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REPORT:

ESKOM KUSILE POWER STATION

Baseline Hydrogeological investigation for the proposed
railway route between the existing Pretoria-Witbank railway at
Kusile Power station

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KUSILE POWER STATION –Baseline Hydrogeological Report

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1 INTRODUCTION

Aqua Earth Consulting was appointed by Zitholele Consulting (Pty) Ltd on behalf of Eskom to conduct a *baseline* hydrogeological study and impact assessment for the proposed railway and associated infrastructure from the existing Pretoria-Witbank railway to the Kusile Power Station. The objective of the study is to describe the general study area, the site specific environment, and the potential impacts as a result of the proposed railway project with respect to the hydrogeological environment and to provide mitigation measures where possible impacts are identified.

1.1 Scope of work

The scope of work included the following:

- Review of existing and available geological and hydrogeological information;
- Conduct a borehole hydrocensus in the area,
- Describe the topography, geology and hydrological setting of the study area;
- Characterise the groundwater regime in a regional geological and geohydrological context, based on existing information and information obtained from the hydrocensus;
- Describe the aquifer parameters;
- Determine the pre-project groundwater quality;
- Assess the impact of the proposed development on the environment;
- Determine the preferred railway corridor from a groundwater perspective
- Provide mitigation measures to minimise negative impacts;
- Provide a groundwater level contour map of the area; and
- Compile a report based on the findings and recommendations of the study.

1.2 Background Information to the Project

The following information was available for study:

- Kusile Power Station surface and groundwater monitoring report May 2009 – Zitholele Consulting
- Kusile Power Station surface and groundwater monitoring report June 2009 – Zitholele Consulting

- Kusile Power Station surface and groundwater monitoring report July 2009 – Zitholele Consulting
- Kusile Power Station surface and groundwater monitoring report August 2009 – Zitholele Consulting
- 1: 50 000 Topographical Map of Bronkhorstspuit (toposheet 2528DD),
- 1: 250 000 Geological Map of Pretoria (toposheet 2528),
- 1: 250 000 Land Type Series Map (toposheet 2528)
- 1: 500 000 Hydrogeological Map of Johannesburg (toposheet 2526), and
- Borehole data from Department of Water Affairs (DWA).

2 GENERAL DESCRIPTION OF THE STUDY AREA

2.1 Locality

The study area is located approximately 15 km east of Bronkhorstspuit on the N4 freeway between Witbank and Bronkhorstspuit. The study area includes three farms which are located south of the N4 Pretoria – Witbank Freeway; namely; Onverwacht, Kortfontein and Klipfontein (Refer to figure 2-1).

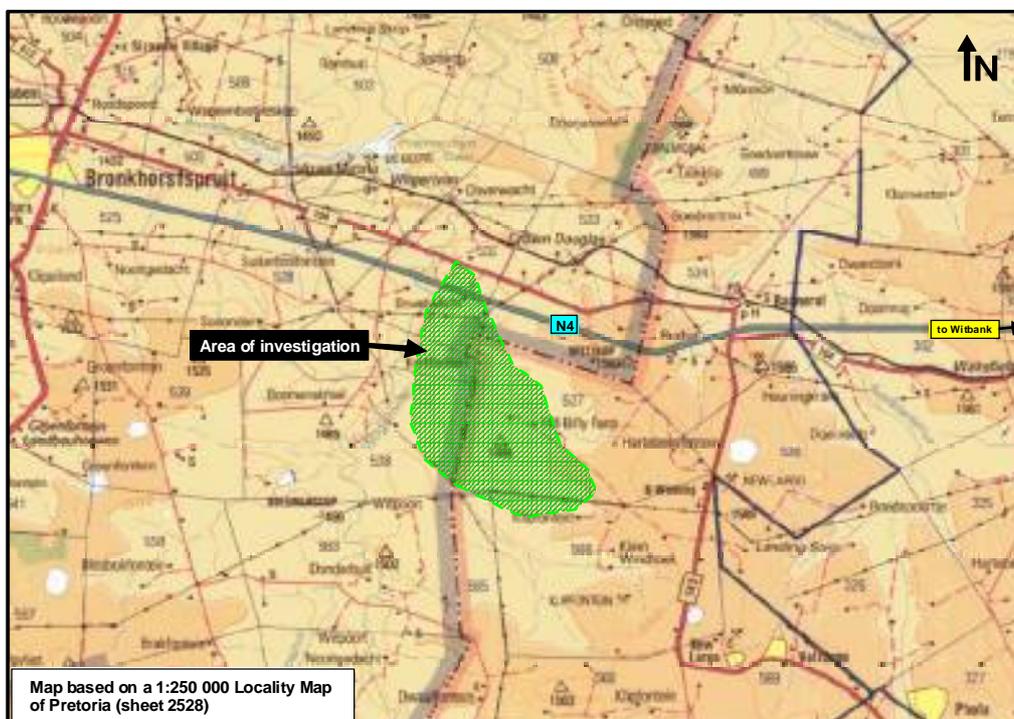


Figure 2-1: Locality map of the study area

2.2 Regional Topography

The topography of the region is gently undulating to moderately undulating landscape of the Highveld plateau. Some small scattered wetlands and pans occur in the area, rocky outcrops and ridges also form part of significant landscape features in the area. The altitude ranges between 1 360 – 1 600 metres above mean sea level (mamsl).

With regards to ridges, all the corridors avoid the ridges found on site, but it should be noted that in various places the corridors do come quite close to ridges.

Surface and groundwater generally flows westwards into the Wilgerivier which in turn flows in a north-northwest direction into the Bronkhorstspruit (refer to figure 2-2).

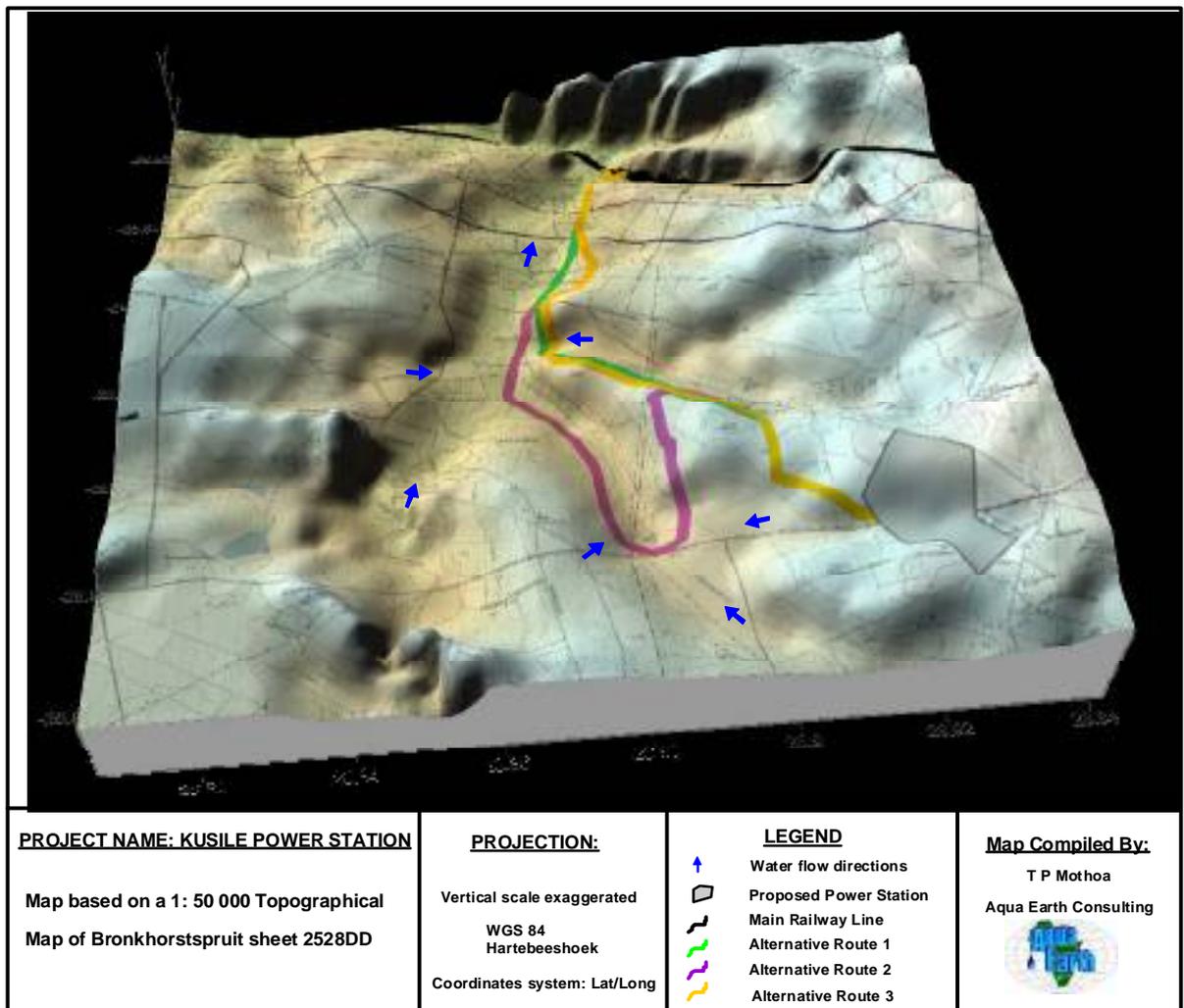


Figure 2-2: 3-D Topographical map illustrating the alternative railway corridors and general surface water flow directions

2.3 Regional Geology

According to the information obtained from a 1:250 000 Geological Map of Pretoria (toposheet 2528), the area under investigation, as illustrated in figure 2-3 and figure 2-4 , is underlain mainly by the following Groups and Formations:

- Dwyka Formation of the Karoo Supergroup (**Pd**) – This formation consists mainly of tillites and shale.
- Wilgerivier Formation (**Mw**) of the Waterberg Group – This formation consists of sandstone and conglomerate.
- Silverton Formation (**Vsi**) of the Pretoria Group – This formation consists mainly of hornfels, carbonaceous and calcareous shale, limestone and quartzite

Early bushveld diabase intrusions (**di**) are also encountered in the study area, mainly in the form of dykes and sills although no specific evidence of these intrusions could be found on site, the presence might be masked by the coverage of both shales and tillites.

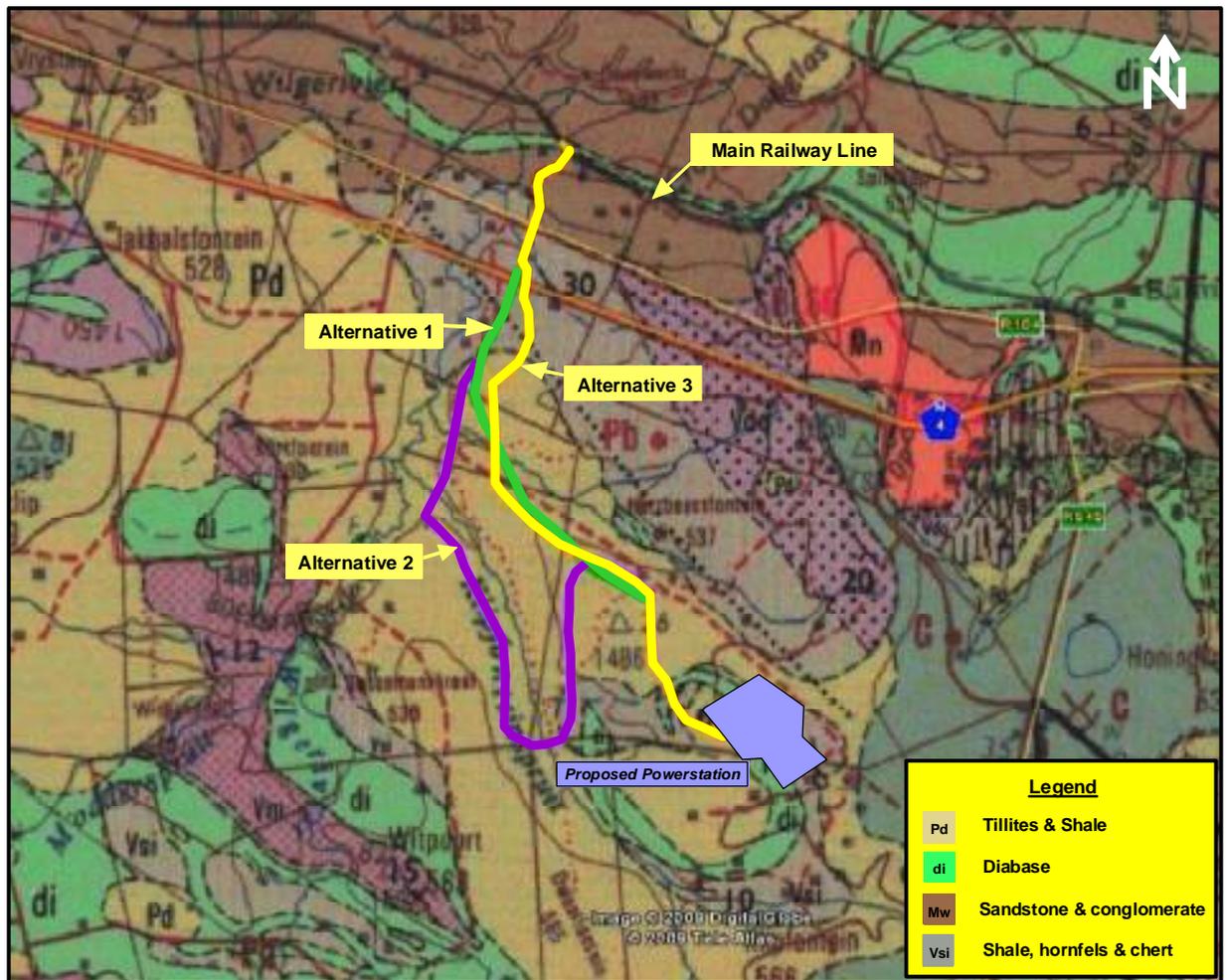


Figure 2-3: Basic Geological map of the study area

The majority of the study area, as indicated in figure 2-5, is covered by the dystrophic or mesotrophic red soils, although in some areas the distribution is somewhat limited.

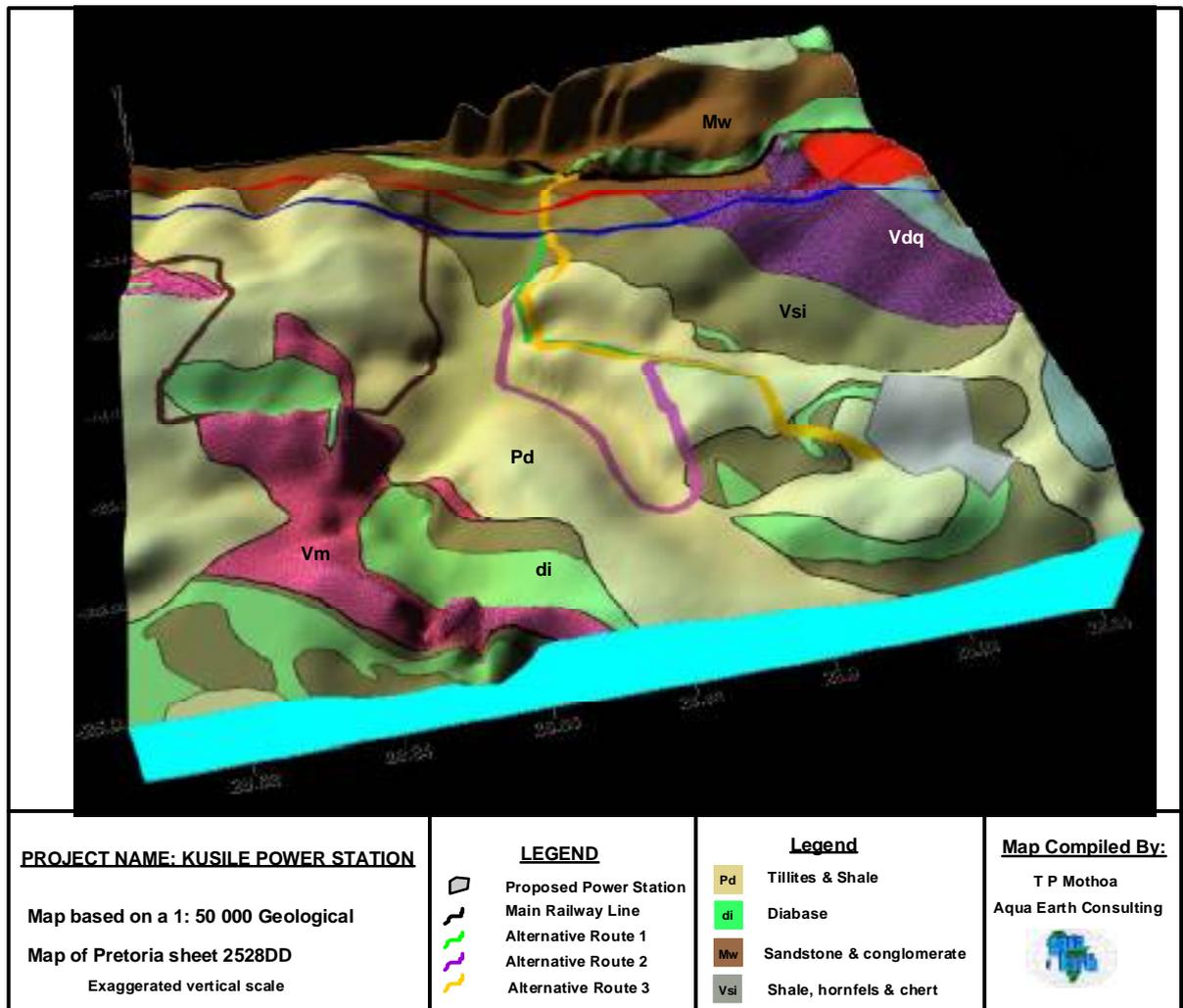


Figure 2-4: 3-D Geological map of the study area – presenting the major lithological unit present in the area.

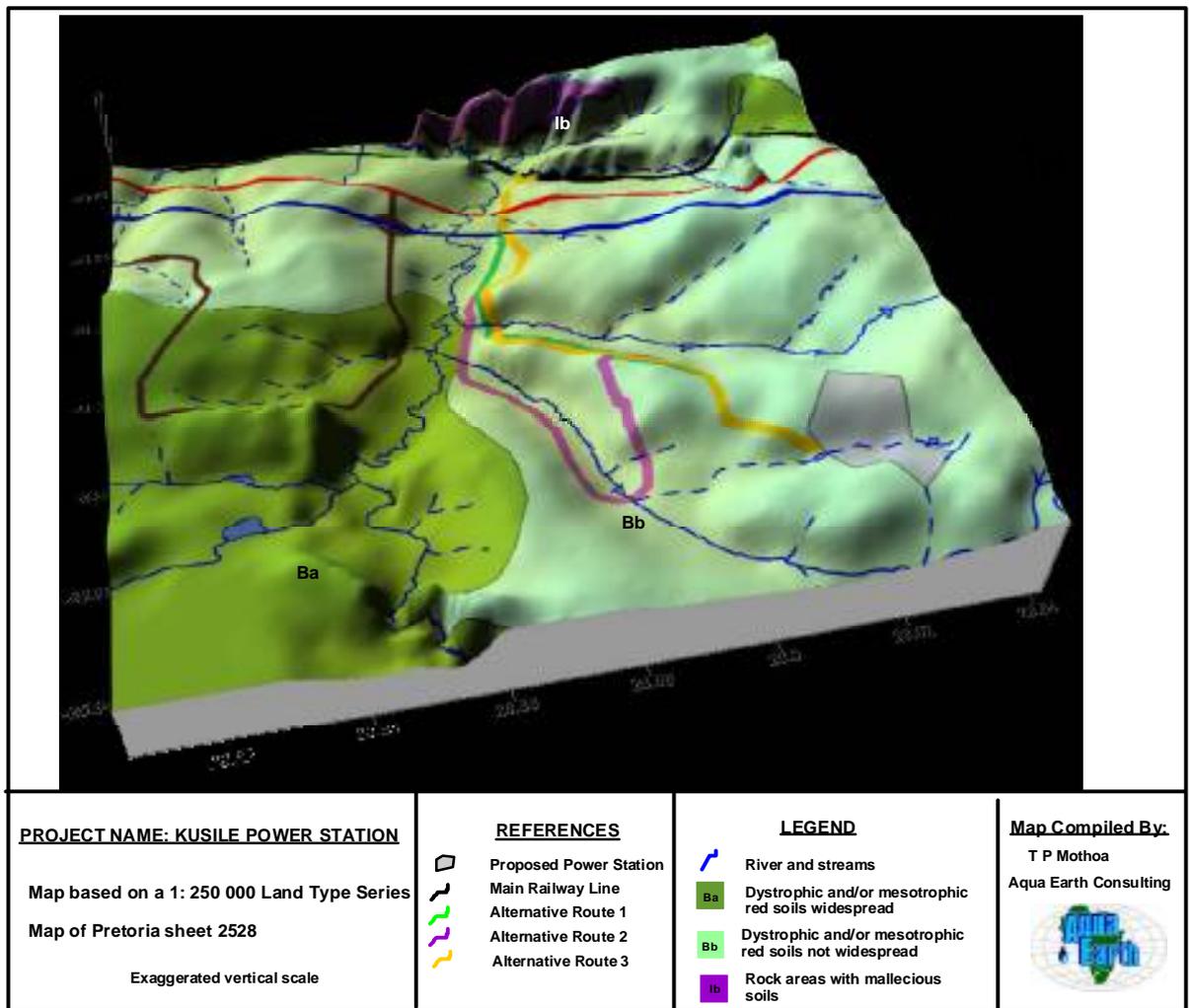


Figure 2-5: 3-D Soil type map

2.4 Hydrogeology:

According to the information obtained from the hydrogeological map of Johannesburg, toposheet 2526, groundwater in the study area occurs mainly within the Dwyka or Silverton Formations of the Karoo Supergroup. The Dwyka tillites are known to have a low permeability. In most cases groundwater in this formation occurs within the weathered zone and sometimes in the contact zone between the Dwyka formation and other formations.

The yield potential is classed as low on the basis that 76 % of boreholes on record produce less than 2 l/s. There is no information regarding the depth of groundwater level for this unit (formation).

The Silverton Formation, which comprises mainly of shales, has a larger groundwater yield potential than that of the overlying Dwyka Formation. Groundwater occurrence in this formation favours weathered shale, brecciated or jointed zones and especially the contact zone between the intrusive diabase sheets and the shale.

The groundwater yield potential is classed as good on the basis that 40 % of boreholes on record produce more than 2 l/s and 22 % produce more than 5 l/s. The groundwater rest level occurs between 10 and 30 mbgl (meters below ground level).

2.5 Groundwater users

The primary groundwater users in the Kusile railway study area are mostly farmers, utilising groundwater for domestic (human consumption and irrigation) and livestock use. Table 3-4 depict the borehole positions and pump installation details as well owner details, where possible, of boreholes identified during the hydrocensus phase of this study.

3 METHODOLOGY

The field investigation was undertaken between the 29 and 30 September 2009. The field activities involved: locating, surveying (determining coordinates), sampling, taking water level measurements and acquiring borehole information of privately owned boreholes in the Kusile Railway study area.

Boreholes samples were collected by means of using the existing pumping equipment and where no equipment was installed, water samples were collected using a hand held bailer. Samples were stored in cooler boxes and delivered to the laboratory the following day.

3.1 Sample Localities

Sampling points were located by means of 1: 50 000 topographical map, aerial photos and information (properties and affected farm owners) provided by Zitholele Consulting.

Information on the positions of sampled boreholes in relation with the proposed railway corridors is provided in Table 3-4 and Figure 3-4 respectively.

3.2 Sampling method

A total of nine samples; six from farm boreholes and two from the nearby stream and/or river; were collected in the field. Six of the hydrocensus boreholes sampled are equipped with submersible pumps and one borehole was equipped with a windpump. These boreholes were sampled at the pump outlet, allowing the pump to run for at least 10 minutes, before collecting a sample. Surface samples were collected from the nearest streams or rivers. The field Ph, EC and TDS were measured by means of a Hanna handheld pH, EC and TDS instrument.

Five water samples (selected based on their spatial distribution) were submitted to an accredited laboratory, in this case UIS laboratory in Pretoria, for analysis.

3.3 Water level measurement

Hydrocensus boreholes sampled were predominantly equipped with submersible or windpumps and measurement of water levels were severely restricted. The sampled boreholes were predominantly equipped with submersible or wind pumps as indicated in table 3-1. As a result most of the boreholes were sealed, which made the measurement of static water levels. In addition to sealed boreholes, farmers were reluctant to allow the field team to lift their pumps to fit the down the hole instruments (e.g. water level meter), in order to take water level measurements.

A recommendation is put forward in this regard.

Extensive water level data does exist for the Kusile Power Station. Monitoring boreholes information provided in monitoring reports compiled by Zitholele Consulting were available for assessment during this study.

Being in similar hydrogeological environments, these levels could provide a fair reflection of what water levels to expect in the newly affected area, and although not ideal does provide some insight as to the depth to groundwater in the area. A recommendation with regards to the measurement of water levels is put forward.

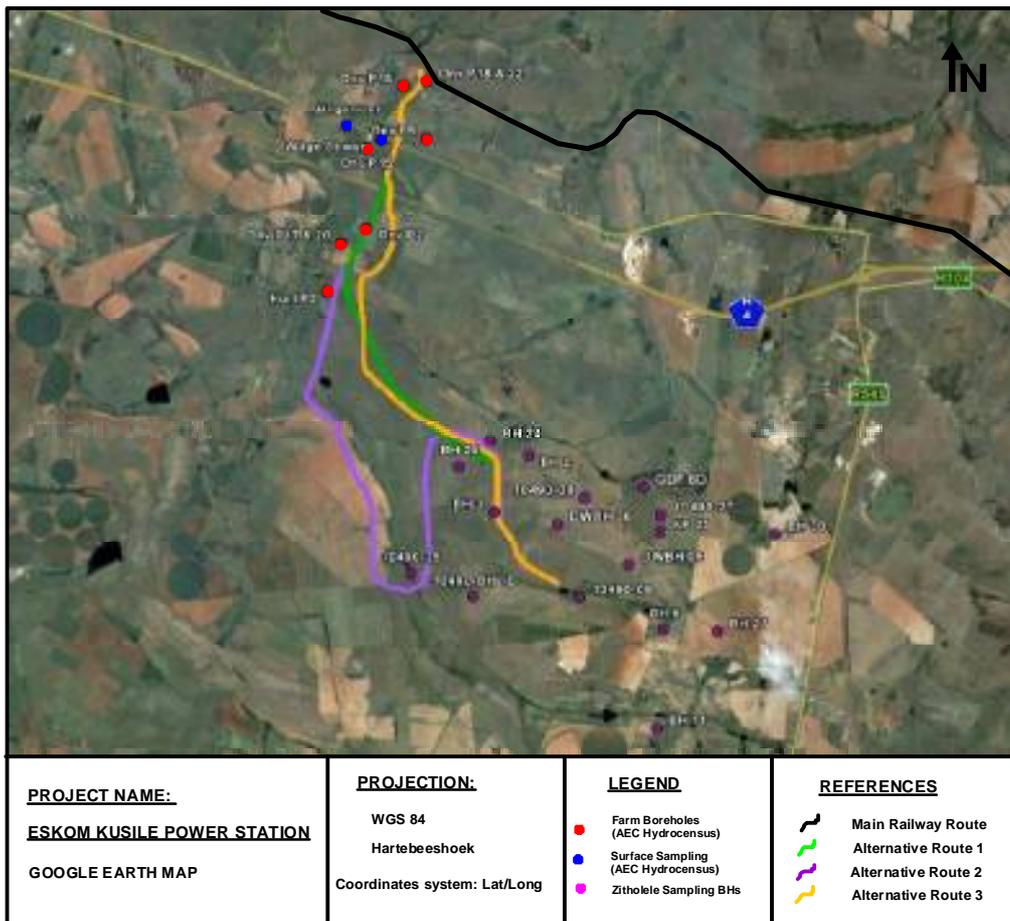


Figure 3-4: Location of boreholes sampled as part of the Kusile station construction site and of the proposed railway corridors

Table 3-4: General borehole information

Table No	Borehole Number	Type of sample	Topographic		Site Name	Owner Name	Date Sampled	Coordinates		Borehole Equipment	Field pH	Field EC mS/m	Field TDS mg/l	Usage
			Map reference					Latitude South	Longitude East					
1	BH 1	BS	2528DDD		Onverwacht P 15	Mr Buks Herman	29/09/2009	-25.84847	28.87527	Submersible	7.23	18.24	130	DWLS
2	BH 2	BS	2528DDD		Onverwacht P 2	Mr Pieter Van Vuren	29/09/2009	-25.86271	28.87527	Submersible	-	-	-	DWLS
3	BH 3	BS	2528DDD		Onverwacht P5,6,9 & 16	Dr Paul Meulenbeld	30/09/2009	-25.84696	28.88706	Windpump	-	-	-	DWLS
4	BH 4	BS	2528DDD		Onverwacht P18 & 22	Mr Thami Sondiyazi	30/09/2009	-25.83665	28.88256	Submersible	-	-	-	DWLS
5	BH 5	BS	2528DDD		Onverwacht P 16	Mr Les Adams	29/09/2009	-25.83753	28.88256	Submersible	6.19	13.18	92.8	DWLS
6	BH 6	BS	2528DDD		Onverwacht P 17 & 20	Mr Manie Venter	29/09/2009	-25.86531	28.87047	Submersible	-	-	-	DWLS
7	BH 7	BS	2528DDD		Onverwacht P 1 & 45	Mr Moses Kgosana	29/09/2009	-25.86001	28.87527	-	-	-	-	-
8	BH 8	BS	2528DDD		Kortfontein P 2	Mr Johan Kotze	29/09/2009	-25.87368	28.86790	Submersible	-	-	-	DWLS
9	BH 9	BS	2528DDD		Onverwacht	-	30/09/2009	-25.84157	28.88772	-	-	-	-	-
10	BH 10	BS	2528DDD		Onverwacht	-	29/09/2009	-25.87251	28.86896	-	-	-	-	-
11	Wilgerivier 1	SS	2528DDD		Wilge Stream	-	30/09/2009	-25.84714	28.87827	N/A	7.74	43	275	-
12	Wilgerivier 2	SS	2528DDD		Wilgerivier	-	30/09/2009	-25.87150	28.87150	N/A	7.77	23.3	163	-

Sampled

* BS - Borehole Sample

* DW - Domestic/ Drinking Water

Not Sampled

* SS - Surface Sampling

* LS - Livestocks

4 CURRENT GROUNDWATER QUALITY

This section illustrates the results of the water quality analysis. These results were interpreted by Aqua Earth in order to form an understanding of the chemical characteristics of the groundwater, i.e. major species distribution. The results of the analyses were also studied in order to evaluate the groundwater in terms of quality compared to drinking water standards set by the Department of Water Affairs (DWA).

4.1 Chemistry results compared to the DWA standards of drinking water

The results presented in table 4-1 illustrate the chemical character of the borehole samples collected during the hydrocensus. These results indicate that groundwater quality in this area is generally of good quality. The inorganic water quality results of these boreholes indicate that water from BH 4 and BH 8 falls into class 4 category; this can be attributed to the elevated Fluoride content. Water from BH 2 and BH 3 falls into a class 1 category while BH 6 falls into a Class 2 category due to elevated iron content.

Class 0 to 1 water is described as good quality water while class 4 is described as water quality not suitable for drinking purposes. Detailed description of these classes is provided in table 4-1 below.

Table 4-1: Chemistry results of samples in the study area compared to the DWA standard for drinking water

PROJECT NAME:		ESKOM KUSILE PROJECT											
Standards		Water Samples								Class of Water			
Borehole No.		Farm Boreholes								Department of Water Affairs and Forestry Standards for drinking water			
Constituent mg/L	BH 2	BH 3	BH 4	BH 6	BH 8	Class 0	Class 1	Class 2	Class 3	Class 4			
						Good				Bad			
TDS	76	94	156	158	256	< 450	450 - 1000	1000 - 2400	2400 - 3400	> 3400			
EC (mS/m)	11.6	16	23	22	41	< 70	70 - 150	150 - 370	370 - 520	> 520			
Nitrate (as N)	1.55	0.75	5.64	0.45	0.06	< 6	6 - 10	10 - 20	20 - 40	> 40			
Fluoride	0.06	0.03	12.85	0.46	12.85	< 0.7	0.7 - 1	1 - 1.5	1.5 - 3.5	< 3.5			
Sulphate	0.9	1.39	2.6	27.75	2.83	< 200	200 - 400	400 - 600	600 - 1000	> 1000			
Magnesium	3.96	3.93	0.19	11.4	0.01	< 70	70 - 100	100 - 200	200 - 400	> 400			
Sodium	15.5	1.93	46.9	20.4	99.1	< 100	100 - 200	200 - 400	400 - 1000	> 1000			
Chloride	1.66	5.33	25.81	4.44	52.18	< 100	100 - 200	200 - 600	600 - 1200	> 1200			
pH	6.7	7.72	8.38	7.29	9.56	5 - 9.5	4.5 - 5 or 9.5 - 10	4 - 4.5 or 10 - 10.5	3 - 4 or 10.5 - 11	< 3 or > 11			
Potassium	0.39	1.28	0.51	1.43	0.19	< 25	25 - 50	50 - 100	100 - 500	> 500			
Calcium	4.57	25.5	8.54	17	1.06	< 80	60 - 150	150 - 300	> 300				
Zinc	-	-	-	-	-	< 3	3 - 5	5 - 10	10 - 20	> 20			
Arsenic	-	-	-	-	-	< 0.01	0.01 - 0.05	0.05 - 0.2	0.2 - 2	> 2			
Cadmium	-	-	-	-	-	< .003	.003 - .005	.005 - .02	.02 - .05	> .05			
Iron	0.65	0.16	0.01	1.87	0.08	< 0.1	0.5 - 1	1 - 5	5 - 10	> 10			
Al	1.49	0.01	0.01	0	0.08			Not Specified					
Min	0	0	0	0.05	0			Not Specified					
Si	9.8	4.84	8.35	12.7	8.15			Not Specified					
N03	-	-	-	-	-			Not Specified					

4.2 Trilinear (Piper) Diagrams

Table 4-1 provides a piper diagram which is commonly developed to evaluate groundwater quality and chemical composition.

Groundwater is described according to the following classifications:

- Recent groundwater having a high calcium or Magnesium bicarbonate (Ca/MgHCO_3) content;
- A dynamic regime containing sodium bicarbonate (NaHCO_3) ground water;
- Stagnant groundwater conditions characterised by calcium or magnesium chloride (Ca/MgCl_2) and calcium or magnesium sulphate (Ca/MgSO_4) groundwater; and
- Old or mature groundwater enriched in Na^+ and Cl^- .

Based on these classifications; groundwater from BH 2, BH 4 and BH8 can be classed as dynamic regime water while BH 3 and BH 6 can be classed as recent water. Dynamic water (often indicates ion exchanged water) contains NaHCO_3 while recent water (or recently recharged) has a high Ca/MgHCO_3 content.

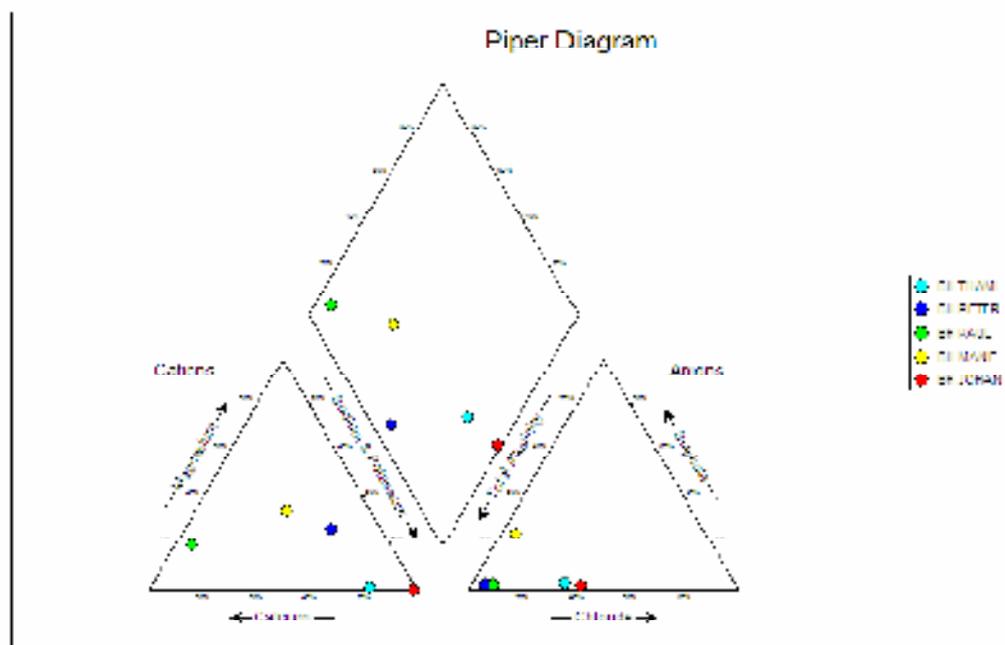


Figure 4-1: Piper diagram of the groundwater chemistry of the hydrocensus boreholes

4.3 Expanded Durov Diagram

In this section the expanded durov diagram is used to classify the groundwater in terms of the water quality (refer to figure 4-2). Water types are classified in terms of the major cations and anions. This diagram can be divided into nine fields each of which describes a particular water type.

The groundwater chemistry of the hydrocensus boreholes plot in the following fields:

- **Field 1 and 2:** Calcium or Magnesium Bicarbonate present in the water. Fresh unpolluted water plots in this field. This water has high $\text{Ca/Mg}(\text{HCO}_3)_2$. The natural geology below the water table could also be the reason for these high chemical elements in groundwater.
- **Field 3:** Sodium Bicarbonate water which often indicates ion exchanged water.

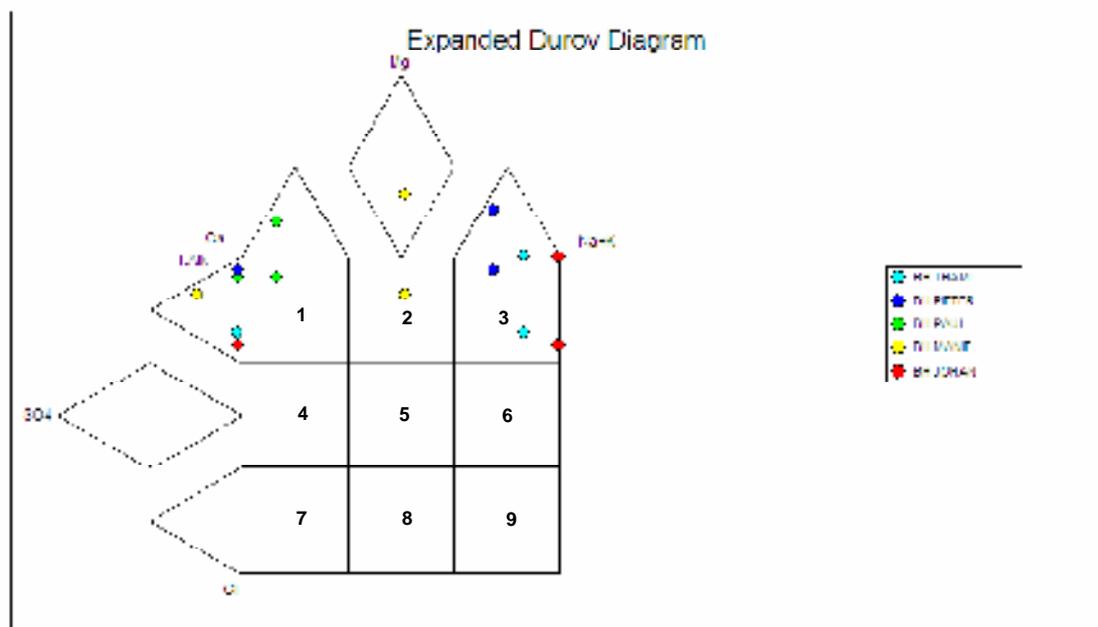


Figure 4-2: Expanded durov diagram of the groundwater chemistry of the sampled boreholes

5 IMPACT ASSESSMENT METHODOLOGY

The impacts are ranked according to the methodology described below. Where possible, mitigation measures are provided to manage impacts. In order to ensure uniformity, a standard impact assessment methodology was 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:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology was used to describe impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in Table 5-1.

Table 5-1: Quantitative rating and equivalent descriptors for the impact assessment criteria

Rating	Significance	Extent Scale	Temporal Scale
1	<u>VERY LOW</u>	<i>Isolated sites / proposed site</i>	<u>Incidental</u>
2	<u>LOW</u>	<i>Study area</i>	<u>Short-term</u>
3	<u>MODERATE</u>	<i>Local</i>	<u>Medium-term</u>
4	<u>HIGH</u>	<i>Regional / Provincial</i>	<u>Long-term</u>
5	<u>VERY HIGH</u>	<i>Global / National</i>	<u>Permanent</u>

A more detailed description of each of the assessment criteria is given in the following sections.

5.1 Significance Assessment

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude, but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of area affected by atmospheric pollution may be extremely large (1 000 km²) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. Similarly, if 60 ha

of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type were known. The impact would be VERY LOW if the grassland type was common. A more detailed description of the impact significance rating scale is given in Table 5-2 below.

Table 5-2: Description of the significance rating scale

Rating		Description
5	Very high	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	High	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	Moderate	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.
2	Low	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	Very low	Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity are needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	No impact	There is no impact at all - not even a very low impact on a party or system.

5.2 Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in Table 5-3.

Table 5-3 : Description of the significance rating scale

Rating		Description
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible, and will be felt at a regional scale (District Municipality to Provincial Level).
3	Local	The impact will affect an area up to 5 km from the proposed study area.
2	Study Area	The impact will affect an area not exceeding the study area.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the power line alignments.

5.3 Duration Scale

In order to accurately describe the impact it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in Table 5-4.

Table 5-4: Description of the temporal rating scale

Rating		Description
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of plant.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

5.4 Degree of Probability

Probability or likelihood of an impact occurring will be described as shown in Table 5-5 below.

Table 5-5 : Description of the degree of probability of an impact occurring

Rating	Description
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

5.5 Degree of Certainty

As with all studies it is not possible to be 100% certain of all facts, and for this reason a standard “degree of certainty” scale is used as discussed in Table 5-5. The level of detail for specialist studies is determined according to the degree of certainty required for decision-making. The impacts are discussed in terms of affected parties or environmental components.

Table 5-6 : Description of the degree of certainty rating scale

Rating	Description
Definite	More than 90% sure of a particular fact.
Probable	Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Between 40 and 70% sure of a particular fact or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact or the likelihood of an impact occurring.
Can't know	The consultant believes an assessment is not possible even with additional research.
Don't know	The consultant cannot, or is unwilling, to make an assessment given available information.

5.6 Quantitative Description of Impacts

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, spatial and temporal scale as described below:

$$\text{Impact Risk} = \frac{(\text{SIGNIFICANCE} + \text{Spatial} + \text{Temporal})}{3} \times \frac{\text{Probability}}{5}$$

An example of how this rating scale is applied is shown below:

Table 5-7 : Example of Rating Scale

Impact	Significance	Spatial Scale	Temporal Scale	Probability	Rating
	LOW	Local	Medium-term	Could Happen	
Impact to air	2	3	3	3	1.6

Note: The significance, spatial and temporal scales are added to give a total of 8, that is divided by 3 to give a criteria rating of 2,67. The probability (3) is divided by 5 to give a probability rating of 0,6. The criteria rating of 2,67 is then multiplied by the probability rating (0,6) to give the final rating of 1,6.

The impact risk is classified according to five classes as described in the table below.

Table 5-8 : Impact Risk Classes

Rating	Impact Class	Description
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

Therefore with reference to the example used for air quality above, an impact rating of 1.6 will fall in the Impact Class 2, which will be considered to be a low impact.

5.7 Cumulative Impacts

It is a requirement that the impact assessments take cognisance of cumulative impacts. In fulfilment of this requirement the impact assessment will take cognisance of any existing impact sustained by the operations, any mitigation measures already in place, any additional impact to environment through continued and proposed future activities, and the residual impact after mitigation measures.

It is important to note that cumulative impacts at the national or provincial level will not be considered in this assessment, as the total quantification of external companies on resources is not possible at the project level due to the lack of information and research documenting the effects of existing activities. Such cumulative impacts that may occur across industry boundaries can also only be effectively addressed at Provincial and National Government levels.

Using the criteria as described above an example of how the cumulative impact assessment will be done is shown below:

Impact	Significance	Spatial Scale	Temporal Scale	Probability	Rating
Initial / Existing Impact (I-IA)	2	2	2	<u>1</u>	0.4
Additional Impact (A-IA)	1	2	<u>1</u>	<u>1</u>	0.3
Cumulative Impact (C-IA)	3	4	<u>2</u>	<u>1</u>	0.6
Residual Impact after mitigation (R-IA)	2	1	<u>2</u>	<u>1</u>	0.3

As indicated in the example above the Additional Impact Assessment (A-IA) is the amount that the impact assessment for each criterion will increase. Thus if the initial impact will not increase, as shown for temporal scale in the example above the A-IA will be 0, however, where the impact will increase by two orders of magnitude from 2 to 4 as in the spatial scale the A-IA is 2. The Cumulative Impact Assessment (C-IA) is thus the sum of the Initial Impact Assessment (I-IA) and the A-IA for each of the assessment criteria.

In both cases the I-IA and A-IA are assessed without taking into account any form of mitigation measures. As such the C-IA is also a worst case scenario assessment where no mitigation measures have been implemented. Thus a Residual Impact Assessment (R-IA) is also made which takes into account the C-IA with mitigation measures. The latter is the most probable case scenario, and for the purpose of this report is considered to be the final state Impact Assessment.

5.8 Notation of Impacts

In order to make the report easier to read the following notation format is used to highlight the various components of the assessment:

- Significance or magnitude- IN CAPITALS
- Temporal Scale – in underline
- Probability – *in italics and underlined*.
- Degree of certainty - **in bold**
- Spatial Extent Scale – *in italics*

6 IMPACT ASSESSMENT

The impact assessment was undertaken for the construction, operational and decommissioning phases of the project. Due to the close proximity of the corridor alternatives and the regional setting, the potential groundwater impact will be the same for all three alternatives and hence only one impact assessment was undertaken.

The railway line will constitute a single railway line with a single overhead line and an access road. According to the design team at Kwezi V3 the impact footprint for such a railway corridor would be approximately 50 m depending on the cut/fill required.

6.1 Initial Impact

Currently the groundwater of the study area is relatively undisturbed with isolated areas of impact. Current impacts include the construction site of the Kusile Power Station, where major terracing and fill operations are underway. Other potential impacts include mining operations upstream of the study area.

6.2 Additional Impact

The additional impact will be the impact of the railway line on groundwater excluding any mitigation measures. During the construction phase two possible causes for groundwater contamination exist, namely: (1) spillage or leakage of hydrocarbons from heavy vehicles and / or generators on site and (2) contamination from pit latrines infiltration. This impact is rated as **Moderate**. The impact to groundwater during the operational phase could result from the spillage of lime from the railway wagons. This impact is rated as **Moderate**.

6.3 Cumulative Impact

The construction cumulative impact of the railway line in combination with the activities already present on site will be a MODERATE negative impact over the *study area* that will remain for the long term. This impact will definitely occur. This results in a rating of **Moderate**.

During the operational phase there will be a MODERATE impact to groundwater. During the decommissioning and closure, the impacts will be the same as assessed for the construction phase, but the end result would be a positive impact.

6.4 Mitigation Measures

The following mitigation measures are proposed to mitigate the impact on groundwater.

- If generators are used they should be placed in a bunded area to capture all potential spillages;
- No pit latrines should be allowed;
- Rail wagons should be covered to prevent any spillages of lime during operations
- Monitoring of groundwater resources along the chosen railway route should be considered once the final route has been determined. If existing boreholes are situated close to the chosen route, these holes could be tested to determine hydraulic parameters and the holes used as part of the monitoring network and protocol of the existing power station. If the final route indicates that there are no observation holes along the chosen route (mainly route 2), additional borehole should be drilled and constructed under supervision of a hydrogeologist to serve as a monitoring point along the railway line.

6.5 Residual Impact

The mitigation measures proposed above will reduce the impact rating to groundwater to a **low** impact.

Table 6-1: Impact Rating Matrix for Groundwater

Construction phase					
Impact Type	Significance	Spatial	Temporal	Probability	Rating
Initial	Moderate	Local	Short Term	Has occurred	2.6 - Moderate
Additional	Moderate	Local	Short Term	Could happen	1.6 – Low
Cumulative	Moderate	Local	Short Term	Could happen	1.6 -Low
Residual	Low	Local	Short Term	Unlikely	0.9 – Very Low
Operational Phase					
Impact Type	Significance	Spatial	Temporal	Probability	Rating
Additional	Moderate	Local	Medium Term	Could happen	1.2 – Low
Cumulative	Moderate	Local	Medium Term	Could happen	1.2 – Low
Residual	Low	Local	Medium Term	Unlikely	0.4 – Very Low
Closure and Rehabilitation Phase					
Impact Type	Significance	Spatial	Temporal	Probability	Rating
Residual	Moderate	Study area	Long Term	Has occurred	3 - Moderate

7 CONCLUSIONS AND RECOMMENDATIONS

Based on the results during this baseline assessment, the following conclusions can be made:

- The Kusile railway study area is underlain by geological formations of the Karoo and Transvaal Supergroup. The main outcrops in this area consist of the Dwyka tillites and Silverton shale Formations whilst the shales are in some instances intruded by early Bushveld diabase.
- Available hydraulic parameters indicate low permeability for these formations and it is expected that fractures or joints in the aquifer will be the main conduits for groundwater flow and pollutant transport. Fractures occur mainly along fault zones and lithological contact planes. This study was however a baseline study with no drilling and testing of observation boreholes took place, no hydraulic parameters were determined by means of borehole tests. A recommendation is put forward in this regard.
- Water levels obtained from boreholes at the power station construction site, sampled by Zitholele Consulting, lie in the range of 3.5 to 23mbgl.
- Groundwater in the study area is generally of good quality, although elevated concentrations of Fluoride (falling in Class 4 – and unsuitable for human consumption) was measured in two boreholes, and elevated Iron concentrations was measured in one borehole(falling in class2 – making unsuitable for consumption in sensitive groups).
- From a hydrogeological point of view the construction of a railway line will have limited to no impact on groundwater quality unless accidental spills and leakages of certain hazardous and harmful materials occur.
- In a case where spillages might occur, swift action, including immediate containment and rapid cleanup of any spill/incident will minimise any impacts to surface and groundwater sources. The specific nature of spills and or incident should however be analysed by a Hydrogeologist and remedial action implemented based on the severity and extend of the incident.

Based on this baseline assessment and conclusions reached, the following recommendations are put forward for consideration and early implementation:

- The existing monitoring network at the Kusile power station should be extended to include monitoring positions along the chosen railway route; this could be either at existing, private boreholes, or at designated newly drilled observation boreholes. The final decision on which option to choose should be determined once the final railway route has been chosen.
- Borehole tests should be carried out on selected existing boreholes to determine aquifer parameters, and assist in the determination of the aquifer lateral extend. This will also confirm the sensitivity of groundwater resources to any possible impacts from both the railway construction and the railway operation.
- All boreholes should be surveyed to determine actual collar heights in meters above mean sea level. All groundwater levels and groundwater contours should then be reported in terms of groundwater elevations, making for a much more accurate presentation of groundwater levels and flow patterns.

8 REFERENCES

- Department of Minerals and Energy and Council for Geosciences, "1: 50 000 Topographical Map of Bronkhorstspuit toposheet 2528DD"
- Department of Minerals and Energy, "1: 250 000 Geological map of Pretoria, toposheet 2528"
- Department of agricultural and environmental affairs, "1: 250 000 Soil type map of Pretoria toposheet 2528"
- Department of Water Affairs, "1: 500 000 Hydrogeological map of Johannesburg toposheet 2526"

APPENDIX A

WATER ANALYSIS CERTIFICATES



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ANALYSIS CERTIFICATE	
Date	2009/10/14
Request No	1708
Contract No	
Order/Ref No	09/024

SAMPLE ID : 112577	SAMPLE MATRIX : Water
SAMPLE NO. : JOHAN/3/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : pH	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T003 (Accredited)	

PARAMETER	VALUE	UNIT
pH	9.56	
pH Temperature	17.4	Deg C

METHOD : Electrical Conductivity	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T001 (Accredited)	

PARAMETER	VALUE	UNIT
Total Conductivity	41	mS/m
TC Temperature	17.4	Deg C

METHOD : Calculated Total Dissolved Solids from EC	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-CP-T001	

PARAMETER	VALUE	UNIT
TDS by EC * 6.5	267	mg/l
TDS by EC * 7	287	mg/l

METHOD : Total Dissolved Solids	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T005 (Accredited)	

PARAMETER	VALUE	UNIT
Total Dissolved Solids	256	mg/l

analysis (əˈnælysis) *n.* separation of something into its elements or components (*pl.* -yses (ɪsɪz)) — chemical *n./a.*, the analysis of material samples to gain an understanding of their chemical composition and structure

SAMPLE ID : 112577	SAMPLE MATRIX : Water
SAMPLE NO.: JOHAN/3/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Calculated Total Dissolved Solids by Summation
METHOD NO.: UIS-CP-T003 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
TDS by Summation	253	mg/l

METHOD : P and Total (M) Alkalinity
METHOD NO.: UIS-EA-T002 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
P Alkalinity	23.2	mg/l CaCO3
Total (M) Alkalinity	105	mg/l CaCO3

METHOD : Dissolved Cations in Water by ICP-OES
METHOD NO.: UIS-TEA-T001 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Al	0.08	mg/l
Ca	1.06	mg/l
Fe	0.08	mg/l
K	0.19	mg/l
Mg	<0.05	mg/l
Mn	<0.05	mg/l
Na	99.1	mg/l
Si	8.15	mg/l

METHOD : Anions by Ion Chromatography
METHOD NO.: UIS-EA-T008 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
F	12.9	mg/l
Cl	52.2	mg/l
NO3	<0.3	mg/l
NO3 as N	<0.3	mg/l
PO4	<0.8	mg/l
SO4	2.83	mg/l

METHOD : Ion Balance Error
METHOD NO.: UIS-CP-T002 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Sum of Cations	4.38	me/l
Sum of Anions	4.92	me/l
Ion Balance Error	-5.84	%

SAMPLE ID : 112577	SAMPLE MATRIX : Water
SAMPLE NO. : JOHAN/3/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Ion Balance Error

METHOD NO. : UIS-CP-T002

DATE COMPLETED : 2009-10-14

PARAMETER

VALUE UNIT

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ANALYSIS CERTIFICATE	
Date	2009/10/14
Request No	1708
Contract No	
Order/Ref No	09/024

SAMPLE ID : 112576	SAMPLE MATRIX : Water
SAMPLE NO. : MANIE/2/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : pH	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T003 (Accredited)	

PARAMETER	VALUE	UNIT
pH	7.29	
pH Temperature	17.4	Deg C

METHOD : Electrical Conductivity	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T001 (Accredited)	

PARAMETER	VALUE	UNIT
Total Conductivity	22	mS/m
TC Temperature	17.4	Deg C

METHOD : Calculated Total Dissolved Solids from EC	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-CP-T001	

PARAMETER	VALUE	UNIT
TDS by EC * 6.5	143	mg/l
TDS by EC * 7	154	mg/l

METHOD : Total Dissolved Solids	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T005 (Accredited)	

PARAMETER	VALUE	UNIT
Total Dissolved Solids	158	mg/l

analysis (əˈnælɪsɪs) *n.* separation of something into its elements or components (*pl.* -yses (ɪsɪːz)) — chemical *n./a.*, the analysis of material samples to gain an understanding of their chemical composition and structure



SAMPLE ID : 112576	SAMPLE MATRIX : Water
SAMPLE NO.: MANIE/2/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Calculated Total Dissolved Solids by Summation
METHOD NO.: UIS-CP-T003 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
TDS by Summation	170	mg/l

METHOD : P and Total (M) Alkalinity
METHOD NO.: UIS-EA-T002 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
P Alkalinity	<0.6	mg/l CaCO3
Total (M) Alkalinity	83.8	mg/l CaCO3

METHOD : Dissolved Cations in Water by ICP-OES
METHOD NO.: UIS-TEA-T001 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Al	<0.05	mg/l
Ca	17	mg/l
Fe	1.87	mg/l
K	1.43	mg/l
Mg	11.4	mg/l
Mn	0.05	mg/l
Na	20.4	mg/l
Si	12.7	mg/l

METHOD : Anions by Ion Chromatography
METHOD NO.: UIS-EA-T008 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
F	0.46	mg/l
Cl	4.44	mg/l
NO3	1.98	mg/l
NO3 as N	0.45	mg/l
PO4	<0.8	mg/l
SO4	27.8	mg/l

METHOD : Ion Balance Error
METHOD NO.: UIS-CP-T002 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Sum of Cations	2.78	me/l
Sum of Anions	3.06	me/l
Ion Balance Error	-4.83	%

SAMPLE ID : 112576	SAMPLE MATRIX : Water
SAMPLE NO. : MANIE/2/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Ion Balance Error

METHOD NO. : UIS-CP-T002

DATE COMPLETED : 2009-10-14

PARAMETER

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ANALYSIS CERTIFICATE	
Date	2009/10/14
Request No	1708
Contract No	
Order/Ref No	09/024

SAMPLE ID :	112580	SAMPLE MATRIX :	Water
SAMPLE NO. :	PAUL/8/30/09/09	DATE RECEIVED :	2009-09-30

METHOD :	pH	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-EA-T003 (Accredited)		
PARAMETER		VALUE	UNIT
pH		7.72	
pH Temperature		17.7	Deg C

METHOD :	Electrical Conductivity	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-EA-T001 (Accredited)		
PARAMETER		VALUE	UNIT
Total Conductivity		16	mS/m
TC Temperature		17.7	Deg C

METHOD :	Calculated Total Dissolved Solids from EC	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-CP-T001		
PARAMETER		VALUE	UNIT
TDS by EC * 6.5		104	mg/l
TDS by EC * 7		112	mg/l

METHOD :	Total Dissolved Solids	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-EA-T005 (Accredited)		
PARAMETER		VALUE	UNIT
Total Dissolved Solids		94	mg/l

analysis (əˈnælɪsɪs) *n.* separation of something into its elements or components (*pl.* -yses (ɪsɪːz)) — chemical *n./a.*, the analysis of material samples to gain an understanding of their chemical composition and structure

SAMPLE ID : 112580	SAMPLE MATRIX : Water
SAMPLE NO.: PAUL/8/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Calculated Total Dissolved Solids by Summation
METHOD NO.: UIS-CP-T003 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
TDS by Summation	101	mg/l

METHOD : P and Total (M) Alkalinity
METHOD NO.: UIS-EA-T002 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
P Alkalinity	<0.6	mg/l CaCO3
Total (M) Alkalinity	75.7	mg/l CaCO3

METHOD : Dissolved Cations in Water by ICP-OES
METHOD NO.: UIS-TEA-T001 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Al	<0.05	mg/l
Ca	25.5	mg/l
Fe	0.16	mg/l
K	1.28	mg/l
Mg	3.93	mg/l
Mn	<0.05	mg/l
Na	1.93	mg/l
Si	4.84	mg/l

METHOD : Anions by Ion Chromatography
METHOD NO.: UIS-EA-T008 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
F	<0.1	mg/l
Cl	5.33	mg/l
NO3	3.34	mg/l
NO3 as N	0.75	mg/l
PO4	<0.8	mg/l
SO4	1.39	mg/l

METHOD : Ion Balance Error
METHOD NO.: UIS-CP-T002 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Sum of Cations	1.72	me/l
Sum of Anions	1.84	me/l
Ion Balance Error	-3.43	%

SAMPLE ID : 112580	SAMPLE MATRIX : Water
SAMPLE NO. : PAUL/8/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Ion Balance Error

METHOD NO. : UIS-CP-T002

DATE COMPLETED : 2009-10-14

PARAMETER

VALUE UNIT

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ANALYSIS CERTIFICATE	
Date	2009/10/14
Request No	1708
Contract No	
Order/Ref No	09/024

SAMPLE ID :	112578	SAMPLE MATRIX :	Water
SAMPLE NO. :	PIETER/4/30/09/09	DATE RECEIVED :	2009-09-30

METHOD :	pH	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-EA-T003 (Accredited)		

PARAMETER	VALUE	UNIT
pH	6.7	
pH Temperature	17.4	Deg C

METHOD :	Electrical Conductivity	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-EA-T001 (Accredited)		

PARAMETER	VALUE	UNIT
Total Conductivity	11.6	mS/m
TC Temperature	17.4	Deg C

METHOD :	Calculated Total Dissolved Solids from EC	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-CP-T001		

PARAMETER	VALUE	UNIT
TDS by EC * 6.5	75.4	mg/l
TDS by EC * 7	81.2	mg/l

METHOD :	Total Dissolved Solids	DATE COMPLETED :	2009-10-14
METHOD NO. :	UIS-EA-T005 (Accredited)		

PARAMETER	VALUE	UNIT
Total Dissolved Solids	76	mg/l

analysis (əˈnælɪsɪs) *n.* separation of something into its elements or components (*pl.* -yses (ɪsɪːz)) — chemical *n./a.*, the analysis of material samples to gain an understanding of their chemical composition and structure



SAMPLE ID : 112578	SAMPLE MATRIX : Water
SAMPLE NO.: PIETER/4/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Calculated Total Dissolved Solids by Summation
METHOD NO.: UIS-CP-T003 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
TDS by Summation	86.6	mg/l

METHOD : P and Total (M) Alkalinity
METHOD NO.: UIS-EA-T002 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
P Alkalinity	<0.6	mg/l CaCO3
Total (M) Alkalinity	43.6	mg/l CaCO3

METHOD : Dissolved Cations in Water by ICP-OES
METHOD NO.: UIS-TEA-T001 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Al	1.49	mg/l
Ca	4.57	mg/l
Fe	0.65	mg/l
K	0.39	mg/l
Mg	3.96	mg/l
Mn	<0.05	mg/l
Na	15.5	mg/l
Si	9.8	mg/l

METHOD : Anions by Ion Chromatography
METHOD NO.: UIS-EA-T008 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
F	<0.1	mg/l
Cl	1.66	mg/l
NO3	6.87	mg/l
NO3 as N	1.55	mg/l
PO4	<0.8	mg/l
SO4	0.9	mg/l

METHOD : Ion Balance Error
METHOD NO.: UIS-CP-T002 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Sum of Cations	1.43	me/l
Sum of Anions	1.6	me/l
Ion Balance Error	-5.87	%

SAMPLE ID : 112578	SAMPLE MATRIX : Water
SAMPLE NO. : PIETER/4/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Ion Balance Error

METHOD NO. : UIS-CP-T002

DATE COMPLETED : 2009-10-14

PARAMETER

VALUE UNIT

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ANALYSIS CERTIFICATE	
Date	2009/10/14
Request No	1708
Contract No	
Order/Ref No	09/024

SAMPLE ID : 112579	SAMPLE MATRIX : Water
SAMPLE NO. : THAMI/7/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : pH	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T003 (Accredited)	

PARAMETER	VALUE	UNIT
pH	8.38	
pH Temperature	17.4	Deg C

METHOD : Electrical Conductivity	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T001 (Accredited)	

PARAMETER	VALUE	UNIT
Total Conductivity	23	mS/m
TC Temperature	17.4	Deg C

METHOD : Calculated Total Dissolved Solids from EC	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-CP-T001	

PARAMETER	VALUE	UNIT
TDS by EC * 6.5	150	mg/l
TDS by EC * 7	161	mg/l

METHOD : Total Dissolved Solids	DATE COMPLETED : 2009-10-14
METHOD NO. : UIS-EA-T005 (Accredited)	

PARAMETER	VALUE	UNIT
Total Dissolved Solids	156	mg/l

analysis (əˈnælɪsɪs) *n.* separation of something into its elements or components (*pl.* -yses (ɪsɪːz)) — chemical *n./a.*, the analysis of material samples to gain an understanding of their chemical composition and structure



SAMPLE ID : 112579	SAMPLE MATRIX : Water
SAMPLE NO.: THAMI/7/30/09/09	DATE RECEIVED : 2009-09-30

METHOD : Calculated Total Dissolved Solids by Summation
METHOD NO.: UIS-CP-T003 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
TDS by Summation	152	mg/l

METHOD : P and Total (M) Alkalinity
METHOD NO.: UIS-EA-T002 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
P Alkalinity	0.8	mg/l CaCO ₃
Total (M) Alkalinity	66	mg/l CaCO ₃

METHOD : Dissolved Cations in Water by ICP-OES
METHOD NO.: UIS-TEA-T001 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Al	<0.05	mg/l
Ca	8.54	mg/l
Fe	<0.05	mg/l
K	0.51	mg/l
Mg	0.19	mg/l
Mn	<0.05	mg/l
Na	46.9	mg/l
Si	8.35	mg/l

METHOD : Anions by Ion Chromatography
METHOD NO.: UIS-EA-T008 (Accredited) **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
F	5.64	mg/l
Cl	25.8	mg/l
NO ₃	<0.3	mg/l
PO ₄	<0.8	mg/l
SO ₄	2.6	mg/l

METHOD : Ion Balance Error
METHOD NO.: UIS-CP-T002 **DATE COMPLETED :** 2009-10-14

PARAMETER	VALUE	UNIT
Sum of Cations	2.5	me/l
Sum of Anions	2.79	me/l
Ion Balance Error	-5.5	%

 AUTHORISED SIGNATURE