GEOHYDROLOGICAL INVESTIGATIONS FOR THE PROPOSED DEVELOPMENT OF SAMARA PTY LTD PROSPECTING ACTIVITIES FOR ALLUVIAL DIAMONDS AND ASSOCIATED INFRASTRUCTURE, NORTHERN CAPE PROVINCE

Prepared by

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Prepared for

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Date: August 2020

EXECUTIVE SUMMARY

Introduction

Nyamoki Consulting Pty Ltd has been tasked to undertake the geohydrological study for the proposed prospecting activities for alluvial diamond on the remainder on the Farm Than No.280 (Vaal River) and the portion of the farm No.350 located within the Administrative District of Barkly West in the Northern Cape Province. The proposed Prospecting Right The proposed prospecting area is located approximately 22 Km Northwest of Barkly West in the Barkly West Magisterial District 25.49 hectares for prospecting activities for alluvial diamonds.

The proposed project involves the development of an opencast diamond mine and supporting infrastructure. The diamond material will be excavated from the pit using a bucket excavator and transported by an ADT to the overburden stockpile area. The proposed mine will require support infrastructure such as water access roads, storage, fuel storage, waste dump, topsoil storage

The project involves the development of an opencast diamond mine and supporting infrastructure. Due to the proximity of the diamond resources to the surface, an open cut method was the best option to extract the resources hence the diamonds will be mined through opencast using conventional truck and excavator mining methods. The mining blocks will be 50m by 20m and the benches 10m high.

Recommendation

Based on these principle's objectives and the significance of this aquifer classification, if any potential risk exist, measures must be put in place to limit the risk to the environment, which in this case is the protection of the Primary Underlying Aquifer.

Due to low likelihood of pollution as a result of the nature of the proposed activity, it is therefore recommended 2 prospecting boreholes be used for water quality monitoring and groundwater level monitoring. These boreholes should be on the southern boundary of the farm Than to monitor possible impacts to the Vaal River and groundwater within the proposed prospecting area.

Conclusions

- The study area is characterised by clay and dolerite rocks;
- The groundwater flow direction is expected to be towards the northern boundary of the proposed project area;
- Vaal River is the only river flowing passing along the vicinity of the proposed project area;
- The main aquifer is fractured with estimated borehole yield of 0.1 to 0.5 l/s;

- Groundwater quality was not sampled due to the lack of borehole within the site;
- However, 2 prospecting boreholes to be drilled and were recommended for water level and quality monitoring;
- The aquifer is classified as a minor aquifer but with high vulnerability to pollution due to its natural composition, hence monitoring was recommended;
- The aquifer risk assessment was ranked medium, however strict implementation and compliance to pollution prevention and mitigation measures was emphasized;
- The proposed activity (prospecting) has less potential for groundwater contamination
- Potential risk, impact level and mitigation were indicated for each activity;
- It is therefore recommended that the proposed prospecting activity be granted as it has low impact on groundwater resource.

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1. INTRODUCTION

1.1. Project description

Nyamoki Consulting Pty Ltd has been tasked to undertake the geohydrological study for the proposed prospecting activities for alluvial diamond on the remainder on the Farm Than No.280 (Vaal River) and the portion of the farm No.350 located within the Administrative District of Barkly West in the Northern Cape Province. The proposed Prospecting Right The proposed prospecting area is located approximately 22 Km Northwest of Barkly West in the Barkly West Magisterial District 25.49 hectares for prospecting activities for alluvial diamonds.

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1.2. Terms of Reference

The specified terms of reference for the Specialist Geohydrological study are as follows:

- Conduct a desktop study of the geology and geohydrology of the study area with specific reference to the water production potential of the aquifers related to the catchment;
- A site visit to the study site and adjacent farms which could be impacted by the activities in order to observe the geology, specific features and rivers in the catchment. Identify features which have particular significance;
- Conduct a pump test to determine the yield of aquifer within the study area;
- Describe potential impact of aggregate stone-dolerite, clay and sand prospecting activities on the receiving environment particularly as related to water production of the property and the catchment and also any pollution to the water in other properties.

1.3. Methodology

The study will be conducted as follows:

- Conduct a detailed desktop study gathering existing information from topographical maps, geological maps, geohydrological maps, hydrological information, National Groundwater Data Base (NGDB), published and unpublished reports etc.
- Perform 1km radius borehole hydro-census survey around the proposed prospecting area to assess groundwater use status in the area.
- Perform a risk assessment including possible mitigation measures and recommendations.
  The risk assessment will be 1st order assessment in line with the guidelines of DME's Aid Memoir of 1992, with the aim of identifying all of the possible impacts.
- Compile a basic assessment report incorporating all the above items and also line with the TOR.

2. DESCRIPTION OF THE RECEIVING ENVIRONMENT

2.1. Locality

The proposed Prospecting Right The proposed prospecting area is located approximately 22 Km Northwest of Barkly West in the Barkly West Magisterial District 25.49 hectares for prospecting activities for alluvial diamonds. The application runs on the remainder on the Farm Than No.280 (Vaal River) and the portion of the farm No.350. The property is accessed via R31 Main Road which doesn't also form part of the boundary (Fig 1).

Figure 1: Locality Map of the proposed activity

2.2. Topography

The Municipality's landscape consists of main plains, the escarpment, and hills. The latter covers 80% of the study area. This landscape is broken in places by a series of often dramatic ridges. The pattern of the topography reinforces the dual nature of the Municipality with the Harts and Vaal River Valley as a divide. To the west, the Municipality rises over the Ghaap Escarpment which forms a dramatic barrier in a line from the southwest to the northeast. The escarpment of the Ghaap Plateau represents the eastern fringe of the Kalahari. To the east of the Vaal River, the area comprises mainly hills and plains of a morphological system that is physically part of the larger Free State Province.

These hills and plains are cut by the major rivers, the Vaal, and the Harts, sometimes through dramatic gorges and along scenic river cliffs, e.g. along Barkly West. The scenery is dramatic in these areas which are seen as having important tourism potential. Breaches in the Ghaap Escarpment create passes through which the major road routes cross; the N8, the R31 and rail line to Sishen, and the minor route to the north of the Municipality that links with the R31 route to Kuruman. Morphologically it can be seen that the Municipality east of the Vaal River is part of the Free State plains. This pattern gives rise to vast wilderness areas offering extensive views contrasted with dramatic river gorges offering considerable visual amenity and tourism potential (Fig 2).

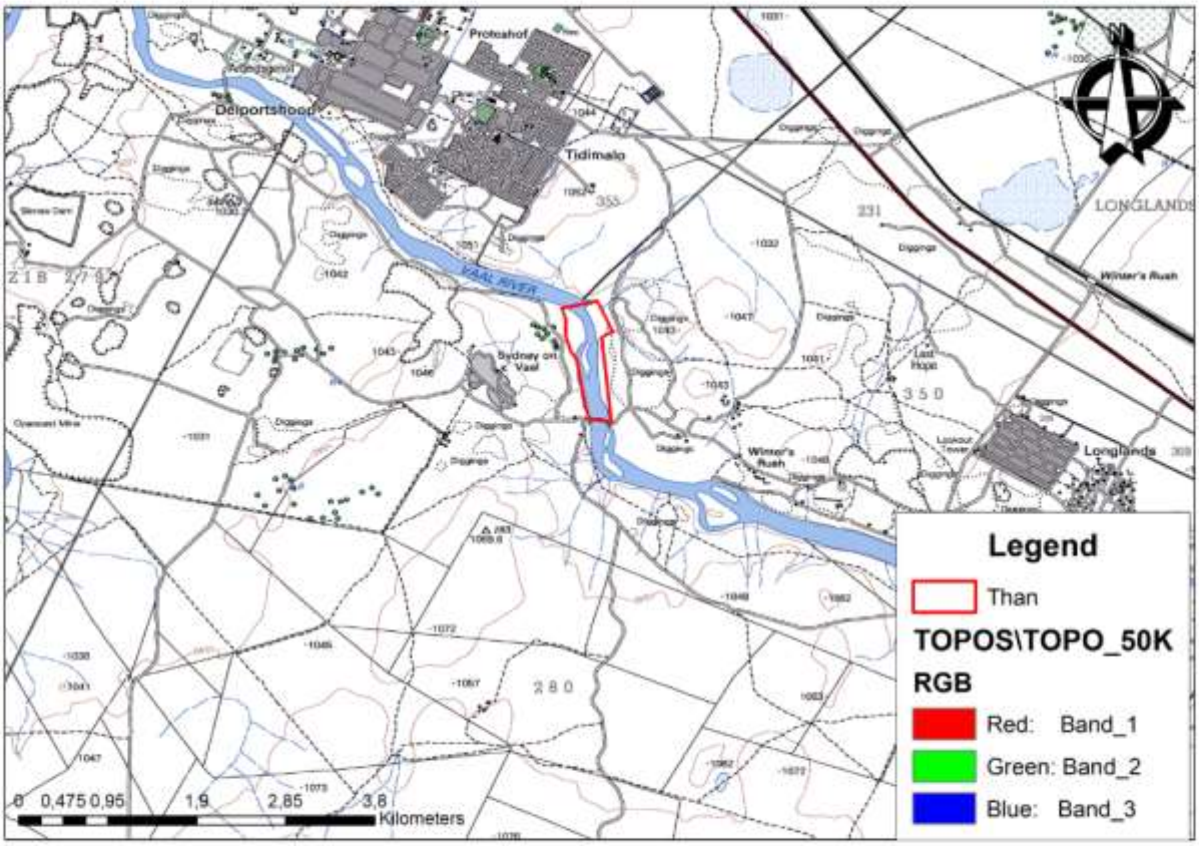

Figure 2: Topography of the area

2.3. Climate

The interaction of the climatic patterns of the earth's atmosphere, with the underlying geological structure, gives rise to the patterns of soil, rivers, and vegetation. The climatic patterns of the Municipality closely correlate with the broad pattern of the geology. To the west above the Ghaap Escarpment temperatures tend to be the most extreme ranging from 10 to 42 degrees Celsius. Rainfall tends to be lower in this region. The average annual rainfall in the Municipality is about 250mm per annum. As one moves westwards temperatures remain extreme although maximum temperatures may be slightly lower in some cases. However, rainfall increases as one move westward averaging from 330mm to over 420mm in some cases. The study area is located within the Northern Steppe climate region which implies that the area receives predominantly summer with some spring and autumn rainfall.

2.4. Biodiversity

The interaction of geology and soils, climate, hydrology, and topography gives rise to the patterns of biodiversity on the land. At the macro level the Municipality is entirely located within the western parts of the Savannah biome, see Figures 3. Continuing the dual pattern found with the other natural systems the Municipality reveals two distinct vegetation regions. The Savannah biome consists of thornveld and bushveld. This comprises a herbaceous layer, mainly small bushes, and a woody layer of small trees, mainly thorn trees. This indicates that there is sufficient soil moisture to support woody species but insufficient to sustain forests. In areas where moisture levels are higher more, woody tree species occur such as in vleis and wetlands and along river banks. To the west is the Kalahari plateau bushveld, comprising thornveld and bushveld. This is located on the shallow, rocky soils of the Ghaap plateau, (the eastern fringes of the Kalahari). East of the Harts and Vaal Rivers the hills and plains comprise the Kimberley thorn bushveld which is mainly associated with the deep, sandy sedimentary soils of this region. The Griqualand West Centre of Endemism is associated with the Kalahari plateau Bushveld.

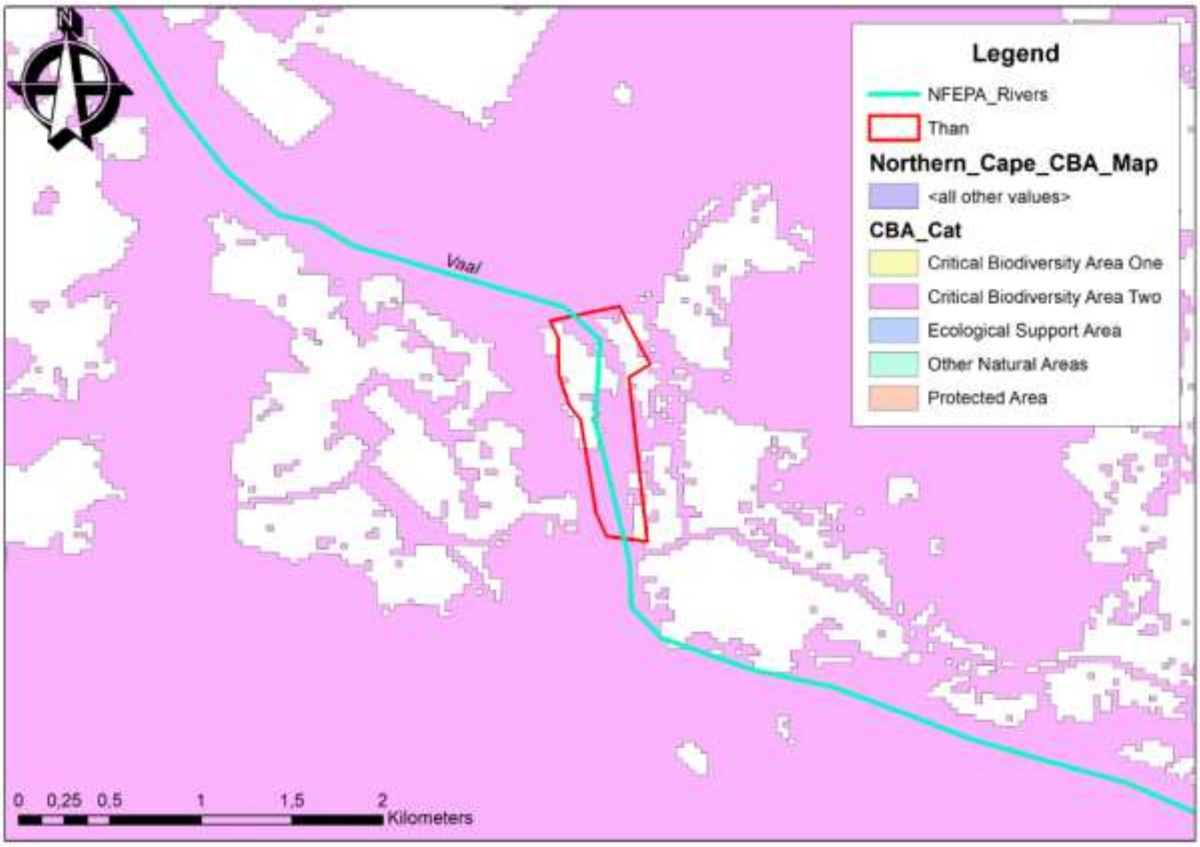

Figure 3: Vegetation Map for Samara Mining

2.5. Soil pattern

Soil type refers to red and yellow well drained sandy soils with high base status soils that are more than 300 mm deep with no dunes. The soil pattern is characterised with red yellow well drained massive or weakly structured soil see Figure 4.

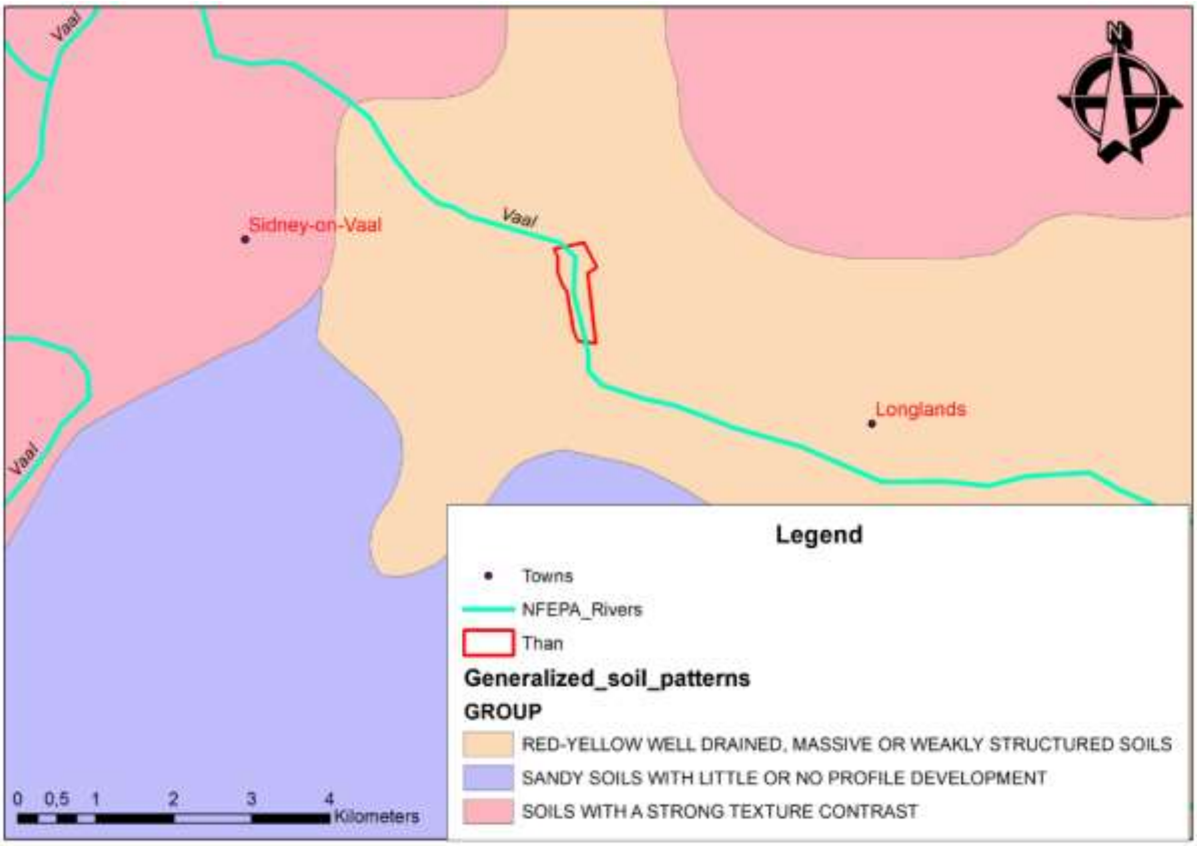

Figure 4: Soil pattern of the Samara Proposed prospecting area

2.6. Land use

The main mining activity in the region is diamond mining. Diamond mining has been a cornerstone of the Region's economy for the past century. It has essentially been the main economic driving factor of Kimberley and formerly Barkly West which, as has been noted, owes its location not to factors such as proximity to arable land or a strategic location on a river crossing but to the presence of kimberlite pipes in the area which has yielded large quantities of diamonds over the past 140 years. Settlements based on kimberlite pipes tend to be footloose in their location in relation to river crossings, proximity to agricultural land, and other inherent locational factors as they mine directly into the resource. There are also a number of alluvial deposits near the major rivers where surface material from the kimberlite pipes has washed down the rivers in over geological time.

Because of the low rainfall and extreme climate in the area, the crop production potential of the area is low. The veld carrying capacity with respect to biomass is also relatively low. The area indicates the agricultural potential of the area and it can be seen that it varies from low to moderate. There is no moderate to high land in terms of agricultural production potential in the Municipality which means that what agricultural resources there are must be carefully conserved. There has been an improvement to the agricultural potential due to large scale irrigation. Although the irrigation activities, of which the largest irrigation schemes are the River Bend Estate scheme and the scheme near Stilwater represent a major increase in the arable land resource, they also have negative side effects particularly with regard to long term soil fertility and water quality. The IEMP observed an indication of reduced flow in the rivers and signs of nitrification and sedimentation. However, the relationship between these activities and the impact of upstream activities in the Gauteng province and farmers along the river must also be understood because it would appear that the rivers have poor water quality and quantity when they enter the District (Fig 5).

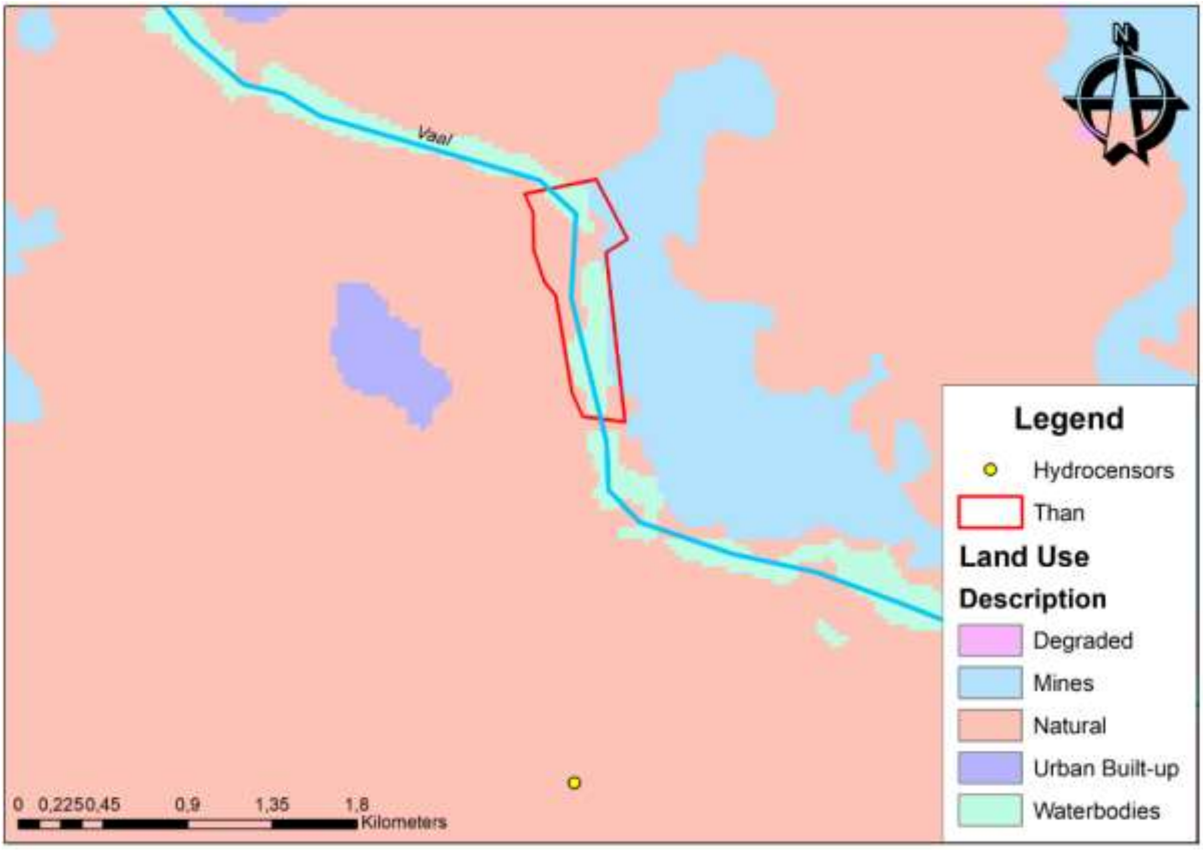

Figure 5: Land use and hydrocensus

3. GEOHYDROLOGY

3.1. Regional Geology

Alluvial diamonds are found in gravel deposits associated with the ancient Vaal River drainage system. According to Mathews, (1990), in the Barkly West District, the Ventersdorp Supergroup is only represented by a basal unit of quartzite overlain by a thick sequence of andesitic lavas interbedded with minor agglomerate. The former is regarded as the equivalent of the Bothaville Formation while the latter is regarded as the equivalent of the Allanridge Formation (SACS, 1980). The succession has a minimum thickness of 1000 m. On the basis of a U/Pb study on zircons, the Ventersdorp Supergroup has been dated at about 2,7 Ga (Armstrong *et al.,* 1990).

The andesites are green to dark-grey fine-grained microcrystal fine rocks which are usually altered by chloritisation, epidotisation, uralisation, saussuritisation and calcitisation. The andesitic lavas forming most of the roches moutonnees and striated pavements in the area show the development of amygda les of quartz, chalcedony, carnelian, agate, jasper, calcite, epidote, chlorite and pyrite. Porphyritic and non- porphyritic zones are present, while pillow lavas are found in a few places. The Ventersdorp rocks exhibit displacement faulting which trend extensive jointing and variable in a NNW, NNE, and NE directions. Except for outcrops close to or in the river bed, these rocks are covered by a variable thickness of reddish sandy loam or even tufa. Visser *et al.,* (1976) suggested that the accumulations of andesite took place in broad basins largely under subareal conditions and interpreted them as plateau lavas (See Fig 2).

The onset of deposition of the Ventersdorp volcanics has been constrained by dates of 2714 ±16 and 2709 ±8 Ma determined for samples from the Klipriviersberg Group, near the base of the supergroup, and of porphyry from the overlying Makwassie Formation of the Platberg Group (Armstrong et al., 1991) respectively.

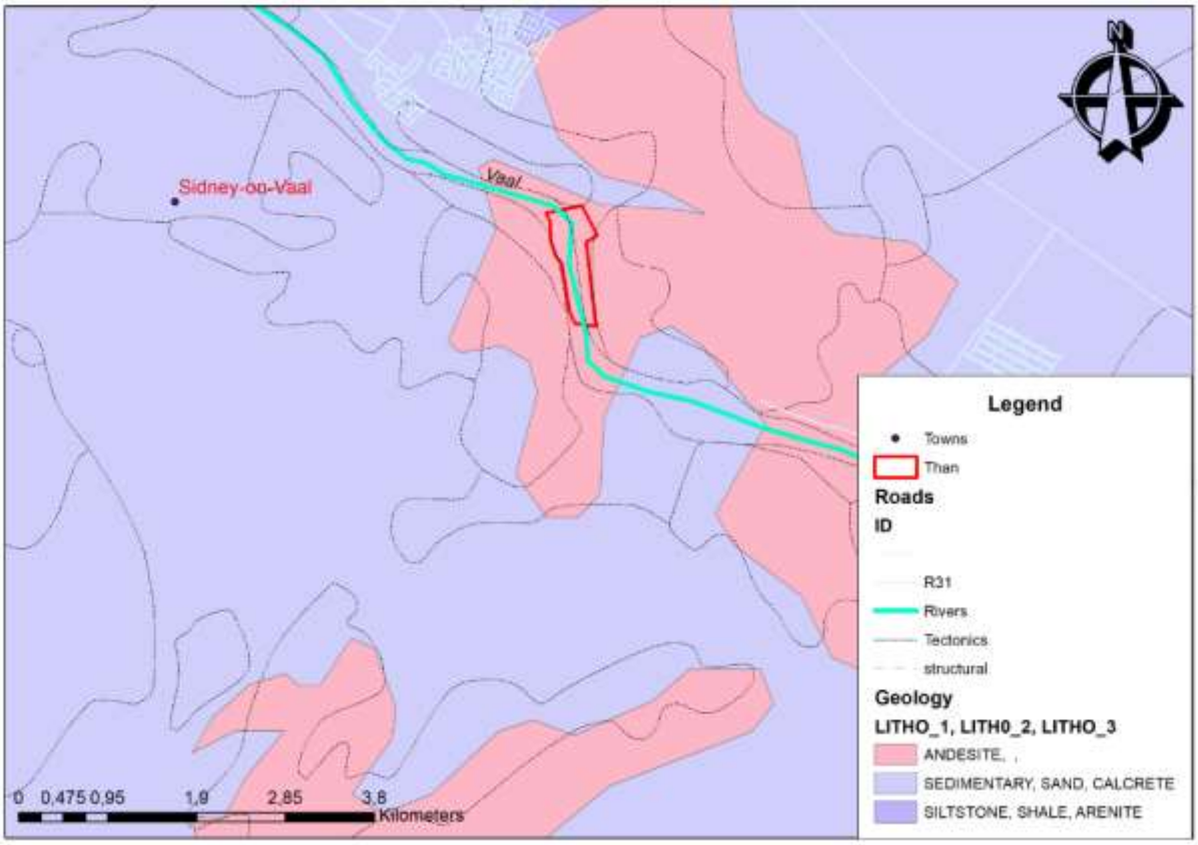

Figure 6: Regional Geology

3.2. Local Geology

The area along the Vaal River is mostly covered by Quartenary Age deposits. These are alluvial diamondiferous gravel as well as the red and grey aeolian sand. A small portion of the application area is covered by calcrete, cacified pandune and surface limestone. The western part of the application area consists of the andesite which in places comprise of amygdaloidal and/or porhyritic quartzite and conglomeratic lenses towards the bottom. The andesites belong fall under the Allanridge Formation belongs to the Platberg Group of the Ventersdorp Supergroup in the Randian Era. Figure 7 shows the geology of the application area and its surroundings. Diamond mineralisation is shown as DA on the map in Figure 7.

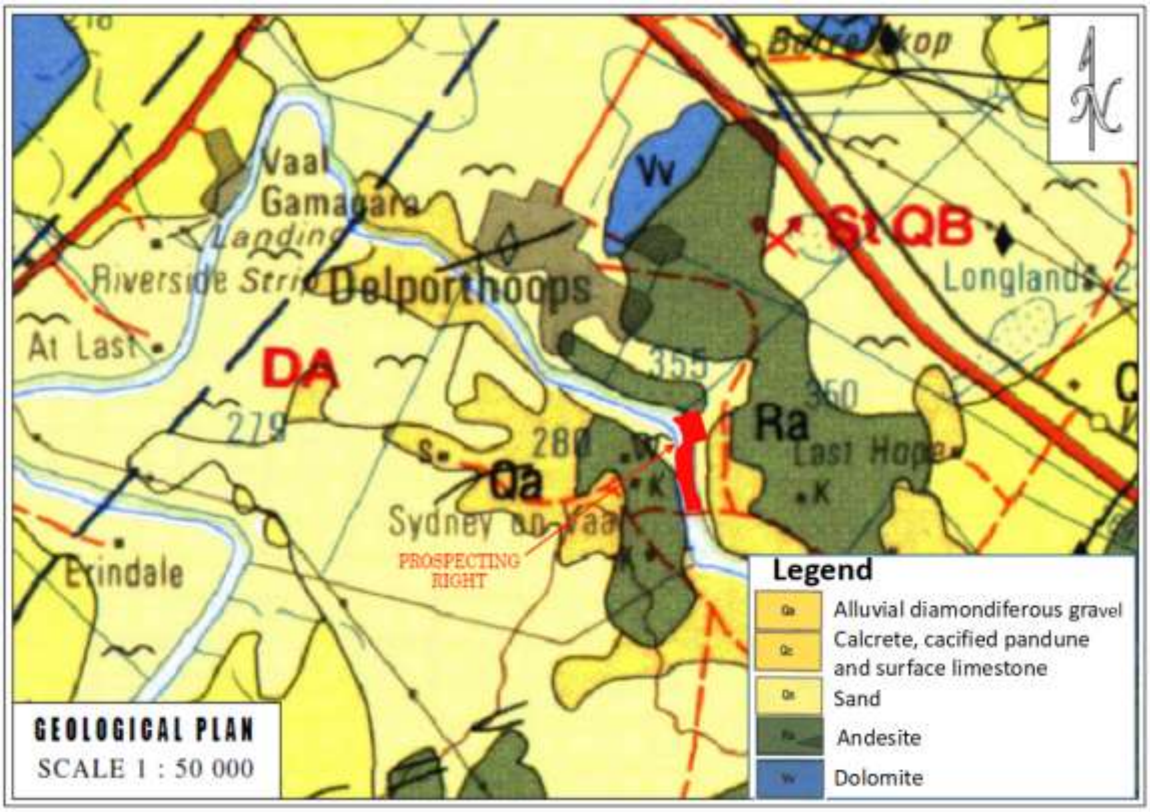

Figure 7: Local Geology

3.3. Water Resources

The interaction of climate, particularly rainfall, and the underlying geology gives rise to the hydrological patterns in the study area. Figure 8 shows the basic surface water pattern in the study area. Again, the clear zonal differences between the east and the west of the study area can be seen. In the west flowing off the Ghaap Plateau into the Harts and Vaal Rivers is a series of non-perennial rivers that only flow occasionally when it rains. To the west, the Municipality is structured by the major mature perennial rivers of the Harts and Vaal. There are very few non-perennial or perennial rivers in the eastern area other than the two major rivers of the Vaal and Harts. The area to the west appears to be underlain by a major aquifer. Details of this aquifer are still required. Figure 8 shows in more detail the surface water pattern in the area. It can be seen that a number of rivers both on the west and eastern parts of the District are “blind” in that they flow into pans rather than a major river.

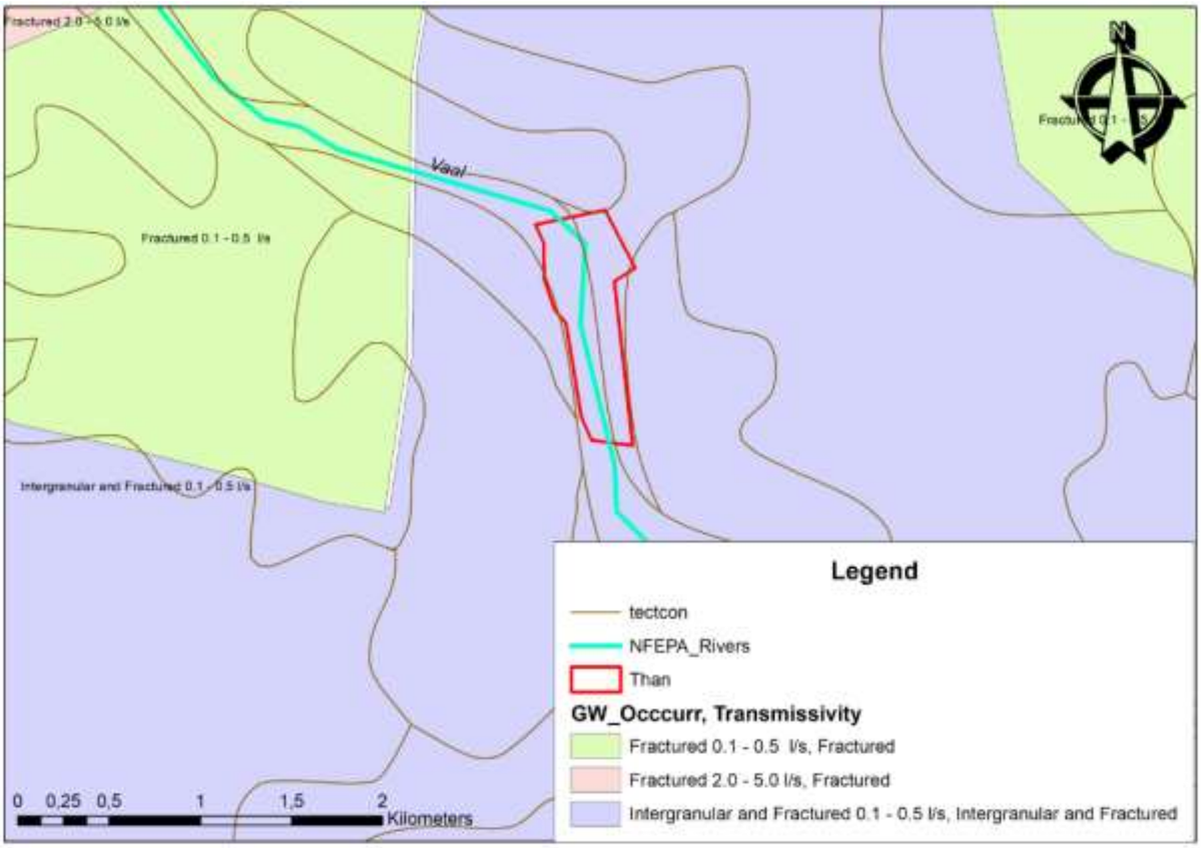

Figure 8: Water Resources

3.4. Aquifer Types

Groundwater in and around the Project area occurs in the unconfined mafic/ultramafic extrusions rocks such as basalt and andesite. The andesites belong fall under the Allanridge Formation belongs to the Platberg Group of the Ventersdorp Supergroup in the Randian Era. The andesites are green to dark-grey fine-grained microcrystal fine rocks which are usually altered by chloritisation, epidotisation, uralisation, saussuritisation and calcitisation. The andesitic lavas forming most of the roches moutonnees and striated pavements in the area show the development of amygda les of quartz, chalcedony, carnelian, agate, jasper, calcite, epidote, chlorite and pyrite. Porphyritic and non-porphyritic zones are present, while pillow lavas are found in a few places. The Ventersdorp rocks exhibit displacement faulting which trend extensive jointing and variable in a NNW, NNE, and NE directions.

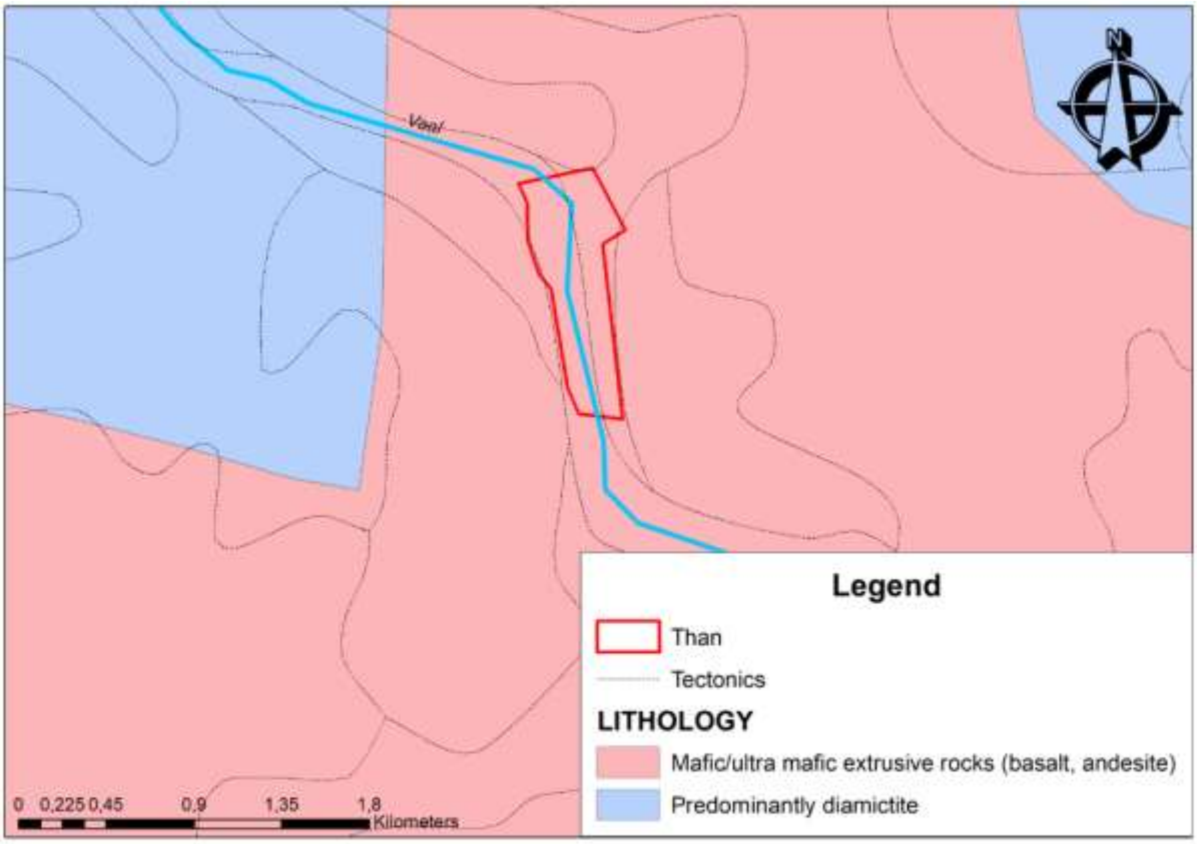

Figure 9: Aquifer types within the proposed prospecting area

3.5. Hydrocensus

Hydro-census was conducted within a limited distance of 1 km radius of the study area to establish groundwater use information such as the registered and unregistered boreholes, borehole depth to water level, groundwater use, springs etc. The study area comprises of flat topography with Vaal River which flows passing through the proposed alluvial diamond prospecting area. However, the area has been disturbed with illegal mining activities converting the land scape to uneven (Fig 10).

No registered boreholes were identified during the desktop study and also on the site visit. However, 6 monitoring boreholes were noted and visited northeast of the proposed prospecting area. However these boreholes were locked and therefore water level could not be measured. The first borehole was out of the 1 km radius of the prospecting area northeast and Southern part of the Vaal River (Fig 10).

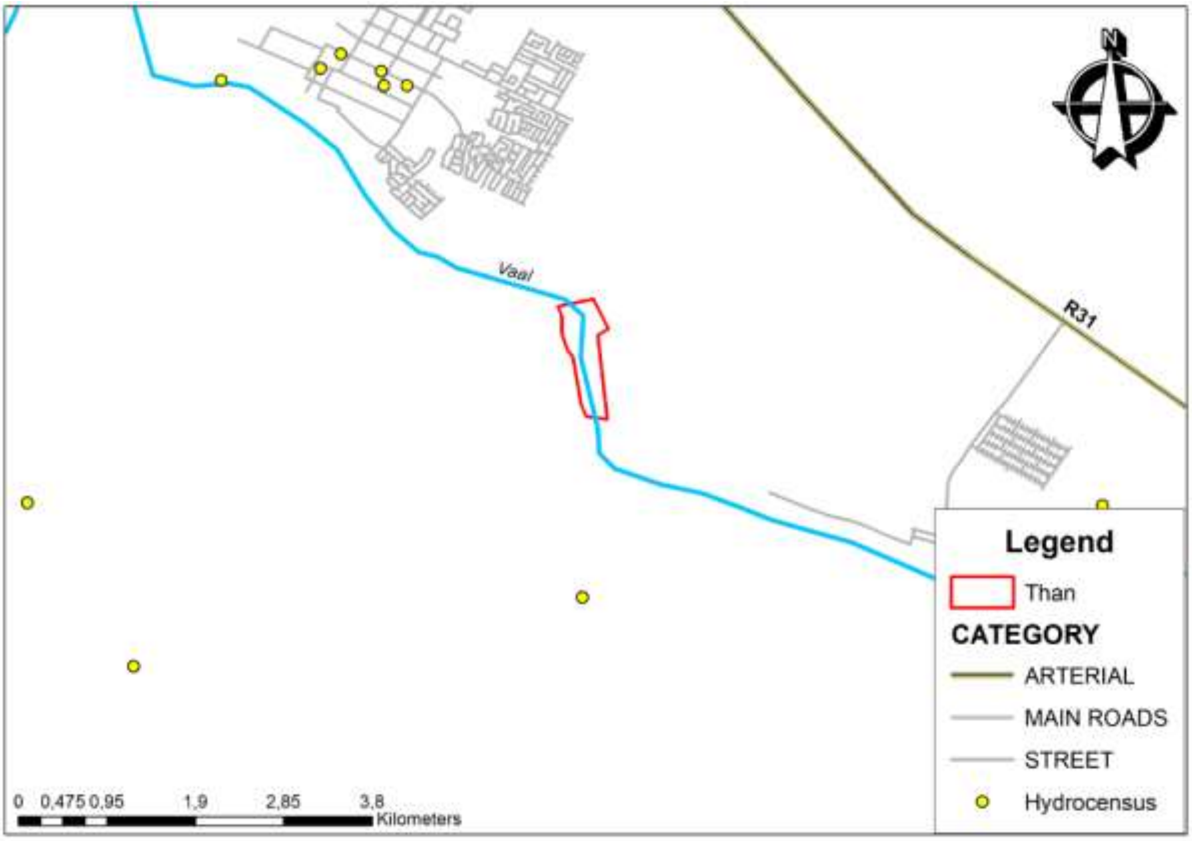

Figure 10: Hydrocensus

3.6. Aquifer Recharge

According to figure 11 the localised aquifer are characterised with intergranular and fractured zones within the mafic to ultramafic rocks. The general recharge within the area is 0.1-0.5 l/s of which implies less fracture geological zone.

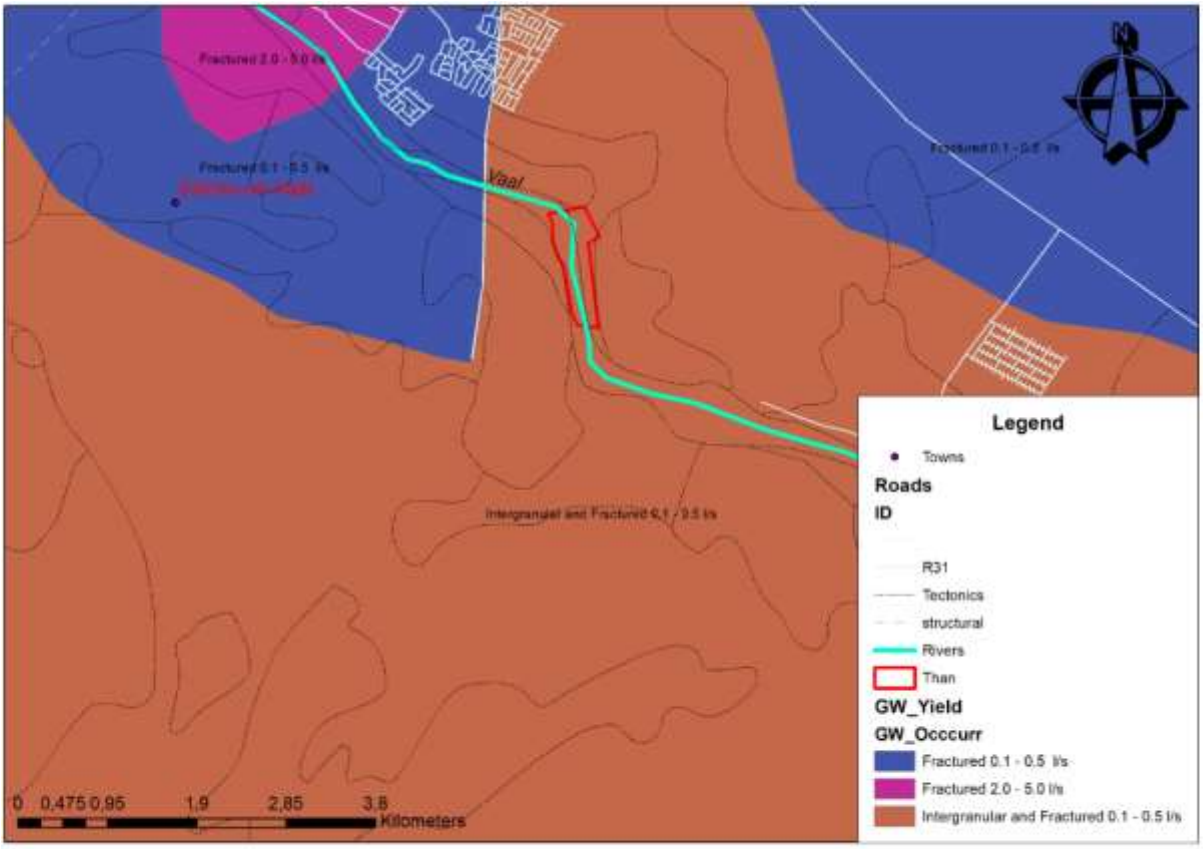

Figure 11: Groundwater recharge

3.7. General groundwater Quality

The electrical conductivity (EC) of water is a physical property which is widely used as an alternative to the chemical measuring of total dissolved solids (TDS), to determine water quality. Pure water has a low conductivity and an increase in conductivity generally reflects a decrease in water quality. The EC of groundwater in the area is generally between 70 and 300 mS/cm (Fig 12). According to WRC (1998) this represents saline conditions and is unacceptable for long-term drinking purposes.

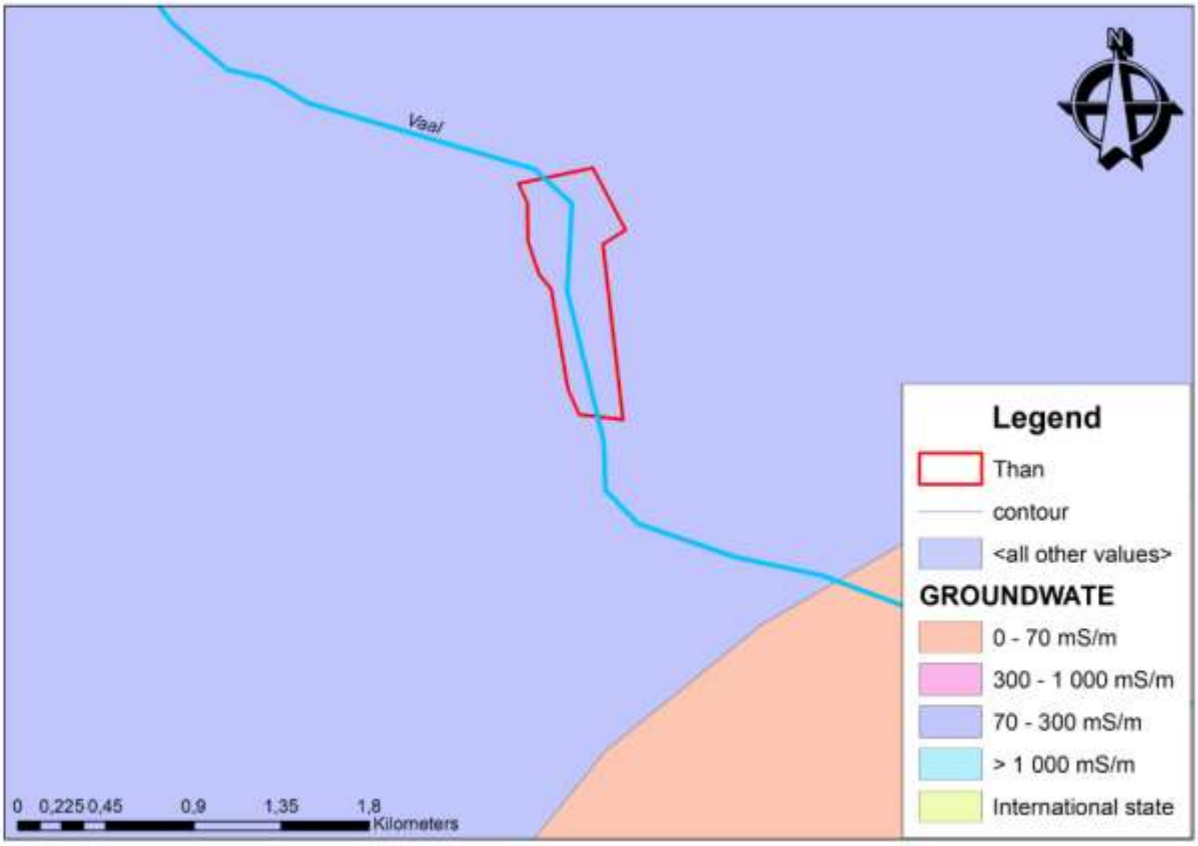

Figure 12: Groundwater quality

Water quality sampling was not conducted due to the unavailability of boreholes in the proposed prospecting area. However, it recommended that some of the prospecting boreholes be used to monitoring groundwater quality mainly on the southern and the northern side of the proposed prospecting right area.

3.9. Pump Testing

The proposed prospecting area had no existing borehole and therefore pump testing was not conducted. However, it must note that the proposed prospecting activity will not use groundwater for their activity but use the Vaal River water to process the alluvial diamond.

3.10. Groundwater Resource Assessment

The quaternary catchment is within the Vegter Region 18 referred to as Western Highveld as indicated on **Figure 13**. Two basic types of aquifer storage are assumed to exist in this region, namely the "Weathered /Jointed" (WZ) and Fractured" Zone (FZ).

In fractured rock (FZ) aquifers the number of water-bearing fractures generally decreases with depth (Vegter, 1995) and this often results in a similar decline in aquifer storativity with depth. While saturated zone (WZ) is normally a relatively thin zone (i.e. 5 to 40m thick) with its upper surface formed by the water table, therefore making this portion of the aquifer semi-unconfined to unconfined. This zone is characterised by a large number of relatively low-yielding water-strikes.

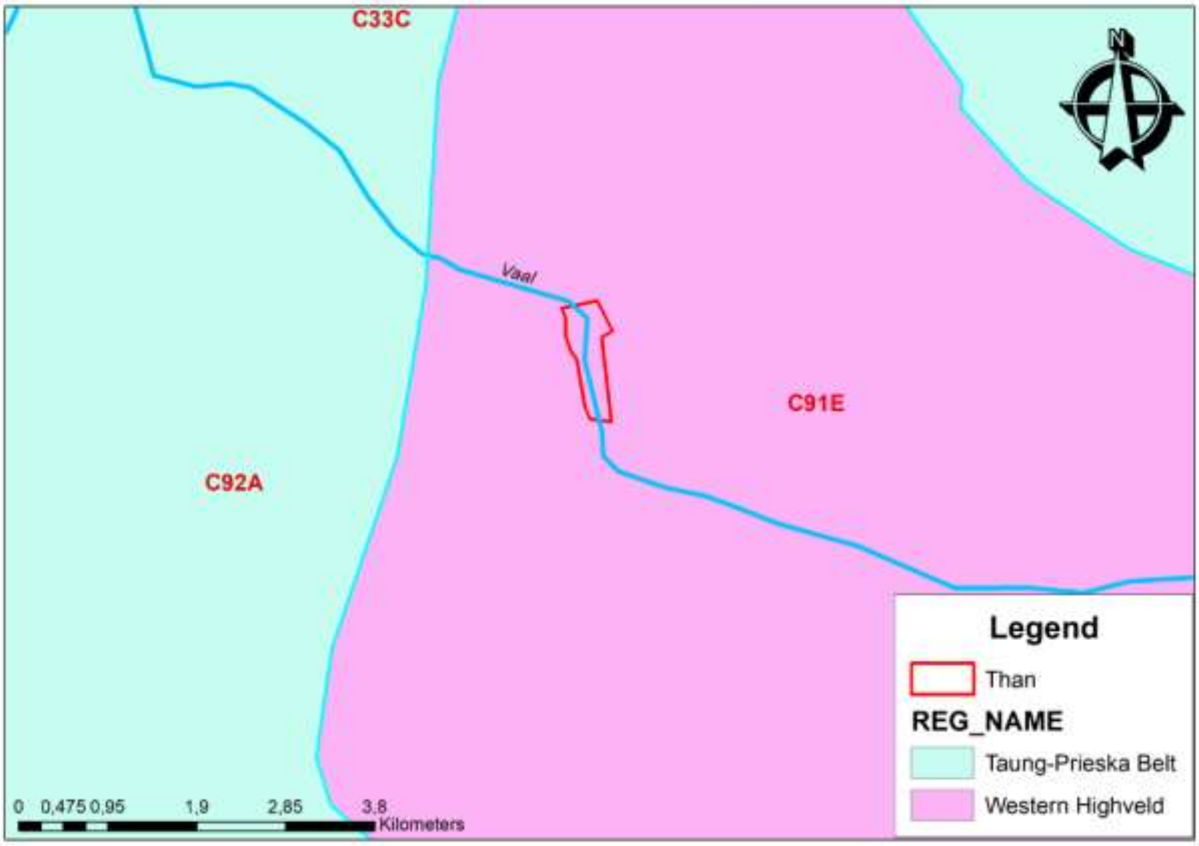

Figure 13: Groundwater region

Table 1 indicates the estimated groundwater quantity for quaternary catchment C91E of which the proposed prospecting project is located. The total volume of water stored in both the weathered and fractured aquifer is also indicated. Groundwater use within the quaternary catchment is very limited as indicated on the hydrocensus, this was further validated by the absence of registered groundwater users on the DWS Water Resource Management Services Database. The proposed project will also not use groundwater but surface water will be pumped from the Vaal River.

Table 1: Groundwater Quantification

Quaternary Catchment	Area km²	Saturated Thickness (m)			Specific Yield Of WZ	Storage Coefficient Of FZ	Volume of Water Stored in Aquifer X 10^3 m^3/km^2		
		Weathered Zone (WZ)	Fractured Zone (FZ)	Aquifer			Weathered Zone	Fractured Zone	Aquifer
C91E	1507	12	149	161	2.08E-03	7.05E-05	33 827	16 630	50 457

Source: Groundwater Resource Assessment: Task 1D

4. AQUIFER RISK AND VULNERABILITY ASSESSMENT

4.1. Aquifer classification/strategic value

Aquifer classification was conducted in terms of the "***South African Aquifer System Management Classification, December 1995***" manual. The following definitions of aquifer management classification were used. The aquifer has **low** strategic value as it does not provide water supply for households as the area is supplied by the municipality. No irrigation activities take place within 2 km radius of the proposed prospecting right project. The aquifer is therefore classified as a **sole/minor** aquifer (Parsons, 1995) due to less dependence.

4.2. Aquifer Risk Level Assessment

There are many activities associated with prospecting such as such as clearing of vegetation, access roads, borehole drilling, ablution etc. These activities may have impact on the receiving environment and the groundwater system in particular. It is therefore important to assess what level of risk is, so that necessary steps can be taken to prevent and mitigate the risk. **Table 2** has been adopted from the "Best Practice Guideline A1.1: Small Scale Mining Practices August 2006". The potential risk is listed on **Table 3** and their significance quantifies based on the **Table 2**.

Table 2: Assessing the significance of impacts

	Low impact	Medium impact	High impact	Severe impact
Frequency	Single event, unlikely to be repeated e.g. spillage	Not regular, but does happen more than once	Regular, but intermittent e.g. soakaways; drains	Continuous e.g. leaks; infiltration
Extent	Limited to only in the mining area	Local water resources. Limited to a 5 km radius of mining area.	Catchment area. Limited to a 50 km radius of mining area.	Wider (regional/national) Can spread to other provinces or regions
Duration	Short term - 0-6 month. Events that will not happen more than once in 6 months	Medium term Up to 1 year	Long term - 5 years	Permanent - No mitigation will shorten impact duration
Intensity	Negligible/Very low Minor disturbances to aquatic ecosystems or local water resources; impact temporary	Low Important but easily controlled by routine management actions	Medium Impacts experienced as temporary or continual loss of amenity or deterioration in water quality and can extend over both small and large areas.	High Impacts serious and requires frequent management attention and remedial action. Large scale effects on water resources; aquatic ecosystems and other water users
Probability	Improbable Low probability.	Probable Distinct probability.	Highly probable Most likely.	Definite Will occur regardless of prevention or mitigatory methods.

Table 3: Potential Risk Significance and Mitigation

Activity of concern	Risk	Risk Level	Recommended Mitigation
Access and mine road	Compaction of footprint area. Reduction in groundwater levels.	Medium Impact	Implement acceptable protection zones around drainage lines, riparian zones. Implement access control. Plan and regulate vehicle movement. Impellent erosion protection.
Storage of chemical and fuels	Potential spillage of fuels, oils and lubricant contaminating groundwater	Low Impact	Train contractors and own staff on re-spills and disposal, procedure for storage, use and disposal of oils and grease. Activities monitored daily.
Exploration Boreholes	Drill chips, lubricant and mud contaminating groundwater resource. Drilled boreholes being pathways for point source pollution into groundwater resource	Low Impact	Clean drill rig after drilling each borehole and contain the mud to no flow into the boreholes. Blow each borehole after drilling to remove lubricant and other particles. Exploration boreholes will be capped after prospecting.

Ablution and waste collection	Faecal coliform and leachate from waste contaminating groundwater resource	Medium Impact	Disposable latrines should be used and emptied in the municipal sewage. Containers should be used to store waste and should be emptied and cleaned weakly depending on the rate of waste generation.

4.3. Aquifer Vulnerability

The aquifer is characterised as intergranular and fractured with medium to high transmissivity and porosity. The water table is estimated to be around at 15 m below ground. High transmissivity, porosity and depth to water table makes the aquifer‘s vulnerability to contamination to be high as indicated on **Figure 13.** This therefore implies that aquifer contamination risk and mitigation measures should be implemented and complied with as the aquifer is already vulnerable due to its natural composition.

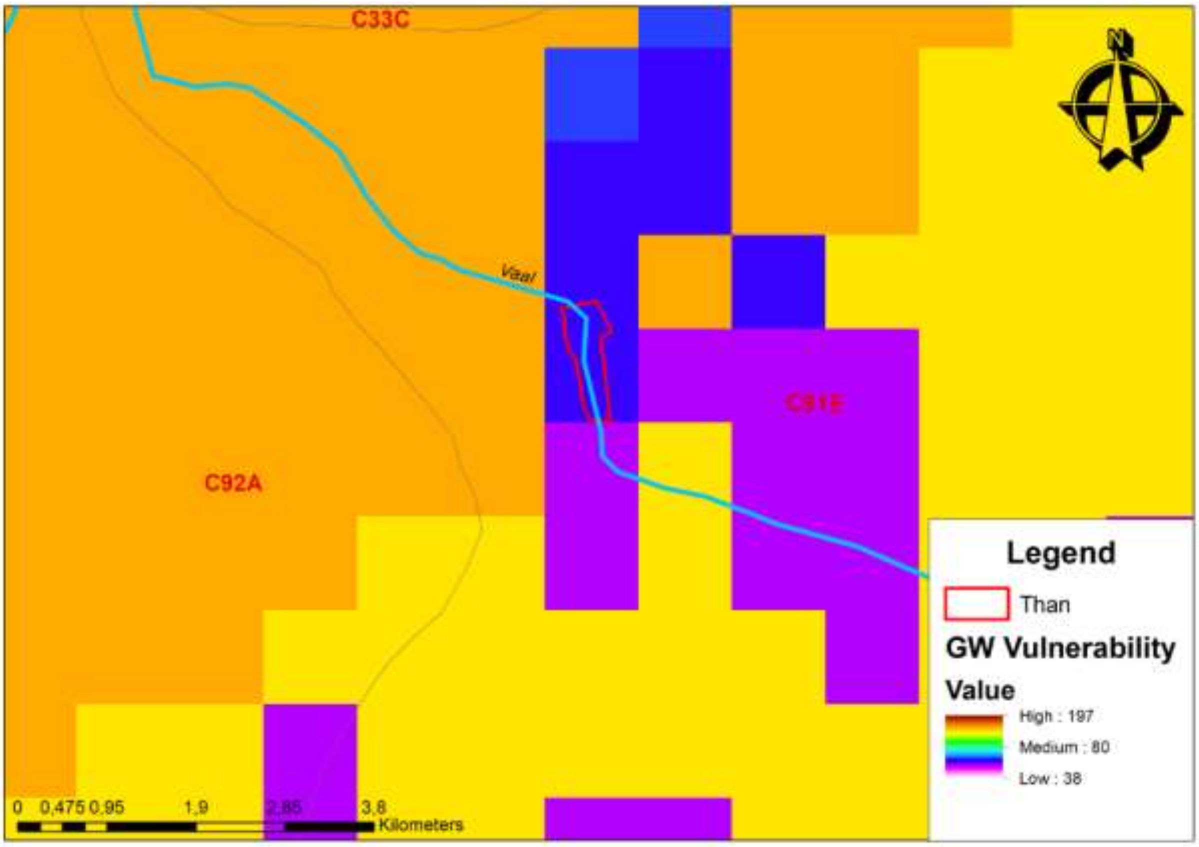

Figure 14: Groundwater vulnerability

5. RECOMMENDED MONITORING PLAN

Possible sources for groundwater contamination are fuels leakage and spillage from machinery and on site latrines and waste as indicated on **Table 2**. DWS overarching water quality management principles are; **(1)** protection of human health and **(2)** protection of the environment.

Based on these principle's objectives and the significance of this aquifer classification, if any potential risk exist, measures must be put in place to limit the risk to the environment, which in this case is the protection of the Primary Underlying Aquifer.

Due to low likelihood of pollution as a result of the nature of the proposed activity, it is therefore recommended 2 prospecting boreholes be used for water quality monitoring and groundwater level monitoring. These boreholes should be on the southern boundary of the farm Than to monitor possible impacts to the Vaal River and groundwater within the proposed prospecting area.

6. CONCLUSION

- The study area is characterised by clay and dolerite rocks;
- The groundwater flow direction is expected to be towards the northern boundary of the proposed project area;
- Vaal River is the only river flowing passing along the vicinity of the proposed project area;
- The main aquifer is fractured with estimated borehole yield of 0.1 to 0.5 l/s;
- Groundwater quality was not sampled due to the lack of borehole within the site;
- However, 2 prospecting boreholes to be drilled and were recommended for water level and quality monitoring;
- The aquifer is classified as a minor aquifer but with high vulnerability to pollution due to its natural composition, hence monitoring was recommended;
- The aquifer risk assessment was ranked medium, however strict implementation and compliance to pollution prevention and mitigation measures was emphasized;
- The proposed activity (prospecting) has less potential for groundwater contamination
- Potential risk, impact level and mitigation were indicated for each activity;
- It is therefore recommended that the proposed prospecting activity be granted as it has low impact on groundwater resource.

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