Hydrogeological Investigation Report for the Proposed Transnet Railway in Lephalale, Limpopo Province

Draft Report Prepared by

NALEDZI WATERWORKS (PTY) LTD
4/24/2019

Prepared for: Naledzi Environmental Consultant

160 Marshall Street

Polokwane

Contact Person: Mr. Desmond Musetsho

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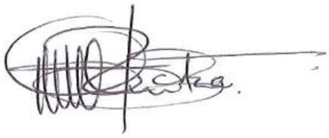
Declaration

We hereby declare:

- ✓ We have no vested interest (present or prospective) in the project that is the subject of this report as well as its attachments. We have no personal interest with respect to the parties involved in this project.
- ✓ We have no bias with regard to this project or towards the various stakeholders involved in this project.
- ✓ We have not received, nor have been offered, any significant form of inappropriate reward for compiling this report.



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R Ramathieledza; **Cand.Sci.Nat**

Naledzi Waterworks (Pty) Ltd

Junior Geohydrologist

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F.D Munyai; **Pr.Sci.Nat**

Naledzi Waterworks (Pty) Ltd

Senior Geohydrologist

1 Introduction and Scope of work

1.1 Background of the project

Transnet is planning to expand the rail transportation from Waterberg region in stages, to meet the potential expansion of the mining activities, coal transportation and transportation of other commodities. The Waterberg Railway Corridor starts in Lephalale, passes through Thabazimbi, Rustenburg, Pyramid South and links to the existing Ermelo railway line, which provides linkage to the main coal export terminal in Richards Bay Harbor.

The yard will consist of different types of facilities and infrastructure, which will include the following:

- The construction of a new railway lines
- Construction and extension of culverts
- Infra Crew Building
- Guard Houses
- Staff amenities
- Provisional facilities
- Fire suppression systems which require a foam storage tank, water storage and foam pipelines
- Roads and carports
- Sanding Facilities
- Effluent management (Water/Oil separator)
- X2 300 0000 liters diesel tanks and decanting slabs
- 6 720 liters of oil storage (32 drums of oil)
- Water Reservoir
- Earth Channel (Storage/evaporation purposes)
- Sewage System (Bio-mite submerged sewage treatment system)
- Rail Over Stream Bridges

The project is located approximately 30 kilometers (km) west of Lephalale (Ellisras) Town (**Figure 1**). Transnet appointed Naledzi Environmental Consulting (Pty) Ltd (Naledzi Environmental) to undertake the Environmental Impact Assessment for the Project.

Mr. Musetsho of Naledzi Environmental has appointed Naledzi Group (Pty) Ltd (Naledzi) to conduct a hydrogeological, which will form part of the Environmental Impact Assessment (EIA) that is being undertaken for the proposed Project. The process is conducted in an integrated approach.

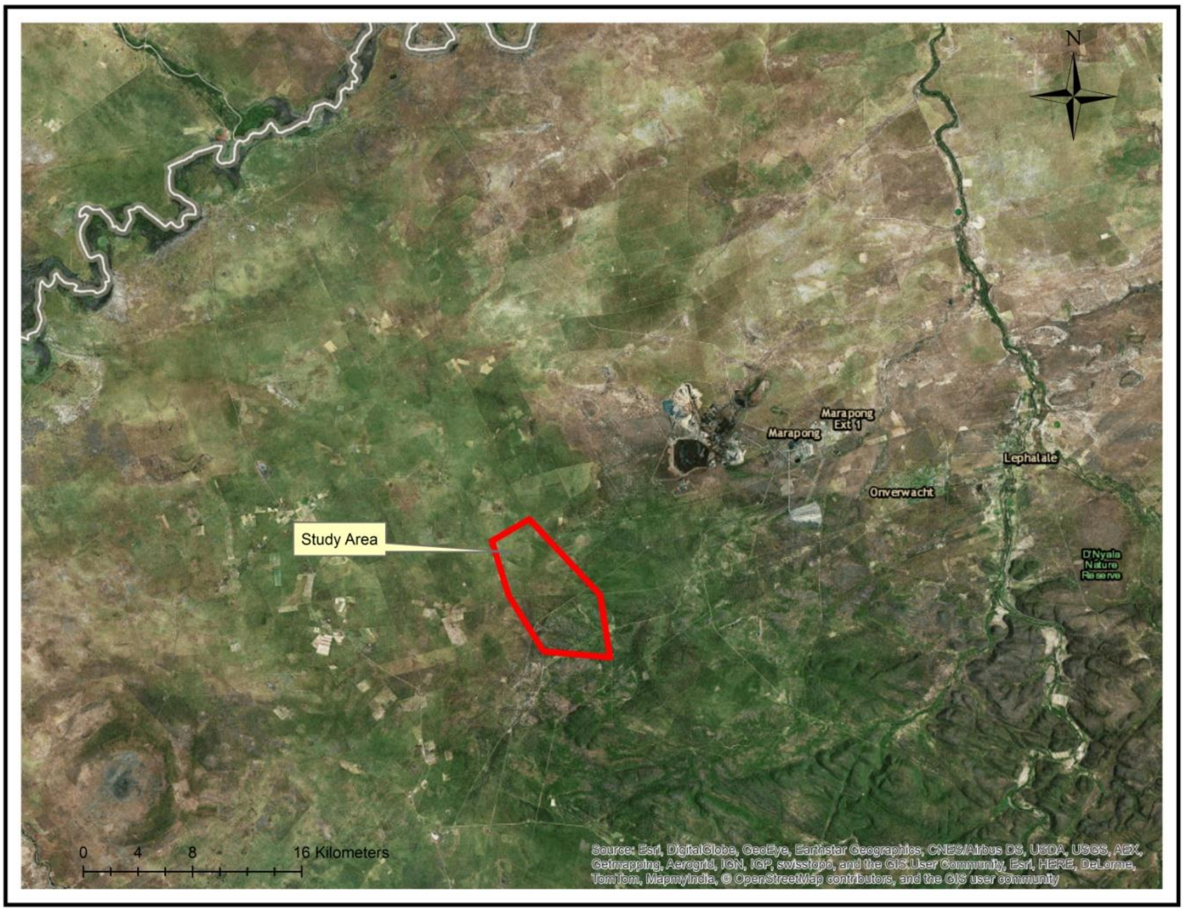

Figure 1: Locality map

1.2 Objectives

The purpose of this report is to present the baseline hydrogeological conditions of the project prior to the establishment of related infrastructures. The baseline assessment of the prevailing groundwater conditions is required for the environmental impact assessment of the project.

This report also quantifies impacts that the proposed project will have on groundwater (levels, quantity and quality) and recommends mitigation and management measures to minimize environmental impacts throughout the construction and operation project.

The objectives for the groundwater study are as follows:

- To characterize the hydrogeological regime and establish baseline conditions for the proposed development;
- To develop a hydrogeological conceptual model to assist in the assessment of the impacts of the proposed development on the water resources;
- Recommend mitigation and management measures to minimize environmental impacts throughout the construction and operation of the project.

1.3 Scope of work undertaken

The completed hydrogeological investigation scope of work for the current study consisted of the following:

- Review of existing relevant data and reports compiled for the project area and the surrounding properties;
- Site visit and hydrocensus;
- Compilation of baseline hydrogeological conditions based on existing data and site observation;
- Development of the conceptual hydrogeological model;
- Impact assessment;
- Development of mitigation measures;
- Reporting.

2 Site description

2.1 Location

The proposed Lephalale Railway Yard project is located approximately 30 km west of Lephalale (Ellisras) Town on the single railway line between Thabazimbi to Lephalale, in the rural area of Steenbokpan. The following farms are affected: Geelhoutskloof 359LQ; Enkeldraai 314LQ; Kringgatspruit 318 LQ (now Pontes Estate 712LQ) and Buffelsjagt 317LQ.

The project area falls within the jurisdiction of Lephalale Local Municipality in the Waterberg District of Limpopo Province.

2.2 Land use

The study area is used as commercial game hunting farms as well as commercial cattle grazing. Some of the farms near the project area are being used for commercial crop farming.

2.3 Topography and Drainage

The Study area is located in the A42J quaternary catchment. There is no perennial river in the vicinity of the study area (Figure 2). There are non-perennial streams within the study area, according to Terblanche (Wetland report, 2019. Figure 3). The area can be classified as plains with low reliefs. The study area has a gentle slope, which ranges between 1.1 % - 1.8 %.

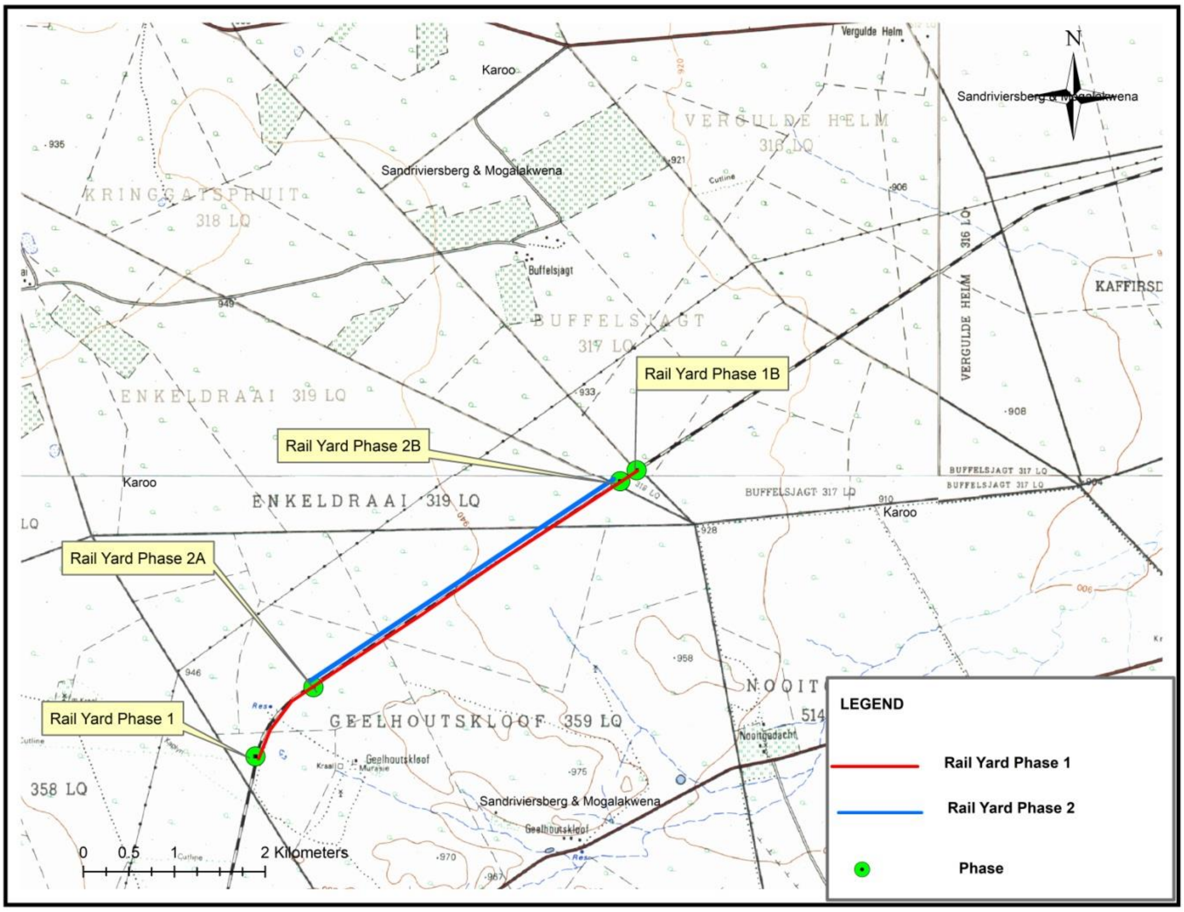

Figure 2: Topographical Map of the study Area

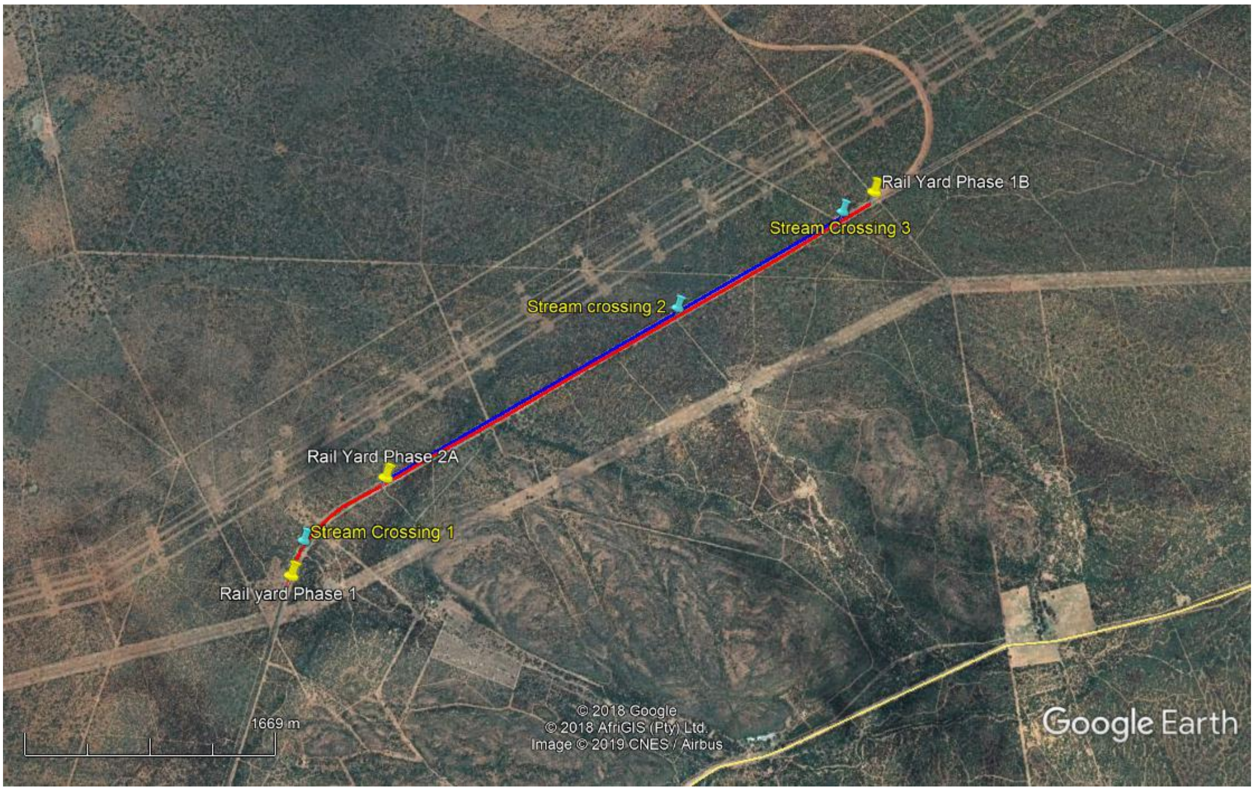

Figure 3: Proposed Lephalale Railway Stream Crossings (Terblanche, 2019)

2.4 Climate

The Climate of the project area is characterized by hot, moist summers and mild, dry winters. The area experiences high temperatures in summer months, with daily maximum temperatures exceeding 30 degrees on a regular basis.

The project area is located within a dry tropical climate zone characterized by dry winters and hot humid summers. The area experiences one cycle of rainfall that extends from October of the previous year and end in March of the following year (approximately 182 days). The rainfall information is based on the data obtained from Meteoblue weather; station N0.7730334 - Lephalale (Figure 4). Most of the rainfall occurs as localized heavy thunderstorms.

The area normally receives about 428 mm of rain per year, peaking during December and January, with most rainfall occurring during the summer. The area receives the lowest rainfall (1 mm) in July and highest (49 mm) in December (Figure 4).

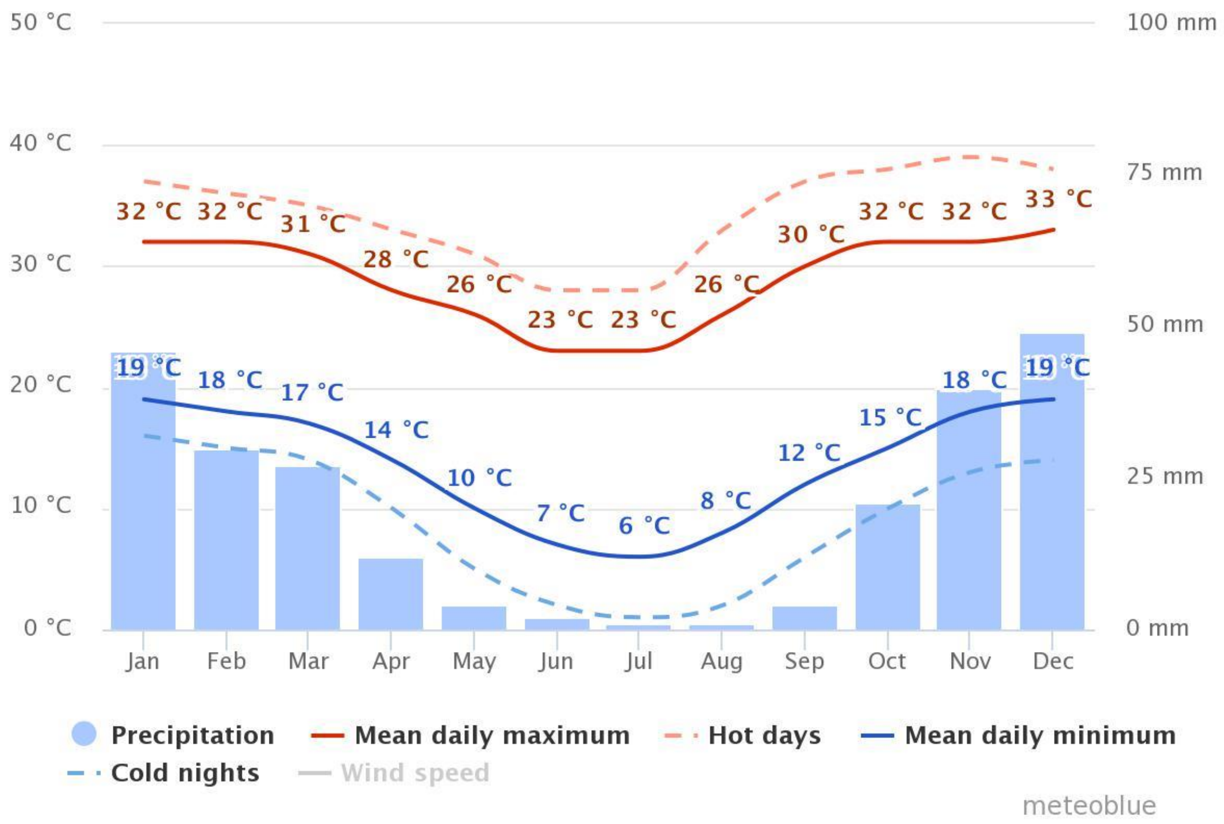

Figure 4: Average monthly rainfall and temperature for Weather Station N0.7730334

The monthly distribution of average daily maximum temperatures shows that the average midday temperatures range from 23°C in July to 33°C in December (Figure 4). The region is coldest during July when the mercury drops to 6°C on average during the night (Figure 4).

2.5 Geology

The regional and local geological setting of the area is well documented in the reports by Golder (2018).

The project area fall within the 1:250 000 Geological Map series of South Africa – Sheet 2326, Ellisras (Council of Geoscience). The description of the regional geological settings of the area is based on the geological description by Günter Brandl (2002).

2.5.1 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 5). 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 5).

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) quartzite, arkoses and conglomerates. Regionally, the Waterberg sediments rest on the rocks of the Transvaal Sequence (Golder 2018).

2.5.2 Structural Geology

The Daarby fault is a major northeast, 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 (Golder 2018).

The Eenzaamheid fault (Figure 5), 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 (Golder 2018).

2.5.3 Local Geology

The local geology of the area can be subdivided into two types, which are Karoo sediments and Waterberg sandstone, just south of the Eenzaamheid fault (Figure 5).

The sediments of the Waterberg Group (sili-clastic red bed successions) underlie the Study area. This is part of the up-thrown sediments comprising the fining upward conglomerate-quartzite facies assemblages of the Mogalakwena Formation. The Waterberg sediments are somewhat re-crystallised and fully oxidised; hence the hardness and red colour of the rock. A thin but permeable layer of sandy topsoil overlies it (Golder 2018).

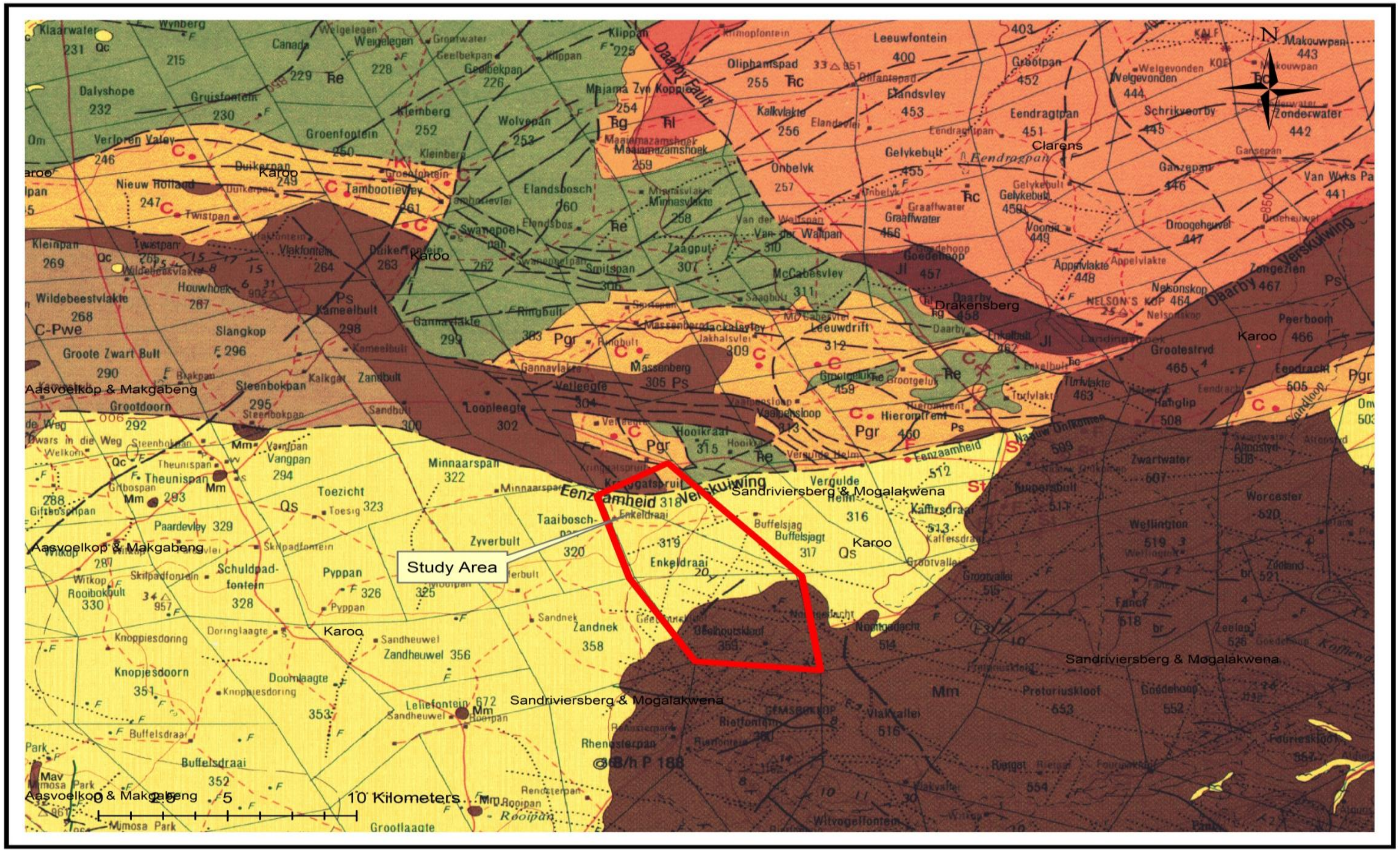

Figure 5: Regional geological setting

2.6 Hydrogeology

2.6.1 Aquifer Systems

Two distinct and superimposed groundwater systems are present in the geological formations of the coalfields in South Africa, as described by Hodgson and Grobbelaar (1999). They are the upper weathered aquifer and the system in the fractured rock below (Golder 2018).

2.6.1.1 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 barriers such as dolerite dykes, paleo-topographic highs in the bedrock obstruct the flow paths, 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).

2.6.1.2 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).

2.7 Hydrocensus

The primary objective of the hydrocensus was to identify the baseline groundwater use and users within the study area. The hydrocensus covered Geelhoutskloof 359LQ; Enkeldraai 314LQ; Kringgatspruit 318 LQ (now Pontes Estate 712LQ) and Buffelsjagt 317LQ farms.

The project site falls within the A42J quaternary catchment area. Groundwater in the investigation area is mainly used for domestic and stock watering purposes, with no irrigation use visible. The average ground water levels measured in the area is 30.4 mbgl. From the available groundwater flow data, the inferred groundwater flow is likely eastwards and towards the non-perennial Sandloop River.

The project site is underlain with sedimentary rocks of the Waterberg Group comprising of sandstone and conglomerates. According to the Limpopo WMA Reconciliation Strategy of 2015, rocks of the Waterberg Group, diabase sills, underlie the area and dykes occur through the area, the strike is predominantly east, north and northeast. If dykes and sills are ignored, the groundwater potential of the Waterberg Group is generally low with majority of yields <2 litres/second. The Waterberg group is considered a poor aquifer due to limited faulting, but where dykes and sills occur higher yields can be found.

From a regional perspective, substantial geohydrological data has been captured for the Medupi Flue Gas Desulphurisation Plant project in February 2018, which is just east of the project site. The study included a hydrocensus of surrounding boreholes in the area and included the proposed rail yard location. Six boreholes were considered relevant to the proposed rail yard project and are tabled in Table 1 below and their locations relative to the project site illustrated in Figure 6. Borehole BH01 (GE06) is closest to the rail yard position. The recorded groundwater level at BH01 (GE06) was 24.21 meters below ground level.

The results of the hydrocensus together with the previous hydrocensus by Golder (2018) were used to determine the baseline water use in the area. The groundwater in the project area is used for domestic and game watering purpose with several boreholes pumping water into the drinking troughs located in the bushes (Figure 6). The details of the visited sites are presented **in Appendix B** and their positions are shown in Figure 7**.**

Figure 6: Existing Borehole and water trough

2.7.1 Existing boreholes

Golder in 2015 visited of 17 boreholes located in and surrounding farms of the study area (Figure 7). Of these, only six falls within the study area and were surveyed by Naledzi during the current hydrocensus. The data suggests that 13 boreholes are equipped, 11 are equipped with submersible and 2 are equipped with windmills. These boreholes are used for both domestic and game watering. A total of 4 boreholes are not equipped and unused.

There are borehole depths records but the static water level in the visited boreholes ranges between 4.41 and 69.99 mbgl, with average static water level of 30.4 mbgl.

Table 1: Hydrocensus boreholes recorded on farms Geelhoutkloof and Zandnek

Site name	Borehole number	GPS coordinates	Mbgl	Use	Condition
Geelhoutkloof	BH01 (GE06)	23°45'56.09"S 27°26'45.71"E	24.21	Stock watering	Working
Geelhoutkloof	BH02 (GE05)	23°46'37.81"S 27°26'26.70"E	9.78	Domestic/All purpose	Working
Geelhoutkloof	BH03 (GE01)	23°46'13.91"S 27°27'51.01"E	13.88	Unused	Open
Zandnek	BH04 (GE03)	23°47'6.11"S 27°24'47.59"E	55.56	Domestic/All purpose	Working
Geelhoutkloof	BH05 (GE04)	23°47'1.61"S 27°27'47.09"E	9.17 (windmill)	Unused	Broken
Geelhoutkloof	BH06 (GE02)	23°47'2.29"S 27°27'54.22"E	9.47	Domestic/All purpose	Working

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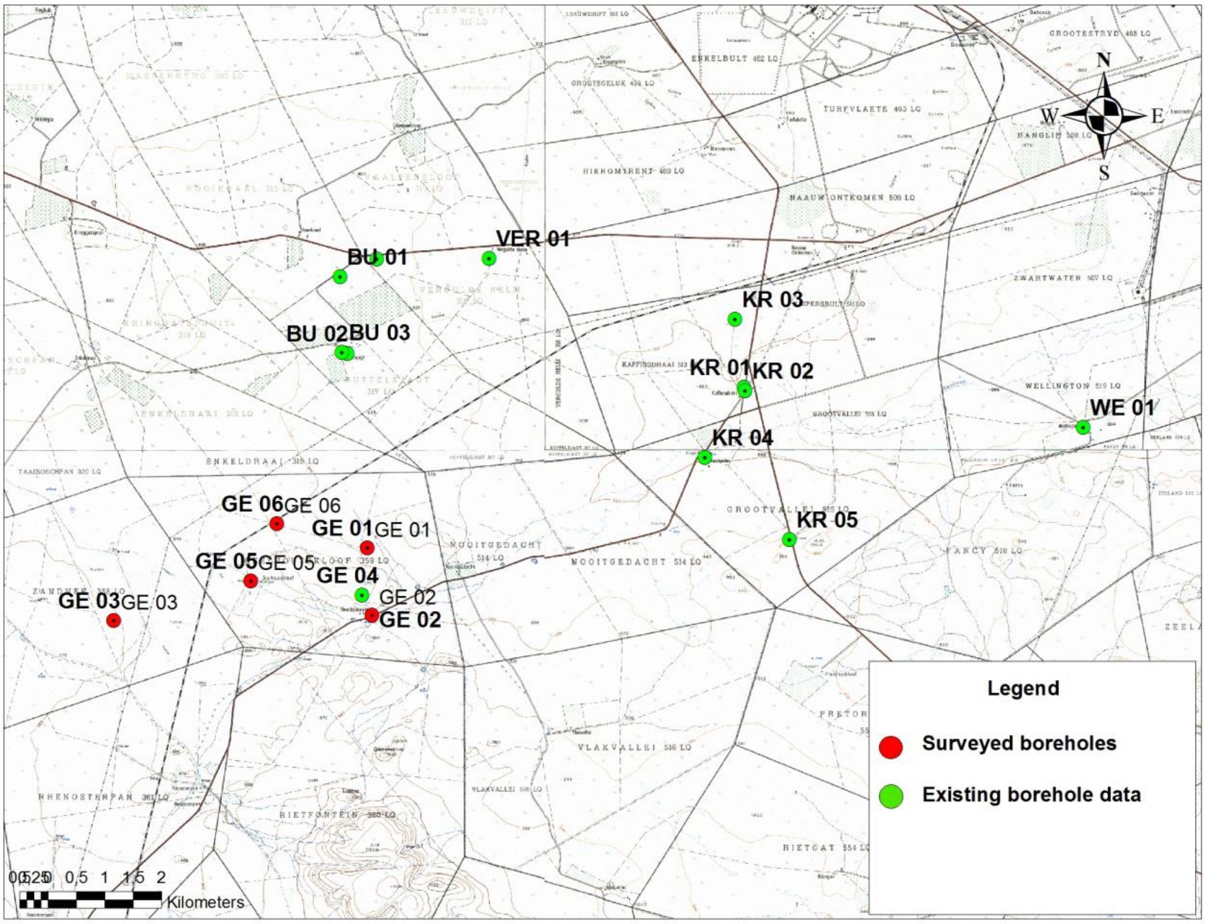

Figure 7: Hydrocensus results

3 Groundwater levels and flow

No consistent groundwater monitoring is being undertaken in the area and no water level data was available for the area until Golder conducted a hydrogeological investigation in 2015. The project baseline groundwater level is based on data obtained from:

- Water levels as measured in the existing boreholes by Golder 2015;
- Water levels as measured in the existing boreholes by Naledzi 2018.

The groundwater level data used to compile the groundwater level map (Figure 8) is presented in Appendix A.

The depth to the groundwater level is generally increasing with an increase in distance from the Sandloop River, therefore, the groundwater flow directions is towards the River, suggesting that Sandloop is a gaining stream.

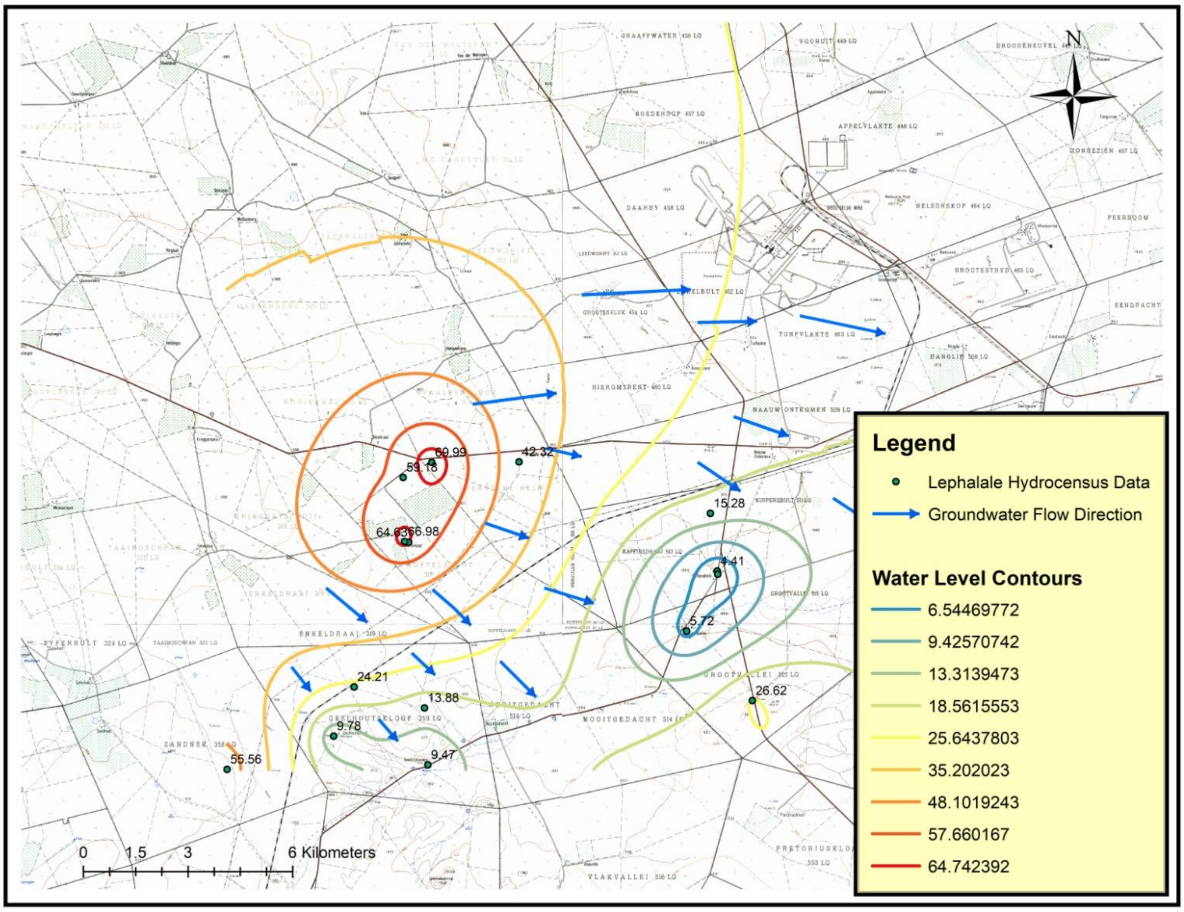

Figure 8: Piezometric surface map of the project area

4 Water quality

4.1 Baseline Water quality

The baseline description for surface and groundwater quality in the study area is required to characterize the water quality condition in the area before infrastructure construction.

4.1.1 Surface water

The rivers and streams in the area are non-perennial and only flow after floods. No surface water samples were collected to determine the surface water baseline quality.

4.1.2 Groundwater

No consistent groundwater monitoring is being undertaken in the area, currently. No samples were collected and analysed in the area prior to the hydrogeological investigations by Golder in 2015. Therefore, the baseline groundwater quality is based on data obtained from water samples collected from the existing groundwater supply boreholes by Golder (2018) and Naledzi (2018). A total of 10 boreholes were sampled by Golder in 2015. Naledzi only sampled two boreholes, which were in use and pumping during the site visit. The samples were submitted to Waterlab Laboratories in Pretoria and Muratho Laboratories for analysis. The water quality analytical results for the samples were used to define the baseline groundwater quality in the area.

The details of the sampled boreholes are presented in Table 2 and their locations are shown in Figure 9.

The water quality gathered in this study will form part of the baseline water quality condition to be used as reference in assessing possible groundwater contamination emanating from proposed activities in the future. The details of the recommended monitoring network to establish a baseline groundwater level and quality data is presented in Section 4 and 6.

Table 2: Details of the sampled boreholes

Site ID	GPS Coordinates WGS 84		Sampling events	Sampled by	Comments
	Latitude	Longitude			
BU-01	-23.71608	27.45864	2015	Golder	Not sampled in 2018
BU-02	-23.73142	27.46008	2015	Golder	Not sampled in 2018
BU-03	-23.73122	27.45906	2015	Golder	Sampled in 2018
GE-01	-23.77053	27.46417	2015, & August 2018	Golder; Naledzi	Sampled in 2018
GE-02	-23.78397	27.46506	2015, & August 2018	Golder; Naledzi	Sampled in 2018
GE-03	-23.78503	27.41322	2015	Golder	Not sampled in 2018
GE-06	-23.76558	27.44603	2015	Golder	Not sampled in 2018
KR-01	-23.73822	27.53972	2015	Golder	Not sampled in 2018
KR-03	-23.72456	27.53794	2015	Golder	Not sampled in 2018
KR-05	-23.76881	27.54878	2015	Golder	Not sampled in 2018
VER-02	-23.71256	27.46608	2015	Golder	Not sampled in 2018

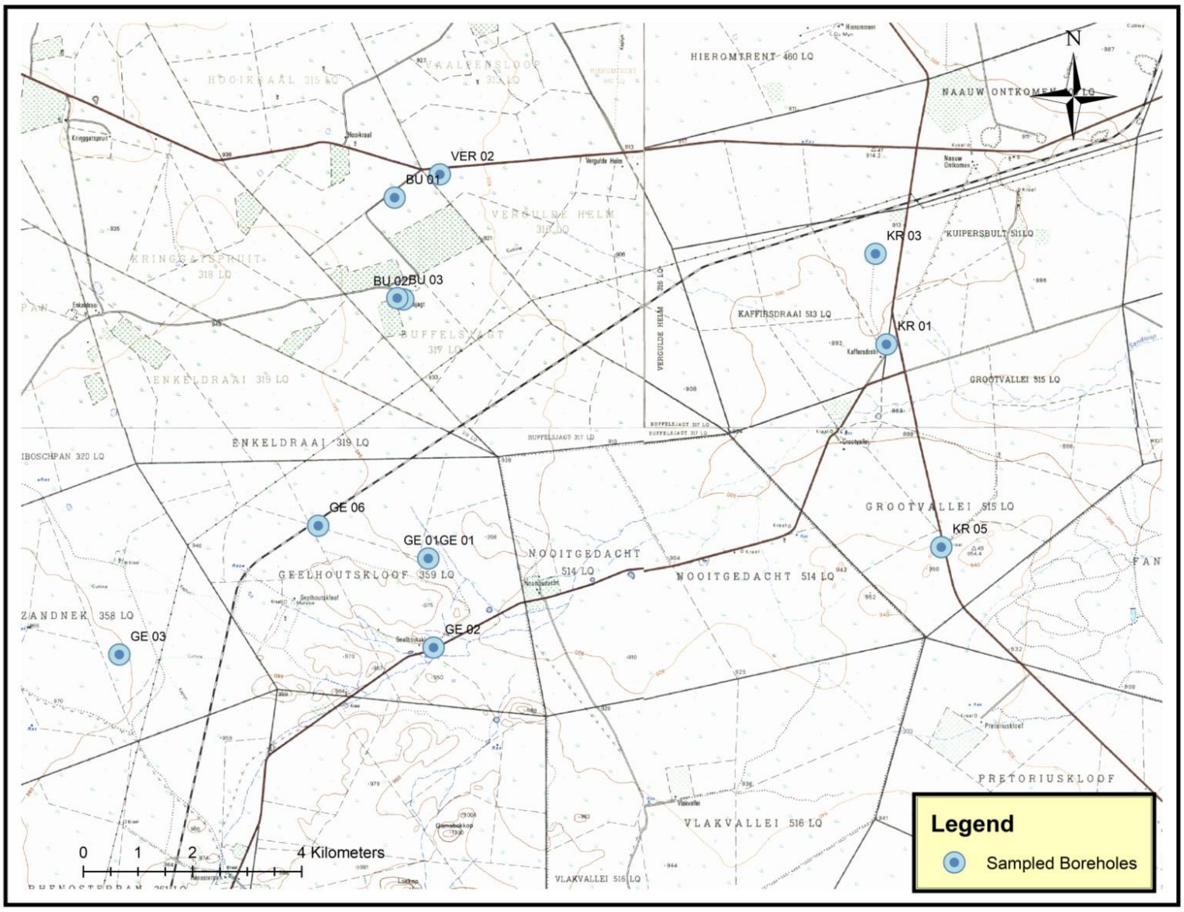

Figure 9: Location of the sampled boreholes

4.2 Applicable guidelines

The land use within the Project area is mainly associated with agricultural practices, game farming, and a few residential areas. The people and wild animals in the area rely on groundwater from boreholes for daily domestic and stock watering purposes. On the basis of the current water use in the area, the baseline water quality is assessed against:

- South African National Standard for drinking water (SANS241:2011); and
- Department of Water Affairs Irrigation and Livestock Watering Guidelines (DWAF, 1996).

A summary of groundwater analytical results together with the stipulated SANS 241:2015 and Irrigation and Livestock Watering Guidelines are presented in Table 3. Parameters with concentrations above the stipulated standards and guidelines are highlighted in yellow.

4.3 Chemical analysis

The analytical results (major cations and anions) of sampled boreholes are listed in Table 3. The water quality classes are classified using the DWAF (1998) drinking water standards.

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 has elevated SO4 concentrations above background groundwater quality levels.

Table 3: Groundwater quality analytical results and compliance limits

WATER CLASS FOR DOMESTIC CONSUMPTION

Light blue	Class 0
Green	Class 1
Yellow	Class 2
Red	Class 3 or 4

	Borehole Number	E.C mS/m	TDS mg/l	Hardness mg/l	NO3 mg/l-NO3	F mg/l	Fe mg/l	Mn mg/l	Mg mg/l	Na mg/l	Cl mg/l	SO4 mg/l
1	BU-01	178.00	1304.39	425.58	0.88	2.30	1.00	0.09	54.05	194.40	336.00	71.00
2	BU-02	204.00	1618.59	603.95	70.72	2.20	6.59	0.78	64.56	194.80	518.00	36.00
3	BU-03	288.00	1828.14	857.68	291.72	2.20	0.11	0.03	95.25	237.80	664.00	62.00
4	GE-01	12.20	535.61	15.00	0.88	0.20	4.82	0.13	1.53	16.91	18.00	5.00
5	GE-01 (Naledzi)	6.50	897.11	163.75	2.96	0.00	4.82	0.08	39.06	6.71	10.20	0.00
6	GE-02 (Naledzi)	56.60	902.72	54.31	11.49	2.80	4.82	0.08	7.04	81.57	134.00	5.00
7	GE-03	124.00	1730.33	126.62	0.88	0.70	0.04	0.12	16.57	200.10	280.00	41.00
8	GE-06	39.60	635.72	187.65	1.33	0.20	0.03	0.07	26.20	11.87	17.00	5.00
9	KR-01	15.70	644.19	31.04	0.88	0.90	7.06	0.07	3.62	11.21	25.00	24.00
10	KR-03	27.40	844.56	49.52	8.84	2.70	0.57	0.14	5.20	23.29	36.00	51.00
11	KR-05	31.00	978.22	44.62	0.88	0.30	2.14	0.04	2.00	52.47	9.00	8.00
12	VER-02	112.00	1073.12	333.61	2.21	1.30	3.61	0.32	34.14	108.10	167.00	40.00

A Piper and Durov diagrams were used to graphically depict the overall composition of the groundwater in the project area based on its major cation and anion composition. To present information on the plots, concentrations in milligrams per litre for major anions and cations are converted to milli-equivalents per litre and then plotted in the lower ternary diagrams to show the percentage contribution of each major ion; one for anions and one for cations. The locations of each sample in the anion and cation ternary fields are then projected into the plots. Waters that lie in similar locations in the plots are interpreted to be of the same origin and general composition.

The groundwater composition of the area is presented on the diagrams (Figure 10 and 11).

The sampled boreholes GE01 Naledzi, GE06 and VER02 groundwater quality on the diagrams (Figure 10 and 11) 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 (Dynamic Water).

Sampled boreholes GE01, GE02 Naledzi, GE01 and KR05 groundwater quality on the diagrams (Figure 10 and 11) show a signature of sodium bicarbonate/chloride type of water, whereas BU01, BU02, BU03, KR01 show a signature of calcium/sodium sulphate water. This type of water is associated with stagnant or old usually polluted groundwater.

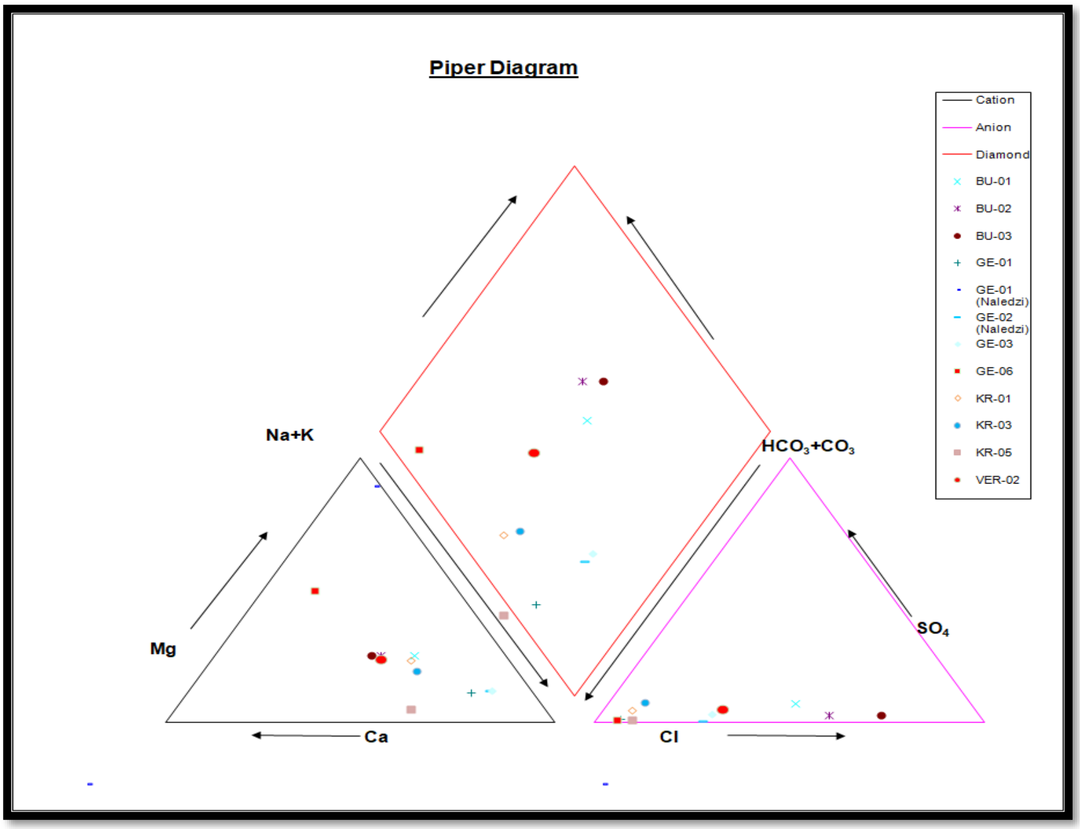

Figure 10: Piper Diagram of the sampled boreholes

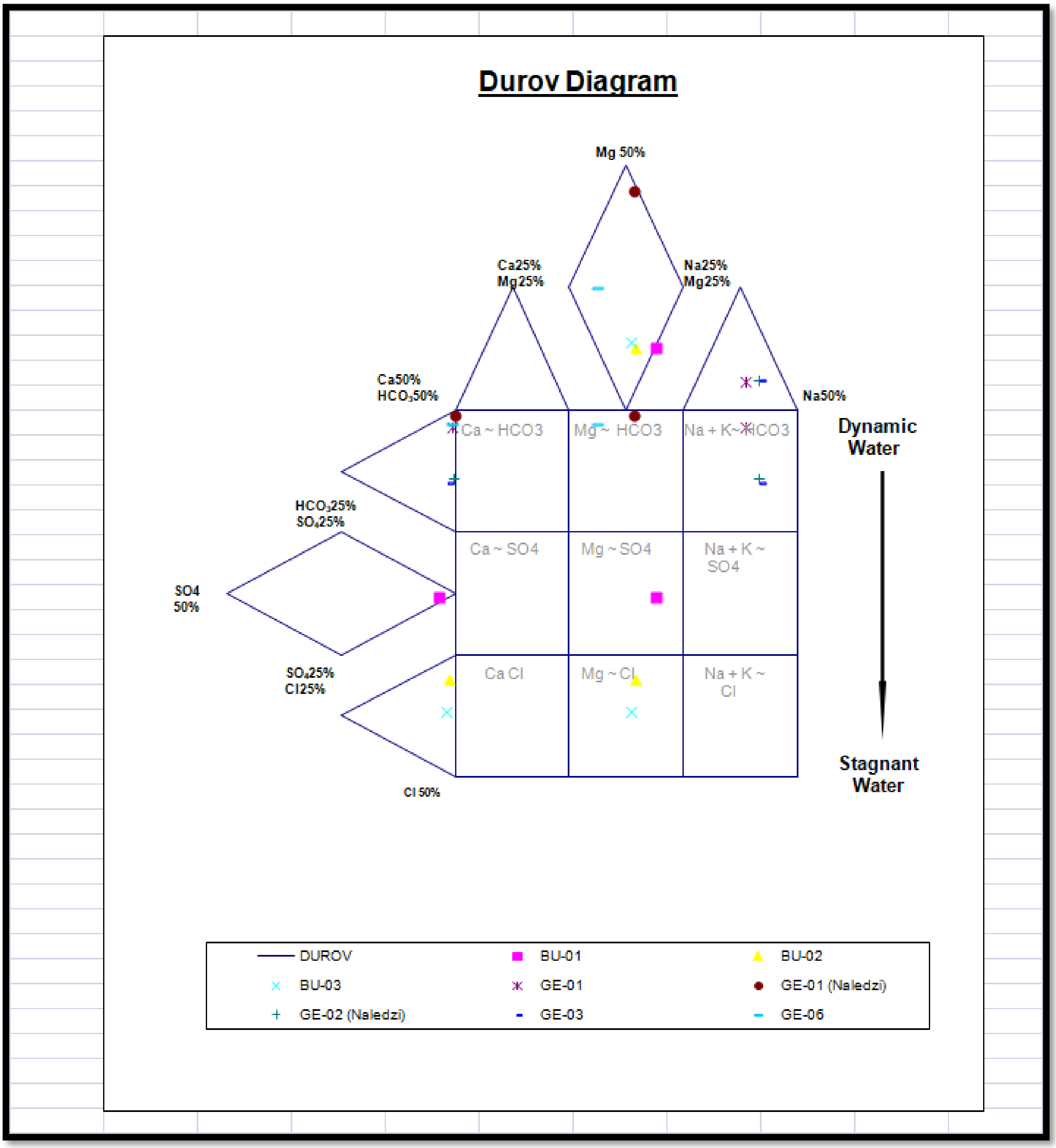

Figure 11: Durov Diagram of the sampled boreholes

5 Impact assessment and mitigation

5.1 Methodology

The major potential risks to groundwater include:

- ✓ Short-term groundwater level impacts
- ✓ Long-term groundwater level impacts (drawdown, and water logging)
- ✓ Interference with existing groundwater users
- ✓ Impacts to groundwater dependent ecosystems

Risk can be defined as the condition resulting from the prospect of an event occurring and the magnitude of its consequences. Therefore, risk is an intrinsic combination of:

- The likelihood of an event occurring and its associated consequences (this incorporates consideration of the frequency of the event and the likelihood of the consequences occurring each time the event occurs)
- The magnitude of potential consequences of the event. The likelihood guide used in the risk assessment is provided as Table 4, while the consequence guide and risk-rating matrix are provided in Table 5 and Figure 12 respectively.

Table 4: Likelihood guide

Likelihood	Description
Almost certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event could occur
Unlikely	The event could occur but not expected
Rare	The event occurs only in exceptional circumstances

Table 5: Consequence guide

Rating	General	Groundwater specific
CRITICAL (5)	Irreversible widespread damage to the environment Stop work notice / fine / prosecution by the relevant authority	1. Short-term groundwater resource depletion with drawdowns greater than 2 metres predicted or impact radius of greater than 300 metres 2. Long-term, widespread (greater than 3 kilometres impact footprint) groundwater resource depletion (drawdown), water level mounding or water logging, or mounding/drawdown greater than 2 metres predicted 3. Interference with existing users, with impact greater than 40% available drawdown predicted or impact to several irrigation/commercial boreholes. 4. Interaction with groundwater from a contaminated site causes irreversible changes to groundwater quality (i.e. to protected beneficial uses of groundwater) – for example, causing human health risk via inhalation of volatile contaminants, and/or existing groundwater borehole no longer safe to use, damage to surface water ecosystems, and/or wetlands 5. Impacts to groundwater dependent ecosystems that result in predicted drawdown greater than 2 metres, or irreversible damage to the beneficial uses of an aquatic ecosystem and/or connected waters/other parts of the environment; localised species extinction
MAJOR (4)	Major environmental hazard caused – long-term recovery. Investigation by the relevant authority	1. Short-term groundwater resource depletion with drawdowns greater than 1 metre predicted or impact radius of greater than 100 metres 2. Long-term, widespread (greater than 3 kilometres impact footprint) groundwater resource depletion (drawdown), water level mounding or water logging (excluding short-term seasonal fluctuations and longer term climatic variation), or mounding/drawdown greater than 1 metre predicted 3. Interference with existing users, with impact of 21% to 40% available drawdown predicted or impact to three or more irrigation/commercial bores or several stock and domestic bores 4. Interaction with groundwater from a contaminated site causes major changes to groundwater quality (i.e. to protected beneficial uses of groundwater) – for example causing human health risk via inhalation of volatile contaminants, and/or existing groundwater bores no

		longer safe to use, and/or damage to surface water ecosystems and/ wetlands 5. Impacts to groundwater dependent ecosystems that result in predicted drawdown greater than 2 metres, or long-term damage to beneficial uses and/or connected waters/other parts of the environment; significant impacts on listed species
MODERATE (3)	Measurable environmental harm – medium-term recovery. Environmental/ heritage/ sustainability incidents reported and managed by agreeing steps with the relevant authority	1. Short-term groundwater resource depletion with drawdowns greater than 0.5 to 1 metres predicted or impact radius of greater than 50 metres 2. Long-term, widespread (greater than 2 kilometres impact footprint) groundwater resource depletion (drawdown), water level mounding or water logging (excluding short-term seasonal fluctuations and longer term climatic variation), or mounding/drawdown greater than 0.5 metres predicted. 3. Interference with existing users, with impact 10% to 20% of available drawdown predicted, or impact to one irrigation/commercial borehole and three or more stock and domestic borehole 4. Interaction with groundwater from a contaminated site causes measurable changes to groundwater quality (i.e. to protected beneficial uses of groundwater) – for example, causing potential human health risk via inhalation of volatile contaminants, existing groundwater borehole require medium term restrictions on use, and/or measureable damage to surface water ecosystems. 5. Impacts to groundwater dependent ecosystems that result in predicted drawdown greater than 0.5 to 1 metres, or short-term damage to beneficial uses and/or connected waters/ other parts of the environment; short-term impacts on species
MINOR (2)	Medium-term immaterial effect on environment. Environmental / heritage / sustainability incidents reported and managed over time by internal procedures in place.	1. Short-term groundwater resource depletion with drawdowns less than 0.5 metres predicted or impact radius of less than 50 metres 2. Spatially limited (less than 1 kilometre impact footprint) long-term groundwater resource depletion (drawdown), water level mounding or water logging (excluding short-term seasonal fluctuations and longer term climatic variation), or mounding/drawdown less than 0.5 metres predicted 3. Interference with existing users, with impact less than 10% available drawdown predicted, or impact to more than one stock and domestic borehole 4. Interaction with groundwater from a contaminated site causes immaterial changes to groundwater quality (i.e. to protected beneficial uses of groundwater) – for example, immaterial effect to

		extractive use of groundwater and/or immaterial effect to surface water ecosystems with medium term recovery time. No human health risk from vapour intrusion 5. Impacts to groundwater dependent ecosystems that result in predicted mounding or drawdown less than 0.5 metres, or localised short-term damage to beneficial uses and/or connected waters/other parts of the environment; temporary loss of water supplies
INSIGNIFICANT (1)	Short-term transient Environmental impact – negligible action required. Environmental incidents reported and managed immediately by internal procedures in place.	1. No inferred short-term groundwater resource depletion or impact radius of less than 10 metres 2. No inferred long-term groundwater resource depletion 3. No interference with existing users predicted, or impact to one stock and domestic bore, or positive impact (increase in available drawdown) to existing bores 4. No long-term impact to groundwater quality (i.e. to protected beneficial uses of groundwater) 5. No predicted impacts to groundwater dependent ecosystems

LIKELIHOOD LEVEL	CONSEQUENCES LEVEL				
	Insignificant	Minor	Moderate	Major	Critical
Almost Certain	Medium	Significant	High	High	High
Likely	Medium	Medium	Significant	High	High
Possible	Low	Medium	Medium	Significant	High
Unlikely	Low	Low	Medium	Medium	Significant
Rare	Low	Low	Low	Medium	Medium

Figure 12: Significance Rating Matrix

5.2 Impact Assessment

5.2.1 Introduction

This section presents the environmental assessment for the effects of the proposed project on groundwater resources. The information presented in this section meets the requirements of the terms of reference as well as the legislative requirements for the project.

The major risk areas identified as relevant to groundwater as a result of short and long-term groundwater impacts due to construction and operation have been assessed in Table 6.

Table 6: Impact assessment and mitigation measures

Activity description	Type of Environment	Initial risk			Action/Mitigations
		Consequence	Likelihood	Risk rating	
Fuel & hydrocarbons spillages from transporting vehicles may cause groundwater contamination	Shallow water Table	Insignificant	Possible	Low	Resort to immediate clean up after accidental spillages. Report any Spillage to the relevant Department
Oil spillages from Storage Drums may cause groundwater contamination	Shallow water Table	Minor	Possible	Medium	The storage facility must be lined and Monitoring of groundwater
Fuel & hydrocarbons spillages from Diesel tanks may cause groundwater contamination	Shallow water Table	Minor	Possible	Medium	Lining of the underlining surface and implementation of monitoring system
Earth Channel (Storage/Evaporation Pond)	Shallow water Table	Minor	Possible	Medium	Lining of the underlining surface
Sewage Treatment System (Bio-Mite)	Groundwater Dependent surrounding Users	Minor	Possible	Medium	Drilling Monitor Boreholes up and down Slope. Implementation of monitoring system
Railyard Stream Crossing	Surface and Groundwater	Minor	Possible	Low	Provide rail Over Stream bridge at stream crossing for storm water runoff

6 Water management and Monitoring

Transnet is currently not or has not started with monitoring of groundwater resources. The proposed monitoring points are listed in Table 7 and Figure 13.

Based on the impact assessment, few groundwater management actions are proposed for the fuel storage tanks and plant upgrade specifically.

The only management actions recommended is to:

- Minimize spillage or wastage of any hazardous material in or at the storage tanks or plant area,
- Thoroughly clean up any leaks, spills or wastage that do occur,
- Implement a regular monitoring program and management actions as required in the event of a significant spill of hazardous material from the plant or storage tanks.
- General waste from the proposed activities should be stored in designated containment areas until removed from the site. These designated areas should be lined surfaces or in the correct storage bins.
- General waste should be handled in a Proper Waste Management procedures.

It is recommended that sampling and analysis of the two boreholes on site be conducted on at least a bi-annual basis, namely towards the end of the dry and the wet seasons. The total organic carbon analysis should continue but additional indicator parameter analyses such as Oil/Soap/Grease analysis is also recommended. For overall impact recognition and effects from nearby industries, inorganic analysis of at least macro element parameters is also strongly recommended at the same time.

Drilling of monitoring boreholes up and down slope of Bio-Mite submerged sewage treatment system for monitoring the waterlevels and quality in case there is leakage in the system is also recommended. BH 3 and BH 4 (Figure 13) are planned for monitoring Bio Mite System (North facility). BH 2 and GE06 (Figure 13) will be used for monitoring Bio Mite System (South facility).

With the mineral oils being mostly in the LNAPL phase, it is recommended that the sampling be conducted from the surface of the water in the boreholes. Different sampling equipment should be used for each borehole to prevent cross-contamination since the hydrocarbons are often only present in very low concentrations.

Table 7: Proposed Groundwater Monitoring points

Site name	Latitude	Longitude	Site description
BH 1 (new)	-23.752126	27.461808	Upslope of the proposed development
BH 2 (new)	-23.764270	27.439973	Upslope of the proposed development
BH 3 (new)	-23.757608	27.455450	Upslope of Bio Mite System (North Facility)
BH 4 (new)	-23.758428	27.458144	Down-slope of Bio Mite System (North Facility)
GE-01	-23.770530	27.464170	Down-slope of the proposed development
GE-06	-23.765580	27.446030	Down-slope of the proposed development

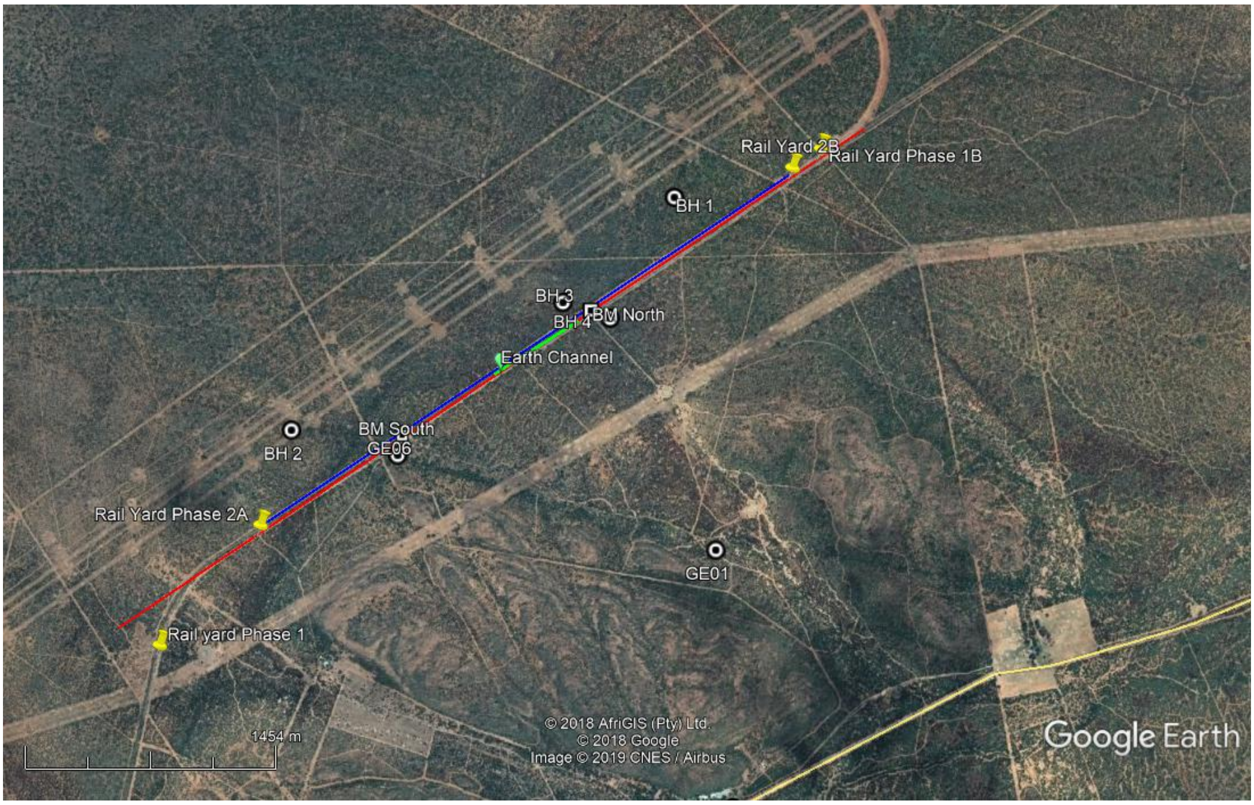

Figure 13: Proposed Activity Localities and Groundwater Monitoring points

7 Conclusions

Extensive work has been done to understand the geological and hydrogeological conditions of the area and the complex water relationships between the underlying geology and the proposed development. Several water specialist reports have been compiled dealing with the availability and quality of the water resources within and around the study area. The following conclusions are based on the finding of the studies conducted within and around the proposed development area:

- ✓ The proposed development area is mainly underlain by Waterberg sediments comprising of sandstone, subordinate conglomerate, siltstone and shale;
- ✓ The initial regional groundwater investigations 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 20.345mbgl; and may take longer for contaminant to reach the water table. Activities such as earth channel, underground fuel tanks or drums, and Bio-Mite sewage system must be lined to minimize leakages and seepages to water table.
- ✓ 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 GE01 Naledzi and GE06 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;
- ✓ Four new boreholes (BH 1, BH 2, BH 3 and BH 4) are proposed for monitoring purposes as indicated on Figure 13,
- ✓ According to simplified groundwater risk rating assessment the proposed development poses a **low to medium** risk of impacting on the surrounding groundwater regime. The management and monitoring system proposed on section 6 must be implemented to minimize impacts from proposed development.

8 REFERENCES

1. Golder 2018. Medupi Power Station: Hydrogeological Impact Assessment for Medupi Flue Gas Desulphurisation Retrofit Project: Report No: 1415777-311754-2_Rev2.
2. IGS 2008. Geohydrological Interpretation, Modelling and Impact Risk Assessment for Medupi Power Station. Report No: 2008/28/PDV.
3. Terblanche R.F, 2019. Wetland Assessment for the proposed Lephalale Railway Yard and Proposed Borrow Areas.
4. 1:250 000, Geological map series.
5. 1:2 500 000, Groundwater Resources map of RSA –Sheet 1 (WRC.DWAF 1995).
6. 1:4 000 000, Groundwater Resources map of RSA – Sheet 2 (WRC.DWAF 1995).
7. 1: 500 000, Hydrogeological Map Series of RSA (1996).

APPENDICES

Appendix A

Borehole Data (Golder 2015)

				MEDUPI FUEL GAS (GOLDER 2015)					
BH NO	**Lattitude**	**Longitude**	**Site name**	**Owner**	**Equipment**	**Diameter (mm)**	**SWL (mbgl)**	**Use**	**Condition**
BU 01	-23.716080	27.458640	Buffelsjagt		Submersible	165	59.18	Domestic/ All purpose	Working
VER 01	-23.712420	27.488560	Verguilde Helm	Hendri Hills	None	165	42.32	Unused	Open
VER 02	-23.712560	27.466080	Verguilde Helm	Hendri Hills	Submersible		69.99	Domestic/ All purpose	Working
BU 02	-23.731420	27.460080	Buffelsjagt		Submersible	165	64.63	Domestic/ All purpose	Working
BU 03	-23.731220	27.459060	Buffelsjagt		Submersible	165	66.98	Domestic/ All purpose	Working
GE 01	-23.770530	27.464170	Geelhoutskloof		None	165	13.88	Unused	Open
GE 02	-23.783970	27.465060	Geelhoutskloof		Submersible	165	9.47	Domestic/ All purpose	Working
GE 03	-23.785030	27.413220	Geelhoutskloof		Submersible	165	55.56	Domestic/ All purpose	Working
GE 04	-23.780000	27.463080	Geelhoutskloof		Windmill	165	9.17	Unused	Broken
GE 05	-23.777170	27.440750	Geelhoutskloof		Submersible	165	9.78	Domestic/ All purpose	Not working
GE 06	-23.765580	27.446030	Geelhoutskloof		Submersible	165	24.21	Stock watering	Working
KR 01	-23.738220	27.539720	Kromdraai	Eskom (Lesee Mr Etienne Rossouw)	Submersible	165	4.41	Domestic/ All purpose	Working
KR 02	-23.738970	27.539860	Kromdraai	Eskom (Lesee Mr Etienne Rossouw)	None	165	Blocked	Unused	Open
KR 03	-23.724560	27.537940	Kromdraai	Eskom (Lesee Mr Etienne Rossouw)	Submersible	165	15.28	Stock watering	Working
KR 04	-23.752390	27.531830	Kromdraai	Eskom (Lesee Mr Etienne Rossouw)	None	165	5.72	Unused	Open
KR 05	-23.768810	27.548780	Kromdraai	Eskom (Lesee Mr Etienne Rossouw)	Submersible	165	26.62	Domestic/ All purpose	Working
WE 01	-23.746280	27.607750	Wellington	Chris Booysen	Windmill	165	8.82	Unused	Not working

Appendix B

Hydrocensus Photos Naledzi 2018

BH01 (GE06)

BH02 (GE05)

BH05 (GE04)

BH06 (GE02)