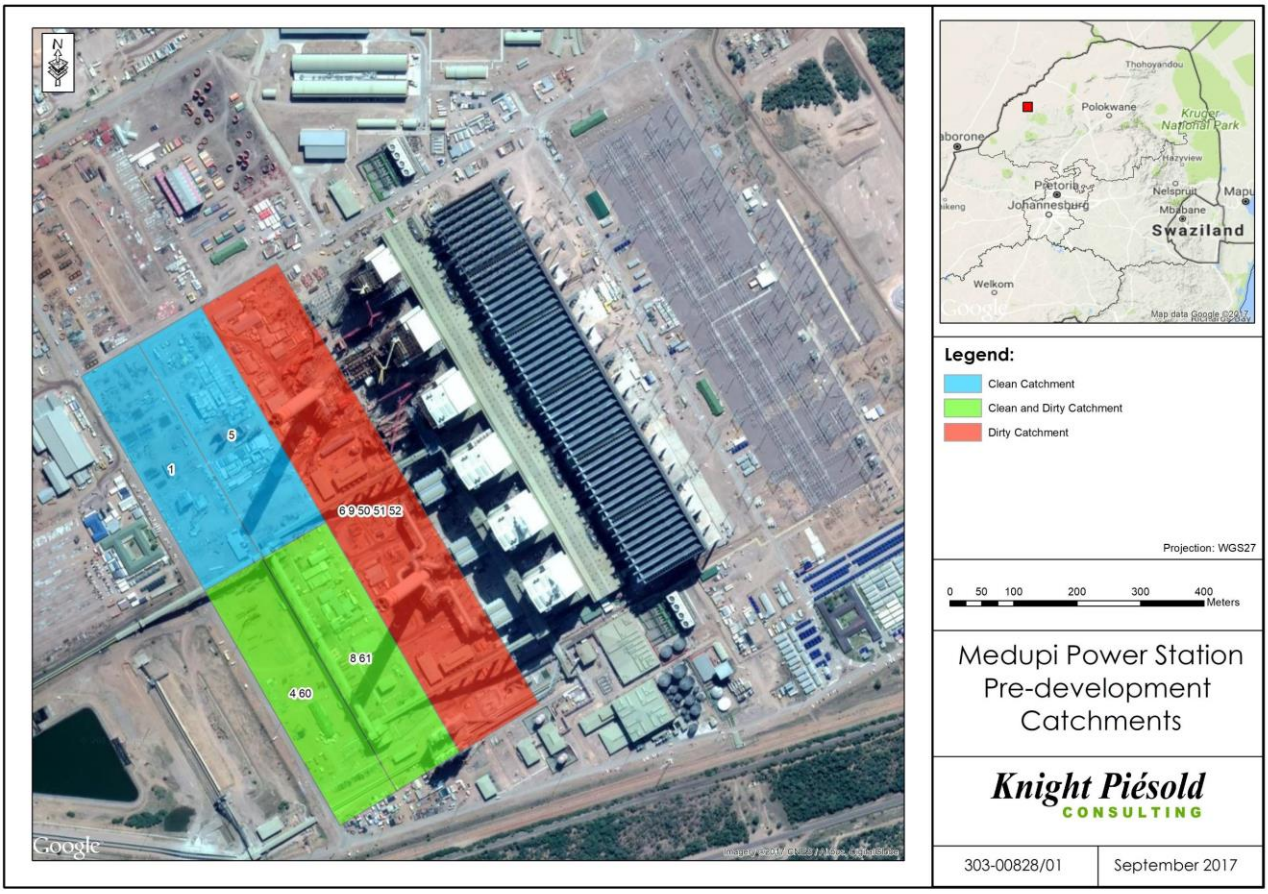


Figure 14: Existing clean and dirty water catchments in the FGD area (Knight Piésold, 2017)

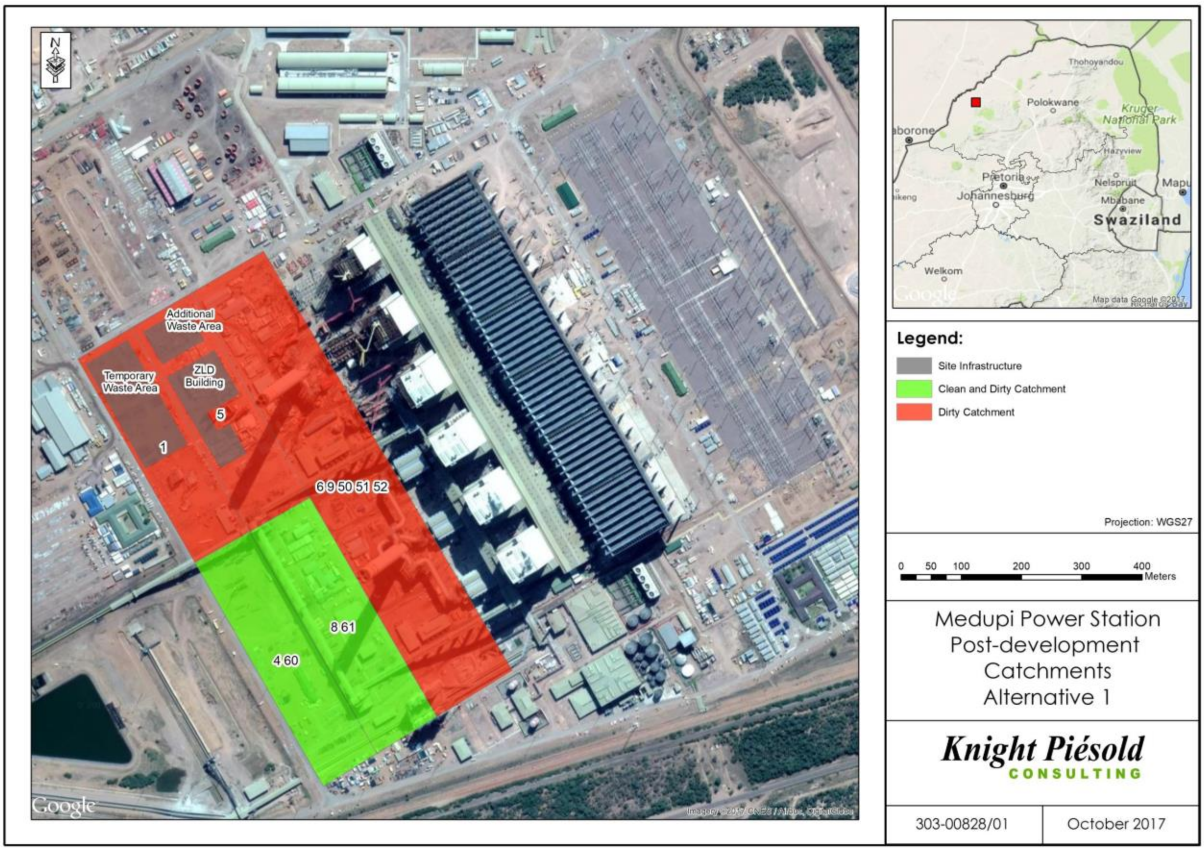


Figure 15: Re-designated catchment areas 1 and 5 from clean to dirty

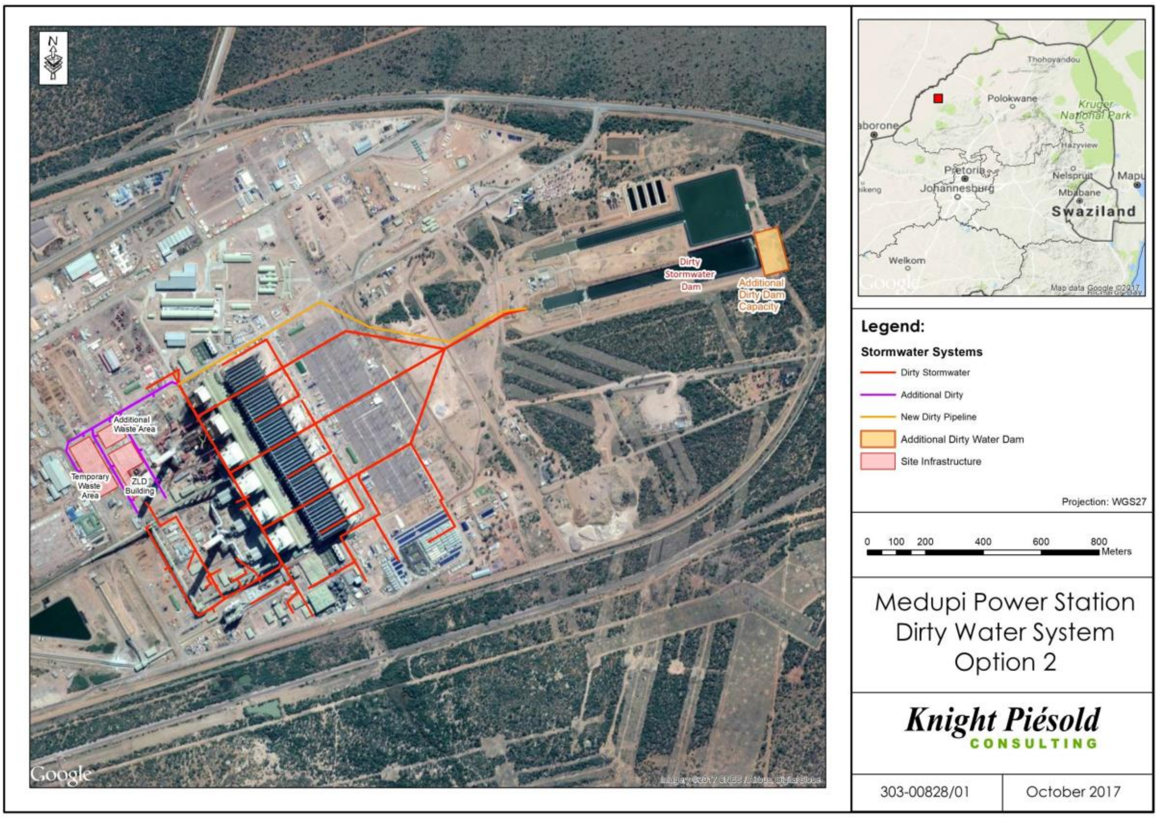


Figure 16: Dirty storm water system recommendation (Knight Piesold, 2017)

5.0 WATER BALANCE

5.1 Overview

A numerical site-wide water balance model has been developed for the existing operations at Medupi Power Station in order to assess the effectiveness of the power stations' water management system. However, a copy of this study has not been obtained at this stage and therefore no further reference can be made or conclusions drawn from it.

It is nonetheless recommended that a revision of this water balance study be carried out to include the FGD retrofit project as well as the proposed expansion of the existing ADF.

5.2 Findings of Water Balance Study

The existing water balance should be made available for detailed analysis. The analysis would typically require a review of the following:

- Modelling methodology highlighting the methodology adopted in modelling the system;
- Model configuration detailing how the model has been configured to simulate the operations of all major components of the water management system. This will include all operating rules of the water balance simulation;
- Water demands within the modelled system;
- Water sources (on and off-site) used in the model;
- Catchment/ site runoff for all the predicted catchment areas that drain to various water management dams and storages;
- Raw water (water imported from the local water authority) that is required to sustain the nominated design production rate and associated operational demands of the project; and
- Detailed analysis of the simulation results, including plant complex storage inventory, offsite water requirements, uncontrolled spills from site water storages, and the overall water balance within the study area.

6.0 FLOODLINE DETERMINATION

The 1:50 and 1:100 year floodline for the streams that could be impacted by the mine site were determined and delineated to ensure safety of mine facilities and maintenance of riparian zones.

6.1 Methodology used to determine the floodline

As per scope of work, the 1:50 and 1:100 year floodline for the Sandloop River tributary which drains adjacent to the existing licensed disposal facility was to be determined. A floodline assessment was required to determine the risk to the proposed ADF site and associated infrastructure from the 1:50 and 1:100 year flood peak. The floodlines were calculated using the HEC-RAS model, which determines the water surface elevations for the 1:50 and 1:100 year peak flow using an energy balance in which the friction loss is estimated using the Manning hydraulic equation. The floodlines of the Sandloop River tributary running in the vicinity of the proposed ADF footprint were determined. The following method was used for the determination of the floodlines:

- The site was visited to assess the site specific hydrological and hydraulic conditions;
- The catchment area of the Sandloop River tributary was delineated based on a 0.5m contour data
- Rainfall data as described in 3.3 was used as used as input into this section;
- A flood peak analysis was undertaken to determine the 50 and 100 year recurrence interval flood peaks for the watercourses within the mining boundary using the Rational Method as described in the SANRAL Drainage Manual (South African National Roads Agency Limited, 2006);

- Cross-sections were taken from the available topographical information. The extent and locations of the cross-sections along the modelled streams and tributaries is shown in Figure 18.
- Dimensions of the railway river crossing as well as other river obstructions such as culverts were determined during the site visit. These were used as input into the hydraulic model;
- The flood peaks and the survey data supplied by the client for the study area were used as inputs to the HEC-RAS backwater programme to determine the water surface elevations for the 1:50 and 1:100 year flood peak; and
- The floodlines were plotted on the available mapping.

6.2 Limitations and assumptions

The following limitations and assumptions have been made in this specialist study:

- No flow and rainfall data against which the runoff calculations might be calibrated were available. The runoff volumes were therefore calculated theoretically;
- Since there is very limited flow data available for a precise estimation of the roughness coefficients, the Manning's 'n' coefficients were estimated by comparing the vegetation and nature of the channel surfaces to published data (Webber, 1971), therefore slightly conservative estimations were adopted.

6.3 Rainfall, sub-catchments and flood peak calculations

The Medupi Ash Disposal Facility is largely located in the Sandloop River tributary sub-catchment. The total drainage area of Sandloop River tributary catchment was delineated into a sub-catchment based on the topography of the area as shown in Figure 17. From initial site investigations, it would seem that the key watercourse for floodline delineation and impact assessment would be the NFEPA to the south western corner of the ADF site. The tributary flows in a south-westerly direction near the ADF, and its catchment is most likely to be affected by the ADF site. The total drainage area of the Sandloop River tributary is small enough for one sub-catchment based on the topography of the area.

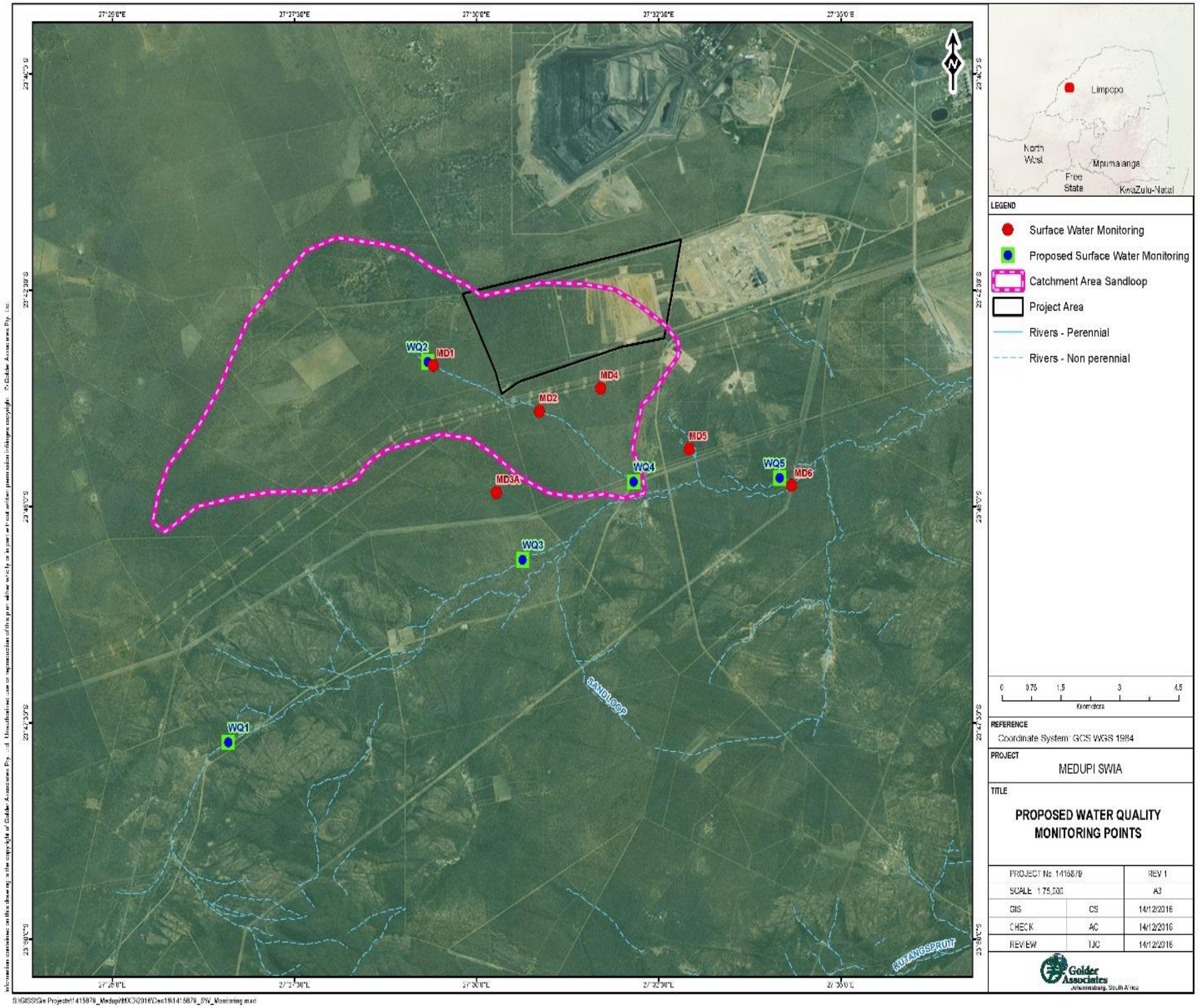


Figure 17: Discretization of Sandloop River tributary drainage area into sub-catchment

Figure 18: The extent and locations of the cross-sections along the modelled stream

Table 11: 100 year 24 hour storm rainfall depth used as input

Return Period (years)	1 in 50	1 in 100
Rainfall Depth (mm)	149.7	170.3

The drainage area of the Sandloop River Tributary was delineated into one sub-catchment based on the topography of the area. The catchment boundary is shown in Figure 17. The Rational Method using Point Precipitation (RM-PP) was applied to the Sandloop River tributary sub-catchment to estimate the 1:100 year flood peak. The rational method considers the entire drainage area as a single unit and estimates the peak discharge at the most downstream point of that area. Rainfall intensity is an important parameter in the calculation of the peak flow; this is because uniform aerial and time distributions of rainfall have to be assumed. The sub-catchment characteristics used in applying the rational method are shown in Table 12.

Table 12: Sub-catchment characteristics used in the Rational Method for the Sandloop River tributary

Name	Catchment Area	Stream Length	10-85 Slope	Time of Concentration
	(km^2)	(m)	(m/m)	(hours)
ST1	44.67	6631.94	0.004	2.43

The rational method was used to calculate the 1:100 year peak discharge for the Sandloop River Tributary. The results are listed in Table 13.

Table 13: Computed 100 year flood peak for the Sandloop River tributary sub-catchment

Catchment	Peak Flow (m^3/s)	
	1 in 50 year	1 in 100 year
ST1	144.94	187.57

The resulting floodline is mapped in Figure 19. For the modelled event, the maximum estimated hydraulic depth is 2.46m and the maximum expected velocity 1.72 $m.s^{-1}$. The road culvert has a restrictive effect on the flow of the stream when both the 1 in 50 and 1 in 100 flood conditions exist, hence some localised damming up at the culvert inlet can be expected. Figure 20 illustrates the encroachment of the PCD into the floodline.

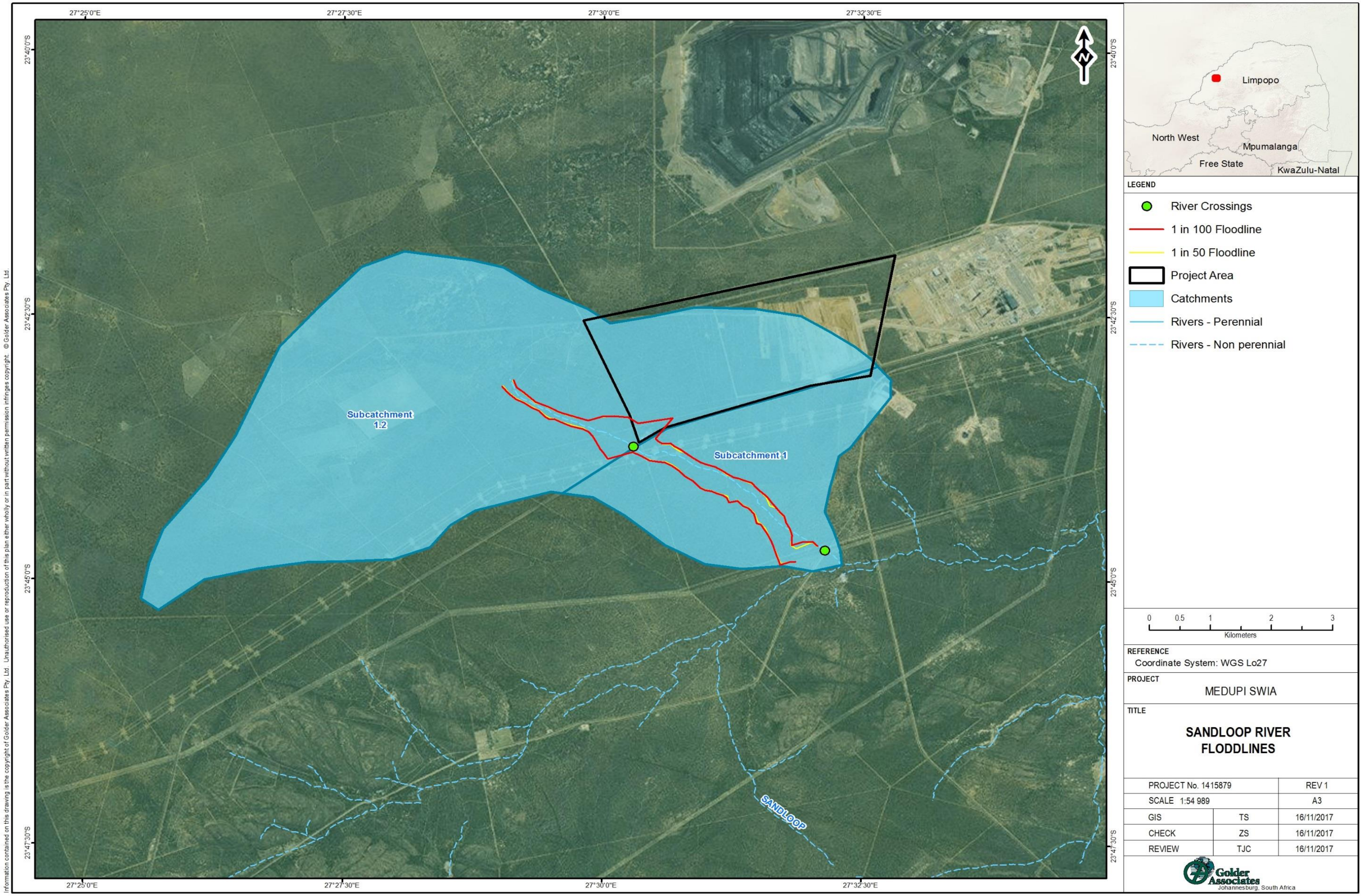


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Figure 19: The 1 in 100 year recurrence interval floodline for Sandloop River Tributary

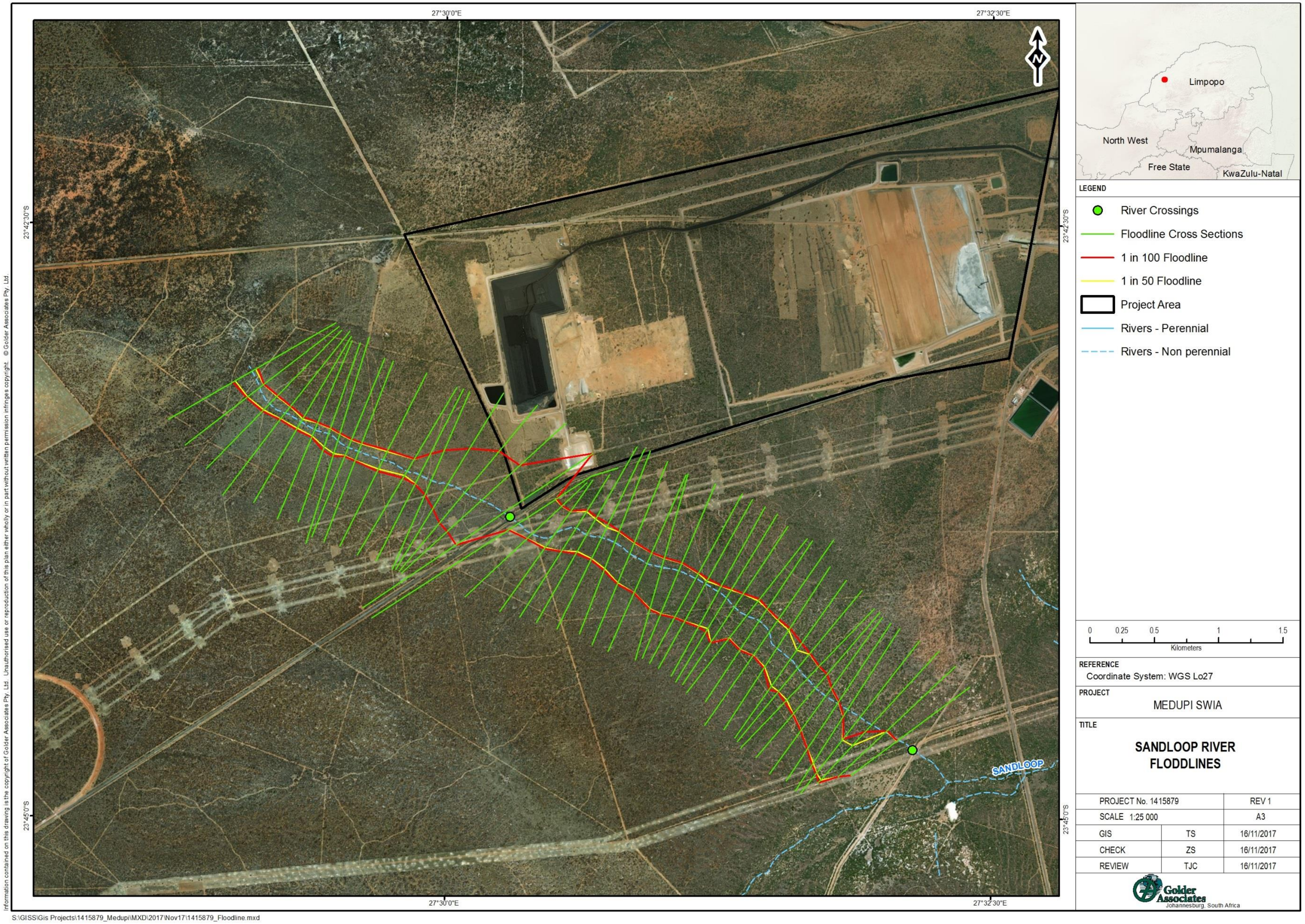

Figure 20: The 1 in 100 year recurrence interval floodline for Sandloop River showing encroachment of the PCD into the floodline

7.0 SURFACE WATER IMPACT ASSESSMENT

In investigating the receiving environment of the Medupi Power Station footprint in terms of surface water, particularly the existing licensed disposal facility, the Sandloop River and its tributaries in the vicinity of the power station were mainly considered.

7.1 Potential Surface Water Impacts

The potential surface water impacts have been assessed for the following activities:

- Construction and operation of the FGD system including the Zero Liquid Effluent (ZLD) Plant and temporary waste storage area within the Medupi Power Station Footprint;
- Construction and operation of the railway yard, limestone and gypsum handling facilities and two diesel storage facilities between the Medupi Power Station and existing ADF; and
- Disposal of ash and gypsum together on the existing ADF, including temporary disposal of salts and sludge; this will necessitate height changes to the existing ADF from 60m to 72m.

The potential surface water impacts from the project, both direct and indirect, are summarised in Table 14. In summary these potential impacts contribute to overall surface water impacts and include:

- Change in surface water catchment areas;
- Changes in surface water quality;
- Change in surface water runoff patterns;
- Erosion; and
- Potential to require off-site water supplies.

If not mitigated, the potential surface water quality impacts will ultimately affect the downstream water users. It should be noted that the Sandloop River and its tributaries are generally downstream of Medupi and the topography around the study area is such that runoff generated at Medupi drains towards the Sandloop River and its tributaries. This potentially polluted water will flow towards downstream users via the river system.

Table 14: Summary of potential surface water impacts with respect to Medupi Power Station

Major aspect	Key Environmental Issues / Potential Impacts
■ Changes in surface water catchment areas	■ Disruption and reduction in land area due to construction and operation of FGD infrastructure, the railway yard and limestone and gypsum handling facilities, and disposal of ash and gypsum to the existing ADF, will be very limited due to the fact that the areas in which these facilities are to be located are within the existing Medupi operations footprint, and no additional areas will be utilised. The catchment areas that feed the Sandloop will therefore not be further impacted.
■ Changes in surface water quality	■ Poor quality runoff during construction and operation of the FGD retrofit; ■ Poor quality runoff during construction and operation of the railway yard and limestone and gypsum handling facilities; due to: ▪ Possible fuel and lubricants spillage from equipment and other chemical spills; and ▪ Inadequate storm water management (design and operation/ maintenance) resulting in poor quality runoff from disposal of ash and gypsum to the existing ADF and spillages from pollution control dams.
■ Change in surface	■ Increased runoff due to vegetation and veld removal decreases infiltration

water runoff	into soil which may impact on downstream water users; ■ Increased runoff due to large concrete terraces and roads; and ■ Potential to increase Sandloop River flood levels and flood extent.
■ Erosion	■ Erosion on site and surrounding areas may be increased due to site clearance of vegetation and veld; and ■ Un-lined storm water management channel erosion.
■ Off-site water requirements	■ The potential need to import raw water in the case of a shortfall of water captured on site during dry periods.

7.2 Impact Assessment Methodology

The Impact Assessment Methodology provided to Golder by Zitholele was used for the surface water impact assessment. The impacts will be ranked according to the methodology described below. Where possible, mitigation measures will be recommended. The impact assessment methodology makes provision for the assessment of impacts against specific criteria discussed below.

7.3 Key Definitions

The following key definitions relate to Impact Assessment Rating:

“Existing” Impact

- These are current activities that potentially have an impact on the surface water resources within the study area;
- These are baseline impacts before the proposed construction and operation of the FGD system within the Medupi Power Station Footprint; the construction and operation of the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF; and disposal of ash and gypsum together on the existing ADF;
- “Existing” excludes the proposed project for which authorisation is required.

“Cumulative” Impact

- These impacts include both the ‘existing” activities as well as activities associated with the proposed project that potentially have an impact on the surface water resources within the study area;
- The project activities include the construction and operation of the FGD system within the Medupi Power Station Footprint; the construction and operation of the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF; and disposal of ash and gypsum together on the existing ADF; and
- The transportation of sludge and salts to an existing licensed facility

“Post-mitigation” Impact

- This impact rating takes into consideration the “cumulative” impacts after the proposed mitigation measures have been effectively implemented;
- The project activities are the construction and operation of the FGD system within the Medupi Power Station Footprint; the construction and operation of the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF; and disposal of ash and gypsum together on the existing ADF, and
- The transportation of sludge and salts to an existing licensed facility.

7.4 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.

7.5 Extent of the impact

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

Table 15: 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

7.6 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 16 for the criteria for rating duration of impacts.

Table 16: 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

7.7 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 considered. 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 17 and Table 18 below.

Table 17: 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 18: 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.

7.8 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 14 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 19: 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

Likelihood Descriptor	Definition	Rating
Definite	More than a 75% chance of occurrence. The impact will occur regularly.	1

7.9 Cumulative Impacts

Cumulative impacts are reflected in the 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.

7.10 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. The significance rating process for impacts follows the established impact/risk assessment formula described in the flow diagram below.

Impact = Consequence x Probability

Consequence = Extent + Duration + Intensity

Probability = Likelihood of an impact occurring

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

Table 20 provides the resulting significance rating of the impact as defined by the equation above.

Table 20: 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

7.11 Surface Water Impact Rating

The impact rating for surface water in terms of water quality and water quantity at Medupi is described are listed in Table 21 to Table 23.

Table 21: Water quality rating scale

Activity	Nature of Impact	Impact Type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
Water Quality (Pre-construction)	Pollution of natural surface water features.	Existing	2	2	4	0.2	1.6 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit. There is therefore already an impact on the environment, however the SWMS appears to be well operated and maintained, therefore the existing impact is rated as low. Cumulatively there is not expected to be further impact to the environment because of where the activities are proposed to be located. With mitigation (SWMS as per GN704, eg. upgrading to include additional pollution controls dams in a phased manner) the residual surface water pollution impact will be kept low due to the probability of dirty water spilling over into the environment from Medupi Power Station. Proper maintenance of the SWMP will reduce the rating to low. Ongoing surface water monitoring is important to ensure that this trend continues, especially during high rainfall events.	Because of the existing facility with SWMS in place and that appears to be well operated and maintained, rated as low impact.
		Cumulative	2	2	4	0.2	1 .6 – LOW		Because of the existing facility with SWMS in place and that appears to be well operated and maintained, rated as low impact.
		Residual	2	2	4	0.2	1.6 – LOW		Because of the existing facility with SWMS in place and that appears to be well operated and maintained, rated as low impact.
Water Quality (Construction)		Existing	2	3	4	0.5	4.5 – MOD	During construction it is possible that there may be increased contaminants reaching the surface water resources due to alterations that need to be made to the SWMS. These impacts should be reduced once construction is complete. With mitigation during construction (Existing SWMS maintained and well operated to deal with an increased pollutant load as per GN704), the residual surface water pollution impact will be reduced.	Because of the existing facility Surface water quality is already rated as moderate impact.
		Cumulative	2	3	4	0.5	4.5 – MOD		Water quality may be slightly further impacted but will remain a moderate impact with all cumulative impacts.
		Residual	2	2	4	0.2	1.2 – LOW/ MOD		Water quality will reduce to low impact with mitigation.
Water Quality (Operational)		Existing	2	2	4	0.2	1.6 – LOW	A SWMS is in place and so the existing impacts should be low. The grab sample taken does appear to indicate this and the SWMS on site appears to be well operated and maintained. During operation a well operated and maintained SWMS with addition PCDs and channels ars required and phased in over time, where clean and dirty water is separated according to GN704, channels are kept clean and PCDs do not overflow, will ensure limited surface water pollution.	Low impact if the SWMS is designed, operated and maintained according to GN704
		Cumulative	2	2	4	0.2	1.6 – LOW		Low impact if the SWMS is designed, operated and maintained according to GN704
		Residual	2	2	4	0.2	1.6 – LOW		Low impact if the SWMS is designed, operated and maintained according to GN704
Water Quality (Decommissioning)		Existing	2	3	4	0.5	4.5 – MOD	As with construction, decommissioning will have an increased load of pollutants where infrastructure is removed, however this should be short term and if adequate storm water management measures are put in place, then this should be limited to the site so the impact would be moderate. Post decommissioning the impact should once again be reduced to low as long as the area is well rehabilitated where infrastructure is removed and the SWMP around those facilities that will stay in place are upgraded as necessary and are maintained.	A moderate impact could be expected once decommissioning of the site occurs
		Cumulative	2	3	4	0.5	4.5 – MOD		A moderate impact could be expected once decommissioning of the site occurs
		Residual	2	2	4	0.2	1.6 – LOW		Reduce to low impact if the SWMS is upgraded as necessary, and maintained, and areas where infrastructure is removed are adequately rehabilitated according to a rehabilitation plan.

Table 22: Water quantity rating scale (surface runoff reduction)

Activity	Nature of Impact	Impact Type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
Runoff Reduction (Pre-construction)	Reduction of the surface water runoff footprint.	Existing	1	1	1	0.1	0.3 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit. There is therefore already an impact in respect of reducing the flow to the Sandloop. However the SWMS appears to be well operated and maintained so that the clean water around the site reaches the river. The existing impact is therefore rated as low. Cumulatively because the new facilities will be part of the existing footprint there is no further impact in respect of run-off reduction.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
Runoff Reduction (Construction)		Existing	1	1	1	0.1	0.3 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit, so no further impact in respect of run-off reduction is expected.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
Runoff Reduction (Operational)		Existing	1	1	1	0.1	0.3 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit, so no further impact in respect of run-off reduction is expected.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
Runoff Reduction (Decommissioning)		Existing	1	1	1	0.1	0.3 – LOW	The run-off may increase as areas are rehabilitated, so this should be a limited but positive impact.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact

Table 23: Water quantity rating scale (Flooding)

Activity	Nature of Impact	Impact Type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
Flooding (Pre-construction)	Flooding of nearby watercourses .	Existing	1	1	1	0.1	0.3 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit. In respect of potential flooding, the existing SWMS appears to be adequately designed to cater for the existing facilities. The runoff around the facility in the clean areas is not markedly changed for the sub-catchment of the Sandloop.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
Flooding (Construction)		Existing	1	1	1	0.1	0.3 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit. In respect of potential flooding, the existing SWMS appears to be adequately designed to cater for the existing facilities. The runoff around the facility in the clean areas is not markedly changed for the sub-catchment of the Sandloop. It will be important to do the relevant upgrades in the phased approach proposed, and then to operate and maintain the system optimally.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact

Activity	Nature of Impact	Impact Type	Extent	Duration	Potential Intensity	Likelihood	Rating	Mitigation	Interpretation
Flooding (Operational)		Existing	1	1	1	0.1	0.3 – LOW	The Medupi Power Station already has a footprint into which the proposed activities will fit. In respect of potential flooding, the existing SWMS appears to be adequately designed to cater for the existing facilities. The runoff around the facility in the clean areas is not markedly changed for the sub-catchment of the Sandloop. The SWMS will need to be optimally operated and maintained.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
Flooding (Decommissioning)		Existing	1	1	1	0.1	0.3 – LOW	The run-off may increase as areas are rehabilitated, so this should be a limited, but positive impact.	Runoff reduction is low impact
		Cumulative	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact
		Residual	1	1	1	0.1	0.3 – LOW		Runoff reduction is low impact

8.0 SPECIALIST OPINION ON SLUDGE & SALTS TRUCKING IMPACT

This section provides specialist opinion on the significance of the surface water impacts for the proposed trucking of sludge and salts from Medupi Power Stations' proposed temporary hazardous waste storage area to an appropriately licensed existing hazardous waste facility outside of the Medupi Power Station study area. Detailed description of the production, processing and disposal of sludge and salts at Medupi can be found in the Medupi Final Scoping Report on DEA REF: 14/12/16/3/3/3110 of June 2015 by Zitholele Consulting.

This section aims to describe the potential surface water impacts that could arise from the disposal of sludge and salts from Medupi to an existing licensed hazardous disposal facility outside of the study area. In general, the FGD retrofit activities, other than the salts and sludge disposal, will occur within the Medupi Power Station footprint and at the existing licensed disposal facility. The surface water resources along the path of transportation of sludge and salts within the study area are in question. Trucking of salts and sludge from Medupi can be summarised as follows:

- The nature of materials being transported, the mode of transportation, the route chosen for transportation, and the distance over which the materials are transported were of most significance in assessing the potential surface water impacts;
- The assumption at this stage is made that the hazardous waste disposal facility is within a 15km radius of Medupi Power Station, the mode of transportation is trucks, and the transportation route does intersect with surface water resources;
- Based on the above considerations and assumptions, it can be highlighted that the trucking of salts and sludge from Medupi to the licensed hazardous waste site will pose a medium potential risk impact to the water resources in the study area;
- The medium, rather than high, risk impact assessment rating is in light of the fact that Medupi Power Station has taken significant steps in investigating this matter beforehand. Various specialist studies have been commissioned to investigate this matter and its associated risks thoroughly and give specialist opinions as well as mitigation measures where possible; and
- It is therefore in our opinion that the transportation of salts and sludge from Medupi Power Station to an appropriately licensed existing hazardous waste facility outside of the study area will not pose a serious threat to water resources in the region.

9.0 MITIGATION AND MANAGEMENT MEASURES

Based on the potential surface water impacts identified in 7.0, the following section describes the associated mitigation measures that Eskom is required to implement at Medupi Power Station, aimed at reducing potential negative surface water impacts and enhancing potential positive environmental and social impacts.

Table 24 and Table 25 present mitigation proposed for the construction and operational phases of the project to limit surface water impacts and get a good understanding of the potential load of contaminants thatt would report to the Mokolo via the Sandloop.

Floodline

The footprint of the proposed Ash Disposal Facility is 925.86 ha (9.26 km^2). The following summary can be made from the floodline study:

- The 1:100 year floodline encroaches on the ADF footprint;
- The south-western portion of the proposed ADF footprint will be mostly affected by the 1 in 100 flood;
- The ADF project disturbance boundary is located within the Probable Maximum Flood (PMF); therefore

- To avoid flooding and contamination of the downstream environment through the transportation of pollutants from the ADF, the existing footprint should be re-designed or decreased in size.
- Water quality monitoring in the small dam on the south west corner must be undertaken monthly or in accordance with the relevant water use authorisation.

Loss of Catchment Flows

- The existing Medupi site and ADF site have a combined area of approximately 1,874 ha (18. 7km^2) which equates to 1.03% of quaternary catchment A42J with a catchment area of 1,812km^2 (WRC, 2012);
- The Sandloop River tributary has an estimated catchment area of 4,467 ha (44.7km^2). The reduction in catchment area from the Medupi site and ADF site of approximately 1,874 ha (18.7km^2) equates to a 49.95% decrease in catchment area; and
- It is therefore anticipated that during the operational phase of the ADF, there will be a reduction in the total runoff reporting to the Sandloop River tributary, however limited reduction to the Mokolo system.

Table 24: Proposed surface water mitigation measures - construction phase

<table>
<tr><th>Activity</th><th>Impact</th><th>Industrial Process</th><th>Proposed Mitigation</th></tr>
<tr><td>Site clearing for construction of FGD and associated waste disposal areas</td><td>Removal of topsoil leading to erosion and increased sedimentation in the surface water resources;
Operation of equipment may lead to spillage of oil that may find its way to the surface water resources;
Polluted surface water resources have reduced availability for downstream water users.</td><td rowspan="2">FGD
ADF
Sludge & Salts</td><td>As this will be within the existing footprint, it is unlikely that there will be considerable impacts from the removal of vegetation and/or topsoil during excavation. However, this aspect should be considered and managed to reduce erosion which could cause siltation of the surrounding surface water resources.
Removal of topsoil should be done systematically, only clearing the necessary areas at a time. As possible, clean and dirty surface water channels should be constructed to divert runoff separately to the appropriate storage dams (dirty water to the PCD to avoid eroded soils entering the clean water areas).</td></tr>
<tr><td>Construction activities</td><td>Operation of equipment may lead to spillage of oil that may find its way to eth surface water resources;
Chemical contaminants from building material may enter the water resources
Polluted surface water resources have reduced availability for downstream water users</td><td>As this will be within the existing footprint, it is unlikely that there will be considerable impacts from the removal of vegetation and/or topsoil during excavation. However, this aspect should be considered and managed to reduce erosion which could cause siltation of the surrounding surface water resources.
Removal of topsoil should be done systematically, only clearing the necessary areas at a time. As possible, clean and dirty surface water channels should be constructed to divert runoff separately to the appropriate storage dams (dirty water to the PCD to avoid eroded soils entering the clean water areas).
The existing SWMS will need to be optimally operated and maintained.
Ongoing monitoring of the surface water for:
pH, Total Dissolved Solids, Electrical Conductivity, Alkalinity, potassium, calcium, sodium, chloride, fluoride, sulphate, nitrate, ammonium, Total Hardness, Metals: arsenic, beryllium, cadmium, barium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, uranium, vanadium and zinc using ICP-MS),</td></tr>
</table>

Activity	Impact	Industrial Process	Proposed Mitigation
			orthophosphate, Total Suspended Solids, Oil and Grease ▪ Monthly when water is available or after a rain event

Table 25: Proposed surface water mitigation measures - operational phase

Activity	Impact	Industrial Process	Proposed Mitigation
Operation of the FGD system within the Medupi Power Station Footprint	Increased contaminants in the area from machinery and operation of the plant	FGD	■ Upgrading of the existing SWMS to comply to GN704; ■ Optimal operation and maintenance of the SWMS to ensure PCDs do not overflow; sediment and any other obstructive material is regularly removed from dams and channels;
Operation of the railway yard and limestone and gypsum handling facilities between the Medupi Power Station and existing ADF	Increased contaminants in the area from machinery and disposal	Sludge & Salts	■ Optimal operation and maintenance of the SWMS to ensure PCDs do not overflow; sediment and any other obstructive material is regularly removed from dams and channels;
Disposal of ash and gypsum together on the existing ADF	Potential for surface water contamination by trace elements associated with the ash and gypsum.	ADF; Sludge & Salts	■ As the south west corner of the footprint is in the 1:100 floodline, measure on how the existing infrastructure can be managed to prevent spills to the river. Water quality monitoring of the small dam in the South west corner needs to be undertaken monthly. ■ Classification of the gypsum purity to assess alternative disposal options; ■ Ongoing monitoring of the surface water at the points identified for: ▪ pH, Total Dissolved Solids, Electrical Conductivity, Alkalinity, potassium, calcium, sodium, chloride, fluoride, sulphate, nitrate, ammonium, Total Hardness, Metals: arsenic, beryllium, cadmium, barium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, uranium, vanadium and zinc using ICP-MS),

Activity	Impact	Industrial Process	Proposed Mitigation
			orthophosphate, Total Suspended Solids, Oil and Grease ▪ Monthly when water is available or after a rain event

10.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn and recommendations made from the Medupi surface water impact assessment study:

- The footprint of the proposed Ash Disposal Facility is 925.86 ha (9.26 km^2). The following summary can be made from the floodline study:
  - The 1:100 year floodline encroaches on the ADF footprint;
  - The south-western portion of the proposed ADF footprint will be mostly affected by the 1 in 100 flood;
  - The ADF project disturbance boundary is located within the Probable Maximum Flood (PMF); therefore
  - To avoid flooding and contamination of the downstream environment through the transportation of pollutants from the ADF, the existing footprint should be re-designed or decreased in size.
- The existing Medupi site and ADF site have a combined area of approximately 1,874 ha (18. 7km^2) which equates to 1.03% of quaternary catchment A42J with a catchment area of 1,812km^2 (WRC, 2012);
- The Sandloop River tributary has an estimated catchment area of 4,467 ha (44.7km^2). The reduction in catchment area from the Medupi site and ADF site of approximately 1,874 ha (18.7km^2) equates to a 49.95% decrease in catchment area; and
- It is therefore anticipated that during the operational phase of the ADF, there will be a reduction in the total runoff reporting to the Sandloop River tributary, however limited reduction to the Mokolo system.
- Natural on land surface water drainages are absent in the existing footprint of Medupi Power Station and will therefore not be impacted by the Flue Gas Desulphurisation (FGD) Retrofit project.
- The 100-year floodline of the Sandloop River in the area of the ADF encroaches on the ADF footprint in the south western corner and this may have a detrimental effect in the event of a major flood event. Should the ADF operate within the 1:100 year floodline, the risk of pollutant transportation towards downstream water users during a flood event will be elevated. This will include flooding of the disposal facility and entrainment of waste materials and sediments downstream, making the management of the facility during significant storm events very difficult.
- If sound engineering flood control and prevention measures are not put in place, the contents of the ADF are likely to be washed away into the receiving environment in the event of a 1:100 flood. Statistically, the 1:100 year flood event refers to the mathematical probability of this flood magnitude occurring once over a 100-year period. However, in reality this flood magnitude may occur more than once in 100 years. With this in mind, the 20-year lifespan of the ash disposal facility should not be directly compared to the 1:100 flood event. ADF design and flood mitigation measures should be based on the 1:100 year flood event.
- Storm water that is generated within the Medupi Power Station, including the ADF, as a result of rainfall is a route by which pollutants may be mobilised and transported into the receiving downstream environment. The National Water Act (NWA) prohibits the discharge of any effluent (including contaminated storm water) into any water resources.
- To prevent possible pollution of the receiving surface water environment, dirty water containment structures should be designed, constructed, maintained and operated such that they do not spill over more than once in 50 years. A minimum freeboard of 0.8 m above full supply level (FSL) must also be maintained as per GN704 requirements (flow-based hydraulic sizing requirements). Water accumulated in the containment facility during the wet season should be used as a priority in the process water circuit to ensure that the capacity requirements are not compromised during periods of heavy and/or extended rainfall.

- It is recommended that an update to both the storm water management plan (SWMP) and the existing water balance be undertaken such that it caters for the proposed FGD and ADF infrastructure as well as be designed and operated in line with the DWS's GN704.
- During construction and times of major disturbances to land cover, it is recommended that sound engineering measures are put in place to protect the receiving surface water environment. It is also recommended that, where possible, construction and land cover disturbance is carried out during the dry season to avoid the washing away of materials by surface runoff (post-construction sediment and erosion control).
- If possible, it is recommended that a detention (dry) pond be constructed at or near the discharge point of the clean water drainage system before it enters the environment. This pond will be constructed for the purpose of flood control as well as storm water runoff treatment. This pond will function to settle suspended sediments and other solids typically present in storm water runoff. In the event of a major storm, the detention pond will slow down water flow and hold it for a short period of time before releasing it to the environment.
- It is strongly recommended that the proposed water quality monitoring programme be strictly followed and sustained so that chemical constituent levels can be monitored and analysed over time. Pollution of surrounding surface water features should be avoided at all costs during the lifespan of the Medupi Power Station project. In the unfortunate occurrence of surface water resources pollution, swift and effective corrective measures should be implemented and the relevant authorities notified without delay.
- With respect to the transportation of sludge and salts from Medupi to a hazardous waste disposal site, it is recommended that a route selection study be carried out to determine the least potential water surface impacts, considering other factors such as the traffic impact assessment. From a surface water perspective, a route via a national road (highway) would be most appropriate as the likelihood of accidents and spillages due to poor road conditions will be minimised.

The impact assessment showed that most impacts were low after mitigation. If the impacts are properly mitigated and Best Management Practices followed at all times, the identified potential impacts can be reduced to negligible.

GOLDER ASSOCIATES AFRICA (PTY) LTD.

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APPENDIX A

Document Limitations

DOCUMENT LIMITATIONS

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APPENDIX B

General layout of the existing ADF and storm water management philosophy

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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