Afrimat Aggregates Operations (Pty) Ltd

Report on Geohydrological Impact Assessment For the Maritzburg Quarry near Pietermaritzburg, KwaZulu-Natal Province

Report Ref: 2021012

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Prepared for

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WATERS WITHOUT FRONTIERS
Water & Environmental Consultancy
Water recognises no borders

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Principal Hydrogeologist

EXECUTIVE SUMMARY

Afrimat Aggregates Operations (Pty) Ltd (hereinafter called Afrimat) appointed Waters Without Frontiers cc to conduct a geohydrological impact assessment in support of the updating of the Environmental Management Plan (EMP) for the Farm Maritzburg Quarries located near Pietermaritzburg in KwaZulu Natal Province.

The study consisted of the evaluation of existing data to assess potential impact of the quarry on groundwater resources in the area. The main concern relates to the potential reduction of flow in the adjacent Mpushini River as a result of dewatering, which in turn would affect ecological systems supported by the river. Data gathering was complemented by a hydrocensus in which existing boreholes and other groundwater related features such as springs and wetlands were sought on the ground.

The main findings of the study were as follows:

- The water levels in the river and in the quarry are almost at the same level resulting in no significant water movement between the two, assuming there is hydraulic connection between the two. Mining has reached its lowest level; hence the hydraulic balance will not be changed.
- There are no major sources of groundwater contamination at the quarry. Existing potential sources of contamination include a septic tank, oil separator, storm water from processing and stockpile areas, and dust suppression.
- Based on visual assessment and judgement, the rate of flow in Mpushini River is estimated to be many orders of magnitude greater than the rate at which potential contamination plume would discharge into the river. In the event that contaminants from the quarry reach the river, their impact is likely to be overwhelmed by dilution in the river.
- Groundwater level and hydraulic properties of rocks at the site are not known, and need to be investigated further by the installation of a monitoring borehole and pumping test.
- The study area has very low borehole yield potential characterised by an average of less than 0.5 L/s (1.8m^3/h).

  There are no groundwater users with one kilometer of the quarry that would be exposed to potential negative impacts from the quarry.

The following recommendations were made:

- Site and drill at least one monitoring borehole downstream of the opencast pit.
- Use geophysics to locate geological structures that control groundwater movement at the site.
- Electromagnetic and magnetic traverses are the recommended geophysical survey techniques.
- Determine hydraulic properties of rocks at the site by conducting pumping test on the proposed monitoring borehole to establish if hydraulic connection exists between Mpushini River and the pit.
- Develop a groundwater flow model to simulate groundwater behavior at the site. Please note that groundwater flow modeling will only be carried out if there is significant water in the proposed

monitoring borehole, at least 0.2 L/s (0.72m^3/h).

- Groundwater monitoring should start immediately after drilling of the monitoring borehole.
- Groundwater quality sampling should be conducted quarterly; whilst monitoring of groundwater level should be carried out monthly.
- Water quality parameters to be monitored should include, but not limited to those for drinking water as given in Table 11.2 in the report.
- Baseline groundwater quality should be established in the first 24 months of continuous collection of water quality data from the monitoring borehole. This will provide a robust long-term groundwater quality baseline that can be used to detect any changes in groundwater quality during operation and post mime closure.
- Groundwater quality monitoring should continue after mine closure until the water quality complies with the Resource Quality Objectives (RQO) embedded in the water use licence for a period of 24 months. RQOs are determined by the Department of Water and Sanitation for the quaternary catchment in which the quarry is located, in this case quaternary catchment U20J.
- Ideally, the aggregate stockpile and processing areas should be lined with low permeability material or bunded to reduce the risk of groundwater contamination. However, due to the extent of the existing facilities, the cost of retro-fitting the liners or bunding would be astronomical. It is therefore recommended that the storm water management system in these areas should prevent water collecting on the surface for extended time; to deny it chance to seep into the sub-surface.

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ACRONYMS

Amsl	Above mean sea level
CC	Close Corporation
DWS	Department of Water and Sanitation
EC	electrical conductivity
EMP	Environmental Management Plan
L/s	Litres per second
NGA	National Groundwater Archive
NMP	Natal Metamorphic Province
NWA	National Water Act
RQO	Resource Quality Objectives
SABS	South African Bureau of Standards
SW	Surface water

1 INTRODUCTION

Afrimat Aggregates Operations (Pty) Ltd (hereinafter called Afrimat) intends to update the Environmental Management Plan (EMP) for the Farm Maritzburg Quarries located near Pietermaritzburg in KwaZulu Natal Province. The site mines granite/gneiss on 84 041 hectares of land.

The quarrying process currently involves the following:

- drilling and blasting of granite/gneiss and stockpiling,
- loading and hauling the material out of the excavation to the crushing and screening plant,
- crushing and screening the recovered material at the crusher plant in order to reduce it to various size aggregate,
- stockpiling the aggregate at a stockpile area until it is collected by clients.

Waters Without Frontiers CC was appointed to conduct a groundwater study in support of the updating of EMP.

2 OBJECTIVES

The main objectives of the study were to establish baseline groundwater conditions at the site against which impacts of quarrying would be monitored; and to recommend management options to mitigate or remedy the impacts.

3 LEGAL CONSIDERATIONS

The proposed project is controlled by a number of legislative instruments that include:

3.1 CONSTITUTION OF THE REPUBLIC OF SOUTH AFRICA ACT, 1996 (ACT 108 OF 1996)

Section 24 of the Constitution provides that everyone has the right to an environment that is not harmful to their health or well-being; and to have the environment protected for the benefit of present and future generations through reasonable legislative and other measures that:

(i) prevent pollution and ecological degradation;
(ii) promote conservation; and
(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Afrimat shall ensure that these rights are not violated.

3.2 NATIONAL WATER ACT, 1988 (ACT 36 OF 1998)

In terms of section 4 of the NWA, water may only be used if it is authorised in terms of:

- **Schedule 1** - relatively small quantities of water, mainly for domestic and stock watering purposes, but also for emergency situations and certain recreational purposes.
- **General authorisation** - by which limited water use is conditionally allowed without a licence. Current general authorisations are described in Government Notice No. 1191, 8 October 1999.
- **Water use licence** - which are used to control water use that exceeds the limits imposed by Schedule 1 and general authorisations.
- **Compulsory licensing -** will apply if It is desirable that water use in respect of one or more water resources within a specific geographic area be licensed:
  - To achieve a fair allocation of water from a stressed water resource;
  - When it is necessary to review prevailing water use to achieve equity in allocations;
  - To promote beneficial use of water in the public interest;
  - To facilitate efficient management of the water resource and to protect water resource quality.

The Act recognises eleven water uses of which the following may be relevant to the current project:

21(a):- taking water from a water resource; - ***relates to groundwater abstraction from a borehole.***

21(e):- engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1); - ***relates to dust suppression.***

21(g):- disposing of waste in a manner which may detrimentally impact on a water resource; ***- relates to disposal of industrial and domestic waste, sewage, and spillages of petroleum products.***

21(j):- removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; ***- relates to potential dewatering should mining intersect the water-table.***

3.3 GOVERNMENT NOTICE NO. 704 (GN704)

In terms of this regulation, no person in control of a mine or activity may:

(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked;

(b) except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest;

(c) place or dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation; or

(d) use any area or locate any sanitary convenience, fuel depots, reservoir or depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year flood-line of any watercourse or estuary.

The proposed quarrying activities do not require any exemptions from GN 704.

4 SITE DESCRIPTION

4.1 LOCATION

The site is situated approximately 10km as the crow flies southeast of Pietermaritzburg. The quarry is located at the boundary between Mkhambathini and Msunduzi Local Municipalities, with the quarry falling within the former municipality. Both municipalities fall under Umgungundlovu District Municipality in KawZulu Natal Province. The site is located about 3.3 kilometres east of the N3 freeway, from which it is connected by a tarred country road, P748. The locality of the site is shown in Figure 4.1.

4.2 TOPOGRAPHY AND DRAINAGE

The study area is located in quaternary drainage catchment U20J of the Pongola-Umzimkulu Water Management Area. The study area is characterised by moderately to high relief, with ground elevation ranging from 544 metres above mean sea level (amsl) in the adjacent Mpushini River west of the quarry to about 740 metres amsl at the highest point about 3 kilometres southeast of the site. The quarry is located on the side of a hill. Figure 4.3 shows the topography around the site. The site is drained by Mpushini River which discharges into the Msunduzi River, about 2 kilometres north of the quarry.

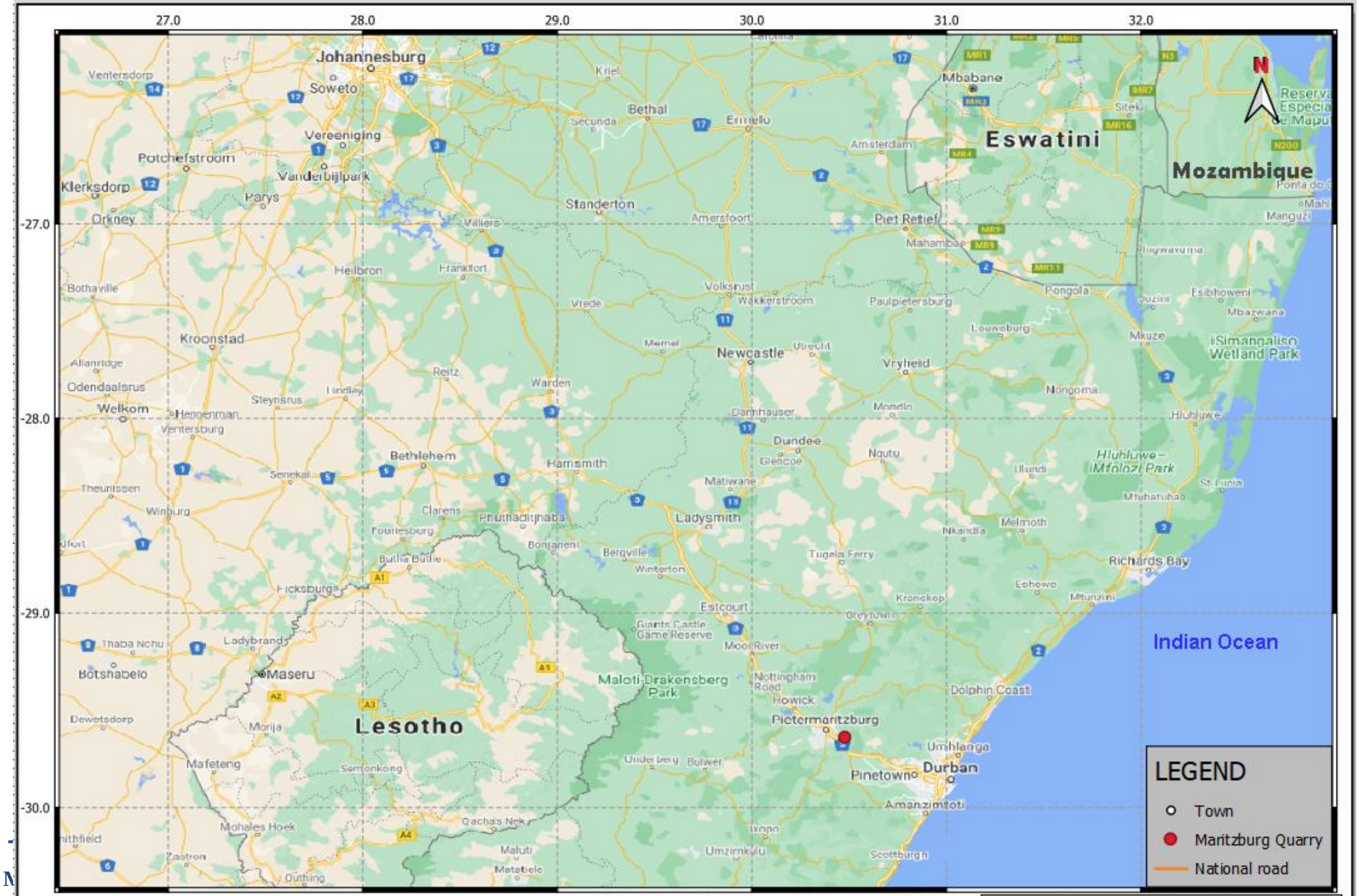
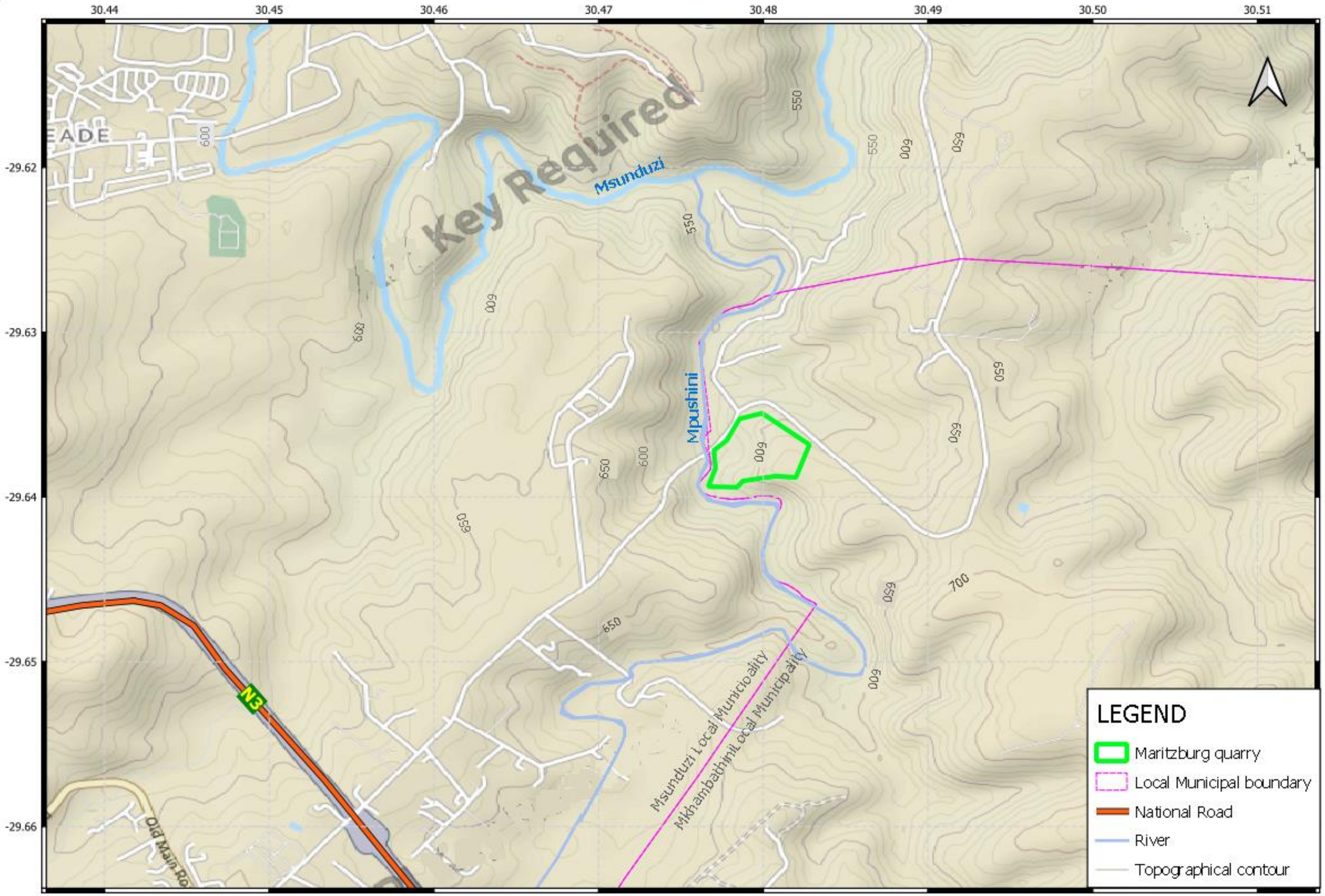


Figure 4.1 Locality of the study area



500 0 500 1,000 m

Figure 4.2 Topography of the study area

Afrimat Maritzburg Quarry
Geohydrological Impact Assessment

4.3 CLIMATE

The nearest weather station to the site is at Pietermaritzburg located about 10 kilometers northwest of the site. Pietermaritzburg receives about 966mm of rain per year, with most rainfall occurring during summer. It receives the lowest rainfall (23mm) in July and the highest (140mm) in January. The average midday temperatures range from 11.9°C in June to 20.1°C in February. The region is the coldest during July when the temperature drops to 5.4°C on average during the night

4.4 LAND USE

The quarry is located in the Pietermaritzburg peri-urban area consisting mainly of small agricultural holdings. There is a great deal of chicken farming. Located east of the quarry lies the Ashburton horse riding training center.

5 GEOLOGICAL SETTING

5.1 REGIONAL GEOLOGY

The regional geology of the study area consists of rocks ranging in age from Mokolian to Recent. The stratigraphic sequence consists of basement metamorphic and intrusive igneous rocks of the Natal Metamorphic Province (NMP), overlain by the Karoo Super-group. The Natal Metamorphic Province is represented by Mapumulo Group, which consists predominantly of gneisses. The Karoo Super-group is represented by its basal units, the Dwyka and Ecca Groups. The study area marks the extreme eastern margin of the Karoo Supergroup. The Dwyka Group consists of tillite and diamictite, whilst the Ecca Group consists of mudstone and shale of the Pieterrmaritzburg Formation. Jurassic dolerite sheets, sill and dykes intruded all of the lithostratigraphic units but are predominantly associated with the argillaceous rocks of the Ecca Group. Figure 5.1 shows the simplified geology of the study area respectively. Table 5.1 shows the stratigraphical sequence in the study area.

Faulting and fracturing of bedrock in the study area is significant. Two dominant fault orientations, north-northeast–northeast and north-northwest–northwest are developed.

5.2 LOCAL GEOLOGY

At local level, the study area is underlain by gneiss of the Mapumulo Group, which is the target mineral extracted at the site. From the air, the gneiss consists of finger-like projections into the Dwyka Group, (Figure 5.1).

Table 5.1 Lithostratigraphical succession in the study area

FORMATION	GROUP		PERIOD
Dolerite			JURRASIC
Volksrust Formation	Ecca Group	Karoo Supergroup	PERMIAN
Vryheid Formation			
Pietermaritzburg Formation			
Tillite	Dwka Group		Carboniferous
Natal Metamorphic Province			NAMAQUAN

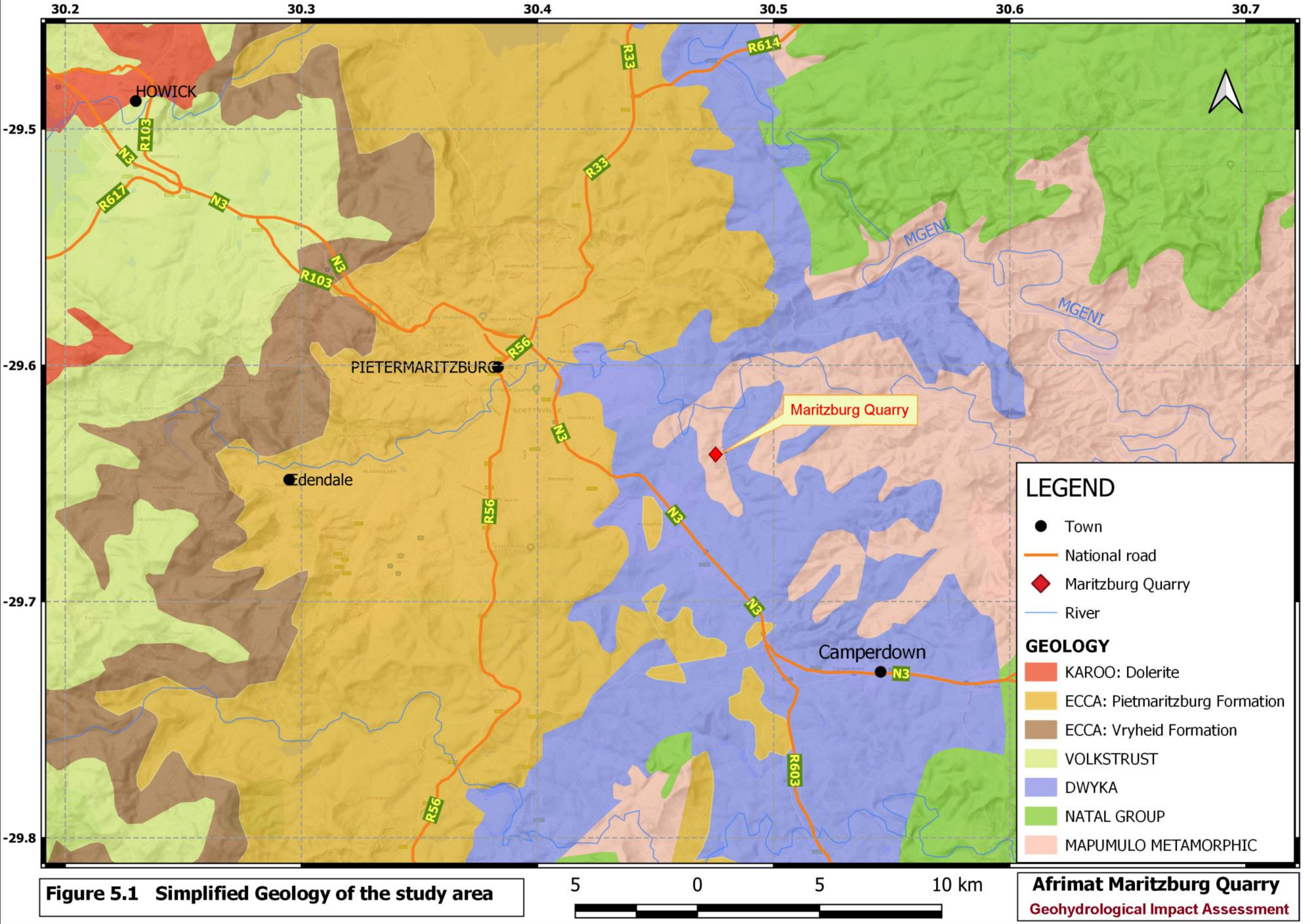


Figure 5.1 Simplified Geology of the study area

6 GEOHYDROLOGICAL SETTING

The study area is underlain by rocks of the gneisses of the Mapumulo Group as described above. These are hard crystalline rocks characterised by very little, if any, primary porosity and permeability. Their water storage and transmission properties arise as a result of secondary processes of fracturing, jointing, faulting and weathering. Fracturing develops due to a number of factors that include tectonic movement in the earth crust, pressure relief due the erosion of overburden and shrinking during cooling of the rock mass. Weathering involves the breaking down of the rock mass into loose grains with the help of rainwater which acts as a weak acid after dissolving carbon dioxide in the atmosphere and in the soil. Groundwater occurs in both the weathered zone as well as the transition between the weathered and fresh gneiss. Basins of weathering normally coincide with the drainage pattern. Fault and fracture zones generally have porosity of less than 1%. Fault and fracture zones tend to narrow and pinch out at depth, with a corresponding decrease in permeability. The groundwater potential of the gneisses is classified as low with an average borehole yield of less than 0.5 L/s, (King, 1998). However, higher yields are not uncommon and are associated with well-developed faults and fractured dolerite dyke margins.

Groundwater recharge in the study area is estimated at between 50 and 75 mm per annum (Vegter 1995). The groundwater harvest potential, which defines the amount of groundwater that can be sustainably abstracted from one square kilometre per annum is estimated at between 10 000 to 15 000 m^3/km^2/annum (Seymour and Seward, 1996). Figures 6.1 and 6.2 show groundwater recharge and harvest potential in the study area respectively.

Groundwater quality is generally good and suitable for human consumption; however pockets of poor water quality do occur. Electrical conductivity (EC) is a useful parameter for evaluating water quality as it reflects the total salts in the water. Groundwater quality of the gneiss is characterised by mean electrical conductivity of less than 70 mS/m (King, 1998).

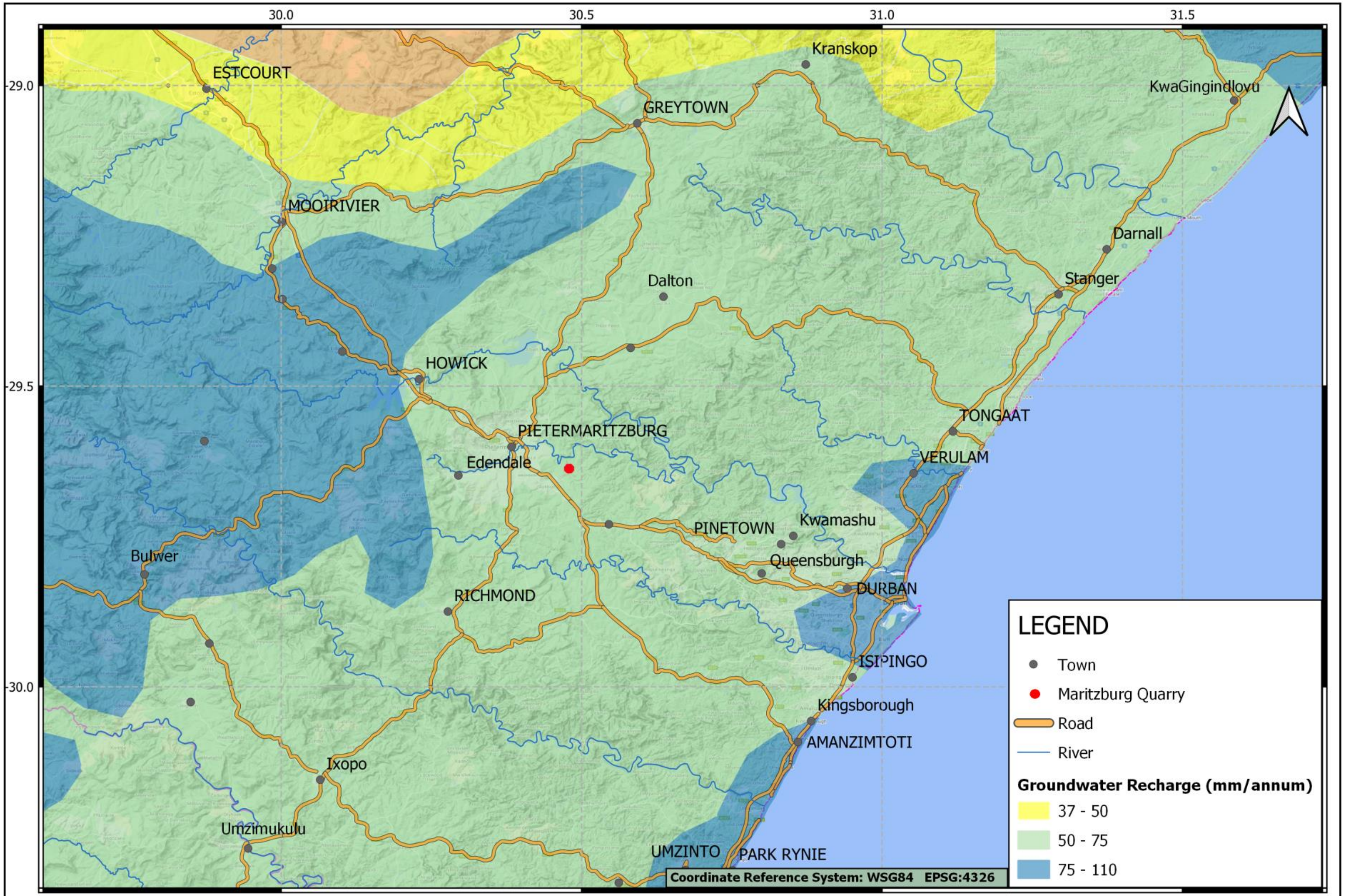


Figure 6.1 Groundwater recharge in the study area

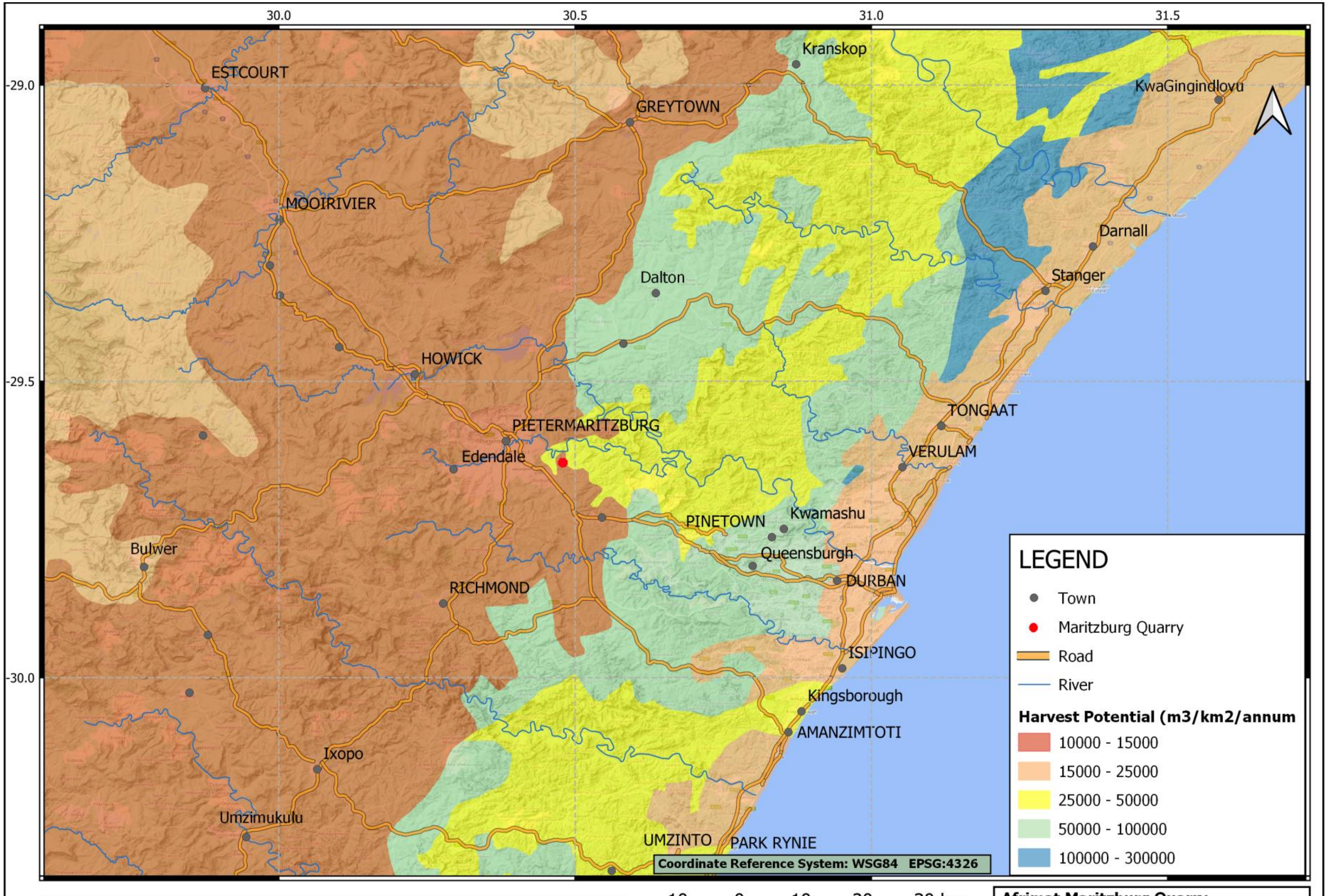


Figure 6.2 Groundwater harvest potential in the study area

7 INVESTIGATION

The study was based entirely on the evaluation of existing information, complemented by limited field work comprising a hydrocensus.

The following activities were undertaken:

7.1 DESKTOP STUDY

The investigation commenced with a desktop study in which existing data and information pertaining to groundwater characteristics at the site were gathered and analysed. Sources of information and data included the following:

- National Groundwater Archive (NGA) of the Department of Water Affairs,
- Published geological reports and maps,
- Published geohydrological reports and maps,
- Consultant's reports provided by the client,

7.2 HYDROCENSUS

The desktop study was complemented by a hydrocensus in which existing boreholes and other groundwater related features such as springs and wetlands were identified. The hydrocensus thus sought to:

- Familiarise with the project area.
- Identify existing water points (boreholes, springs, wetlands, etc.) in the area.
- Assess groundwater use in the study area.
- Where accessible, measure water levels in the boreholes

7.3 INTERVIEWS

During the hydrocensus, interviews were conducted with groundwater users around the proposed quarry to establish issues relating to groundwater resources in the area.

8 DISCUSSION OF FINDINGS

8.1 GROUNDWATER CHARACTERISATION

Groundwater characterisation was based on the evaluation of data from existing boreholes. Unfortunately, no existing boreholes were found within a radius of one kilometer of the site, which is the recommended radius for hydrocensus by the Department of Water and Sanitation (DWS). A total of seven boreholes were identified within a radius of 5 kilometers of the site, comprising six boreholes from the National Groundwater Archive, NGA; and one from a neighboring private farm. The latter borehole is located on the farm Rocky Wonder Aloe Nursery (hereafter called Aloe Farm), about 1 255 metres east of the quarry. The borehole supplies domestic water to the farm homestead, and is presently used for groundwater monitoring by Afrimat. The closest borehole to the quarry (2930CB00040) is about 1.12 kilometres away. Data on the existing boreholes are given in Table 8.1, and the location of the boreholes is shown in Figure 8.1. Most of the boreholes have incomplete, but nevertheless useful information.

Available information shows that the study area has low groundwater supply potential with borehole yield generally less than 1.0 litre per second. Groundwater occurs in fractures ranging in depth from near surface to 140 metres below surface. Higher yields are, however, possible where major fractures and faults are intersected. The rocks exposed in the quarry are highly fractured. The lithologies intersected in the boreholes include granite/gneiss, dolerite, tillite and shale.

No major water strikes or groundwater inflows have been encountered in the quarry. Some minor seepage into the quarry is reported during the rainy season. This, however, is attributed to drainage from the soil layer which acts as sponge; soaking in water during the rainfall season and releasing it later into underlying fractures.

8.2 GROUNDWATER LEVEL

Groundwater level data were evaluated with a view to determining the background water levels at the site, and to determine groundwater flow direction. Available data indicates that groundwater levels range from about 26 metres to 68 metres below surface. There is no existing borehole at the quarry to give an indication of the groundwater level at the site. There is water standing in the quarry, however, at this stage it is not known whether it represents the natural water-table at the site. About 200 metres west of the quarry lies the northward flowing Mpushini River. The quarry floor, which lies at an elevation of 541 metres amsl is slightly below the section of the river adjacent to the pit, whose elevation drops from 548 to 544 metres amsl in that stretch. Figure 8.3 shows a schematic vertical cross-section from Mpushini River cutting across the quarry. Presently there is insufficient data to establish if there is hydraulic connection between the quarry and the river.

Table 8.1 Information on existing boreholes

Borehole Number	Latitude	Longitude	Date	Borehole depth (m)	Water level (m)	Water Strike (m)	Blow yield (L/s)	Lithology	Distance from quarry (m)
2930CB00026	-29.62649	30.43305	16/8/1925	82.29	32.61	75.28	0.5	Shale dolerite	4 650
2930CB00040	-29.63093	30.46999	5/4/1994	150	68	140	0.64	Dolerite	1 120
2930DA00037	-29.65038	30.51639	16/2/1965	28.35	-	-	-	Shale granite	3 880
2930DA00038	-29.65038	30.5164	26/11/65	53.64	25.91	30.48	0.600	Shale Tillite granite	3 880
2930DA00046	-29.65038	30.51778	10/3/1966	61.26	35.36	39.62		Granite	3 690
2930DA00047	-29.65039	30.51778	6/5/1960	61.26	27.43	22.25		Granite	3 690
Aloe Farm	-29.63915	30.491833	-	-	-	-	-	-	1 255

Lack of site-specific groundwater level data precluded the creation of a piezometric surface map to depict groundwater flow patterns at the site. Under these circumstances the principle that the water-table mimics surface topography in hard rock environments was adopted. Figure 8.2 shows the inferred groundwater flow directions at the site.

8.3 GROUNDWATER QUALITY

Afrimat is presently monitoring water quality in Mpushini River, and in a borehole on a private farm, Rocky Wonder Aloe Nursery, Figure 8.2. Details of the monitoring programme can be found in the report "Quarterly Water Monitoring Report for Afrimat Maritzburg Quarry: Q3 of 2020 / 2021" dated 22 April 2021 and prepared by GCS (Pty) Ltd.

The water quality data are given in Table 8.2. The surface water and groundwater monitoring points are shown in Figure 8.2. It should be pointed out that the data do not include a full complement of parameters that are normally analysed for water used for drinking. Generally, both surface and groundwater quality is good, and characterised by electrical conductivity of 51 – 89 mS/m for surface water and 118 mS/m for groundwater; both of which fall within the guidelines. Water from the borehole and the quarry, however, displays elevated nitrate concentration. The borehole is marginally outside the prescribed nitrate limit, whilst the pit is significantly outside the limit. Since nitrate is not a natural constituent of rocks, the source of the nitrate in the borehole is attributed to anthropological activities; whilst the high level in the pit is attributed to explosives used for rock blasting. The relationship between surface and groundwater quality could not be evaluated using standard tools like the Piper diagram due to the data lacking some crucial elements such as chloride and bicarbonate.

It should be noted that the borehole that is presently being monitored is located too far away (1 255m) from the quarry to represent the true groundwater quality at the site. A monitoring borehole closer to the quarry will be required for this purpose.

Table 8.2 Water quality data

Water Quality March 2021		SANS 241 :2015 Drinking water standard	SW Upstream	SW Downstream	Pit	Aloe Farm Borehole
Determinant	**UNIT**		01/03/20	01/03/20	01/03/20	01/03/20
pH at 25°C	pH	≥ 5-9.7≤	8	7.9	8.2	7.9
Electrical Conductivity, EC	mS/m	≤ 170	88.0	89.0	51.0	118.0
Total Dissolved Solids, TDS	mg/l	≤ 1200	480.0	500.0	330.0	650.0
Total Suspended Solids. TSS	mg/l	-	≤21	≤21	≤21	≤21
Calcium, Ca	mg/l	≤ 150	43.0	44.0	32.0	81.0
Magnesium, Mg	mg/l	≤ 70	30.0	31.0	17.0	50.0
Sodium, Na	mg/l	≤ 200	79.0	79.0	38.0	81.0
Potassium, K	mg/l	≤ 50	5.6	5.6	7	6
Sulphate, S04	mg/l	≤ 500	28.0	28.0	68.0	31.0
Nitrate, N03 as N	mg/l	≤ 11	1	1	**22.0**	**13.0**
Iron, Fe	mg/l	≤ 2	0.18	0.2	1.1	0.2
Manganese, Mn	mg/l	≤ 0.4	≤0.01	≤0.01	≤0.01	≤0.01
Aluminium, Al	mg/l	≤ 0.3	≤0.02	≤0.02	≤0.02	≤0.02
Silica, Si	mg/l	-	19.9	19.68	10.27	25.67
Titanium, Ti	mg/l	-	≤0.005	≤0.005	≤0.005	≤0.005

The baseline groundwater quality will be established by sampling and analysing water quality in the proposed monitoring borehole for at least 24 months. This will provide a robust long-term groundwater quality baseline that can be used to detect any changes in groundwater quality during operation and post mime closure.

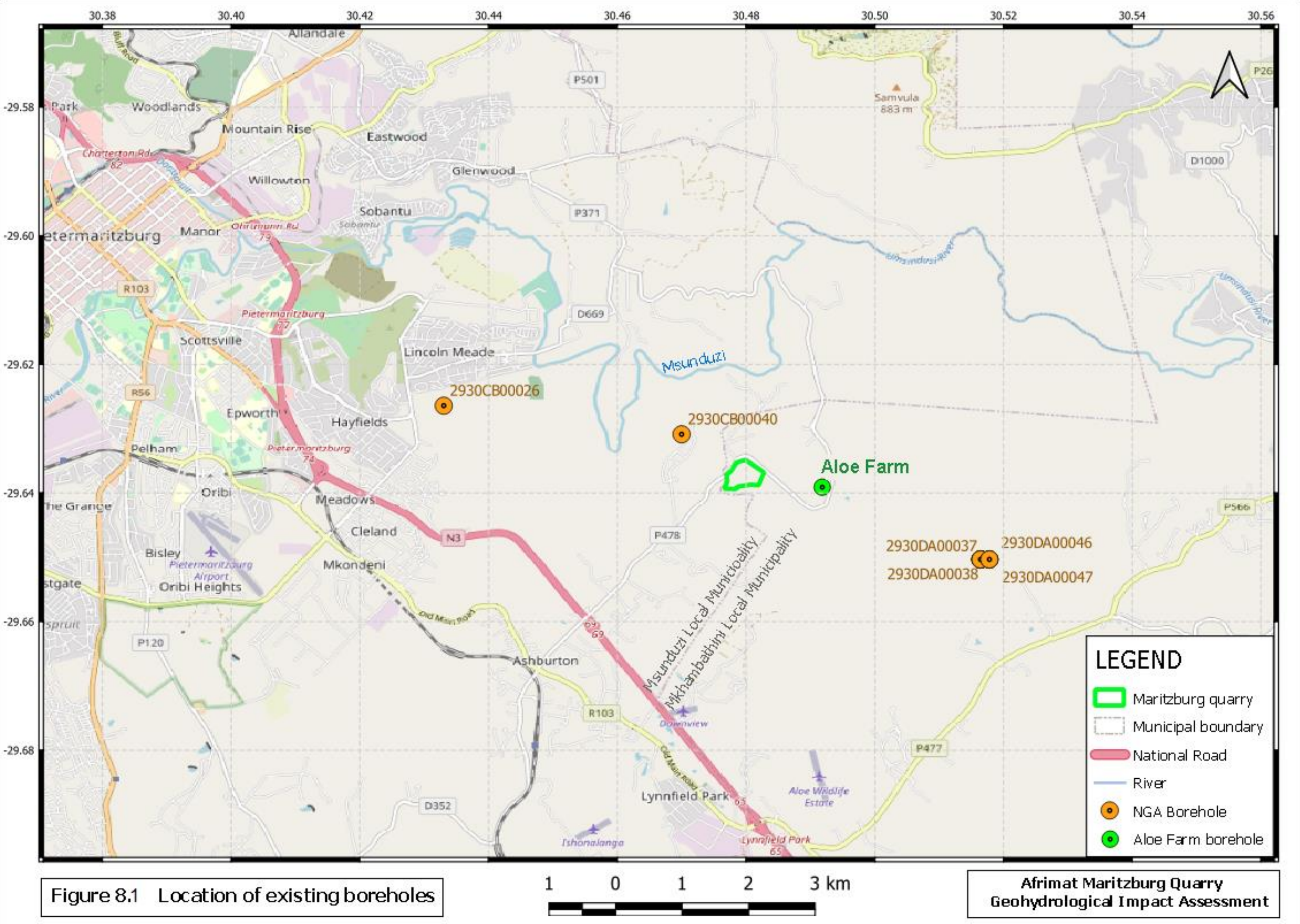


Figure 8.1 Location of existing boreholes

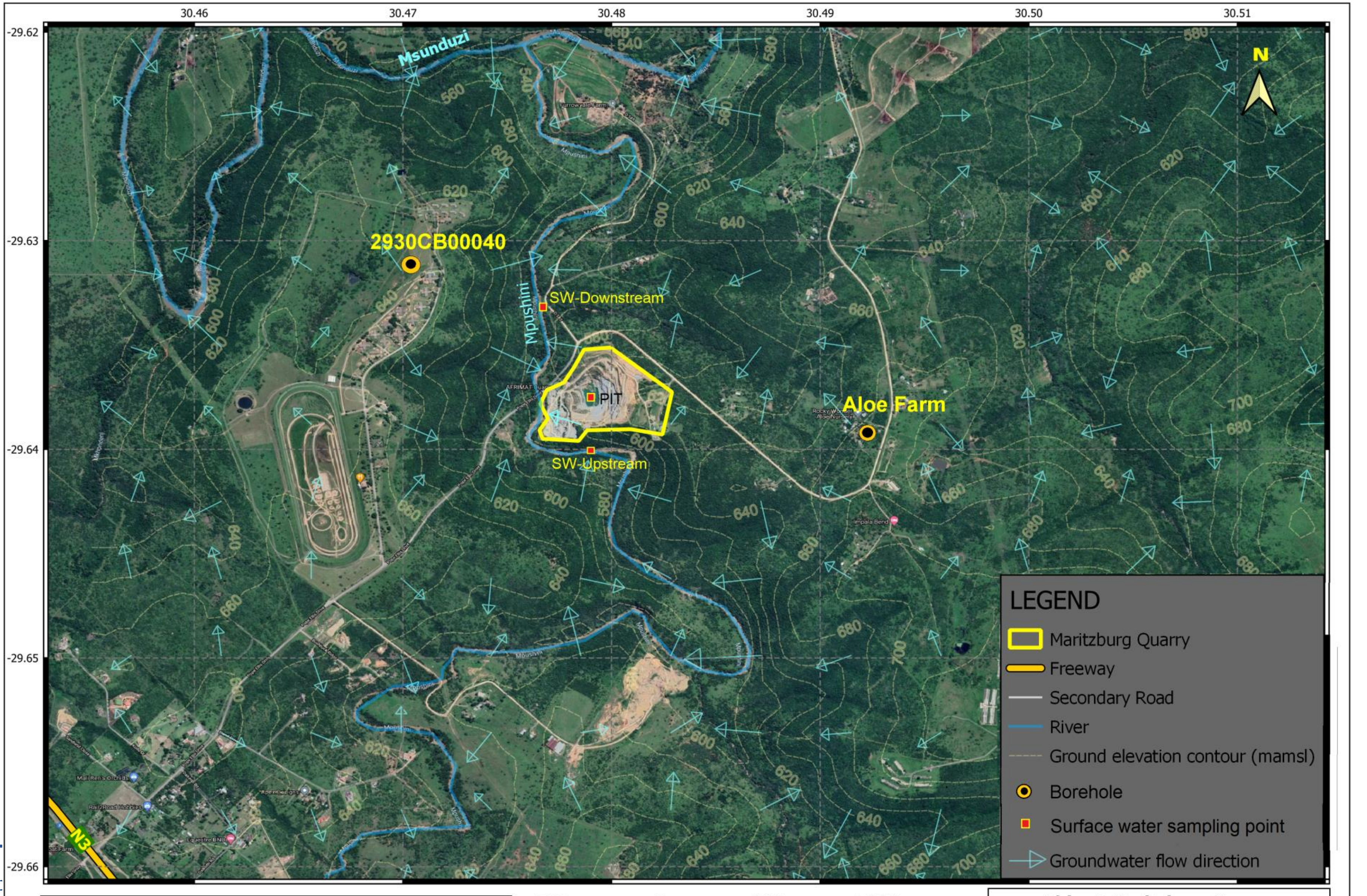


Figure 8.2 Groundwater flow pattern at the site

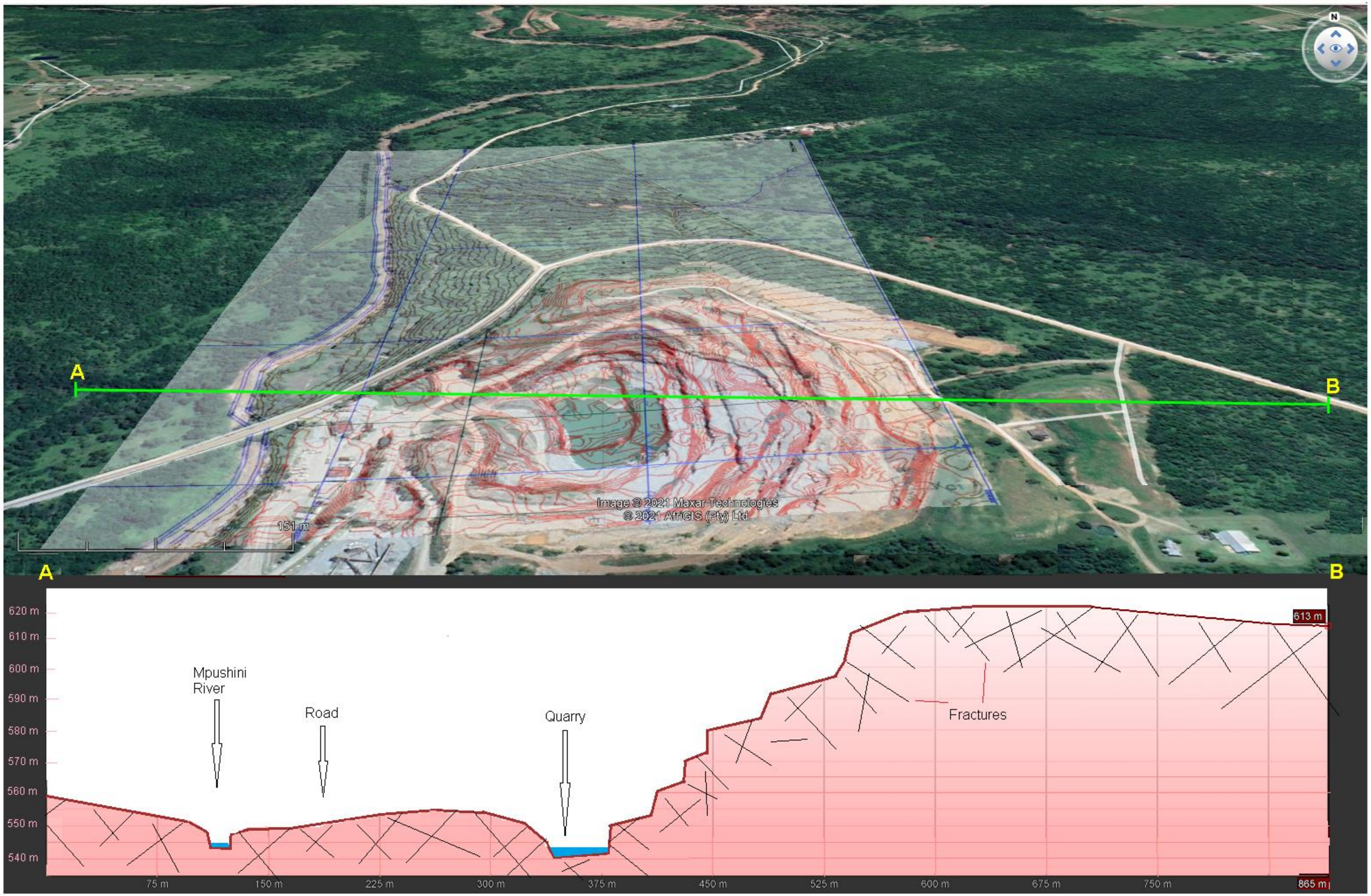


Figure 8.3 Schematic vertical cross-section from Mpushini River cutting through the quarry

9 IMPACT ASSESSMENT

The potential impact posed by the Maritzburg quarry on the integrity of groundwater resources at the site were evaluated according to the Department of Water and Sanitation's "Best Practice Guidelines For Water Resource Protection In the South African Mining Industry, BPG4: Impact Prediction" published by the SABS in 2008. The guidelines require that the impacts be evaluated for all the different phases of the project life cycle, which comprise the following:

1. Feasibility
2. Construction phase
3. Operational phase
4. Decommissioning and closure phase
5. Post closure phase (management of post closure residual and latent impacts).

For the current project, the feasibility and construction phases have passed. The impact assessment therefore begins at the construction phase to the post closure phase.

9.1 DESCRIPTION OF ACTIVITIES

Mining operations at Maritzburg Quarry are on-going. The following activities are taking place:

- Drilling and blasting to extract the desired rock. It is reported that excavation will not go below the current level, which is at an elevation of 541 metres above mean sea level.
- Loading and hauling the material out of the excavation to the crushing and screening plant,
- Crushing and screening the recovered material at the crusher plant in order to reduce it to various size aggregate,
- Stockpiling the aggregate at a stockpile area until it is collected by clients.

The potential **receptors** of negative impacts from the quarry include:

- Mpushini River and associated riparian zones along the river,
- Any future settlements downstream of the quarry.

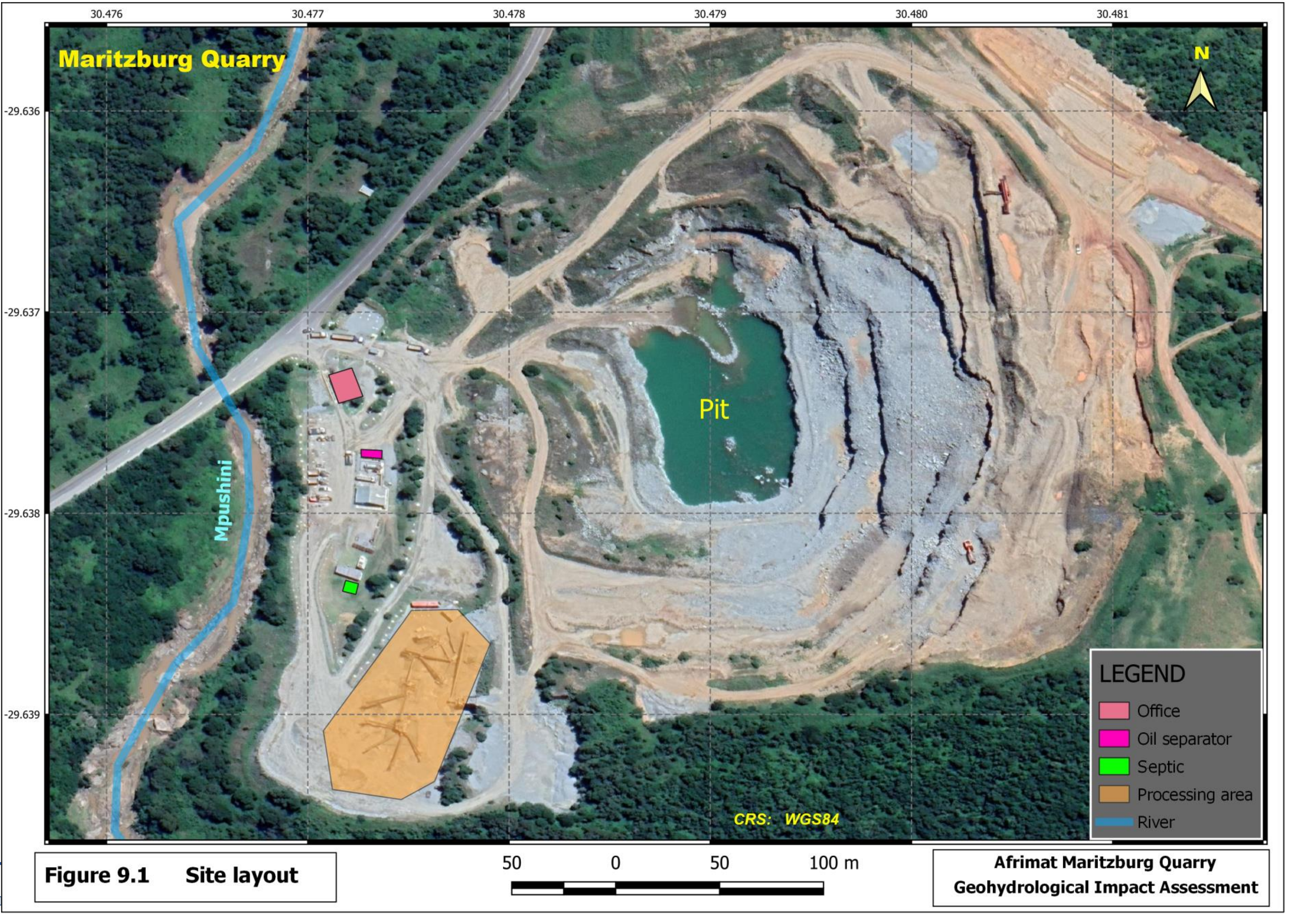


Figure 9.1 Site layout

9.2 OPERATION PHASE

This phase represents the period during which quarrying takes place at the site. Installation of all supporting infrastructure will have been completed.

9.2.1 Impact on groundwater Levels

The excavation of the quarry has reached its lowest vertical elevation, and extraction of rock is now progressing laterally. Available ground elevation data show that the quarry bottom is slightly lower than the section of the river adjacent to the pit, Figure 8.3. The quarry bottom lies at 541 metres amsl, whilst the section of the river adjacent to the pit lies between 548 and 544 metres amsl from upstream to downstream respectively. If it is assumed that there is a water-table connecting the two, it would have a gradient of 3 metres over 200 metres or 1.5% from the river to the quarry. This would lead to little flow towards the pit. The flow would be further constrained by the permeability of the rock between the river and the quarry, which is presently unknown. The hydraulic properties of the intervening rock material need to be determined by drilling and pump-testing a monitoring borehole between the river and the quarry.

9.2.2 Impact on groundwater quality

The processing of rock material consists of crushing and screening, and temporarily stockpiling at the site before sale. The entire process is a physical one, with no toxic chemical additives used. The process therefore does not generate any potential sources of groundwater contamination. No waste facilities such as tailings dams or evaporation dams exist at the site. No significant groundwater contamination is anticipated from these activities.

Other potential sources of groundwater contamination include:

- Septic tank that receives waste from ablution facilities,
- Vehicle wash bay and associated oil separator.
- Incidental fuel and oil leaks/spillages from vehicles and equipment,
- Explosives used for blasting has potential to taint the rocks with residual chemicals, particular nitrates. These chemicals get washed off the rocks by rain in the quarry and stockpile area, and find their way into the underlying aquifers.
- Dust suppression.
- Storm water from processing and stockpile areas.

The extent of the potential groundwater contamination at the site is presently unknown. Contaminated groundwater would be expected to daylight at the Mpushini River. As pointed out earlier, it is presently not known if there is hydraulic connection between the quarry and the river.

9.3 DECOMISSIONING PHASE

The decommissioning phase represents the period leading to the total cessation of mining operations. During this phase, the status quo from the operation phase persists until all activities stop.

9.3.1 Impact on groundwater Levels

On cessation of mining activities, groundwater levels are expected to recover until they equilibrate with the prevailing groundwater levels in the area. This is considered a positive impact.

9.3.2 Impact on groundwater Quality

Residual impacts from the earlier phases may persist for some time after closure.

9.4 POST MINE CLOSURE PHASE

This represents the period after of all mining activities have come to a complete halt.

9.4.1 Groundwater Levels

No impact on groundwater levels is expected.

9.4.2 Groundwater Quality

Residual impacts from the earlier phases may persist for some period after closure.

9.5 SUMMARY OF THE IMPACT ASSESSMENT

A summary of the impact assessment is given in Table 9.1

Table 9.1 Summary of the impact assessment

Phase	Description of activities	Impacts	Recommendation/remediation
Operation	• Extraction and processing of rock. • Disposal of industrial and domestic waste. • Dust suppression. • Monitoring of impacts.	• Quarrying has reached its lowest elevation which is slightly lower than the adjacent river. Minor impact on groundwater levels expected • Blasted rock may be tainted with nitrate explosives with potential to contaminate groundwater. • Accidental fuel and oil spillages may contaminate groundwater. • Dust suppression may wash contaminants from surface to underlying aquifers. • Stormwater from the processing and stockpile area may contaminate groundwater	• Water free of contaminant should be used for dust suppression, • Establish a storm water management system that separates clean and dirty water. • Install a monitoring borehole downstream of the pit. • Establish baseline groundwater quality from water quality measurements over a period of 24 months. • Develop a groundwater flow model to simulate groundwater flow behavior at the site, subject to striking significant water in the borehole, at least 0.2 L/s.
Closure and decommissioning	• Cessation of operations and cleaning up. • Monitoring of impacts.	• Positive impact relating to groundwater level recovery after mine closure. Recovery expected to equilibrate with the prevailing groundwater level in the area. • Residual groundwater contamination may continue	• Continue groundwater monitoring. • Fine tune the groundwater flow model.
Post closure	• Mine rehabilitation continued. • Monitoring of impacts.	• Residual groundwater contamination may continue	• Continue groundwater monitoring until water quality conforms to Resource Quality objectives (RQO) embedded in the water use licence for the quarry.

10 CONCLUSION

The study sought to determine potential negative impacts emanating from the mining activities at Maritzburg Quarry just outside Pietermaritzburg in KwaZulu Natal Province. The following findings were derived from the study:

10.1 GROUNDWATER LEVEL

- The excavation of the quarry to extract granite/gneiss aggregate will have minor impact on groundwater levels at the site because the ultimate operation depth of the quarry is almost at the same level as the adjacent Mpushini River. No significant subsurface water flow from the river to quarry is anticipated, even if there was good hydraulic connection between the two.
- Groundwater level and hydraulic properties of rocks at the site are not known, and need to be investigated further by the installation of a monitoring borehole and pumping test.
- The study area has very low borehole yield potential, characterised by borehole yields of less than 0.5 L/s (1.8m^3/h). However, higher yields are possible where good fractures or faults are intersected.
- There are no groundwater users within a radius of one kilometre of the quarry that may be exposed to negative impacts from the quarry.

10.2 GROUNDWATER QUALITY

- The processing of granite/gneiss aggregate is a physical process that does not use any chemicals. The potential for negative impacts on groundwater quality from the main activities is considered very small.
- Potential sources of groundwater contamination include:
  - Septic tank associated ablution facilities
  - Oil separator that is frequently into the ground
  - Dust suppression:
  - Incidental spillage of fuel and oil
  - Residual chemicals from blasting in the quarry and on the final products in the stockpile area.
- Based on visual assessment and judgement, the rate of flow in Mpushini River is estimated to be many orders of magnitude greater than the rate at which potential contamination plume would discharge into the river. In the event that contaminants from the quarry reach the river, their impact is likely to be overwhelmed by dilution in the river.
- The extent of the potential contamination of groundwater at the site is presently not known. This needs to be further investigated as proposed in the report.

11 RECOMMENDATION

The recommendations seek to ensure that Maritzburg Quarry complies with the relevant government legislation, particularly the National Water Act of 1998.

To this end, the following recommendations are made:

- Site and drill one monitoring borehole downstream of the quarry.
- Siting of the borehole should employ geophysical survey techniques to increase the chances of intersecting geological structures that influence groundwater flow at the site.
- Electromagnetic horizontal profiling is recommended to locate saturated fracture zones and faults; and magnetic traversing to locate dolerite intrusions. The possible positions of the geophysical survey line and the monitoring borehole are shown in Figure 11.1. The drilling site will be located anywhere along the survey line where significant geophysical anomalies are identified. Please note that the positions depicted are for guidance purposes only, the exact positions will be decided on the ground taking local conditions into consideration. The approximate coordinates of the start and end of the survey line are given in Table 11.1.

Table 11.1 Coordinates of the proposed geophysical survey line

Line ID	Line start coordinates		Line end coordinates	
	Latitude	Longitude	Latitude	Longitude
Line 1	-29.639296	30.476687	-29.636181	30.476973

- The borehole should be pump-tested if it has water, to determine the hydraulic characteristics of the aquifer.
- A groundwater flow model should then be developed to simulate the interaction between the quarry and the river. Please note that groundwater flow modeling will only be carried out if there is significant water in the proposed monitoring borehole, at least 0.2 L/s ($0.72m^3/h$).
- Groundwater monitoring should commence immediately after drilling the monitoring borehole.
- Groundwater quality sampling should be conducted quarterly; whilst monitoring of groundwater level should be carried out monthly.
- Water quality parameters to be monitored should include, but not limited to those for drinking water as given in Table 11.2 in the report.
- Baseline groundwater quality should be established in the first 24 months of continuous collection of water quality data from the monitoring borehole. This will provide a robust long-term groundwater quality baseline that can be used to detect any changes in groundwater quality during operation and post mine closure.
- Dust suppression water should not introduce contaminants onto the ground surface.
- Groundwater quality monitoring should continue after mine closure until the water quality complies with the Resource Quality Objectives (RQO) embedded in the water use licence for a

period of 24 months. RQOs are determined by the Department of Water and Sanitation for the quaternary catchment in which the quarry is located, in this case quaternary catchment U20J.

- Ideally the aggregate stockpile and processing areas should be lined with low permeability material or bunded to reduce the risk of groundwater contamination. However, due to the extent of the existing facilities, the cost of retro-fitting the liners or bunding would be astronomical. It is therefore recommended that the storm water management system in these areas should prevent water collecting on the surface for extended time; to reduce the chances of it seeping into the subsurface.

Table 11.2 Parameters to be monitored

Electrical conductivity, EC.	Potassium, K.	Chloride, Cl.
Total dissolved solids, TDS.	Iron, Fe.	Sulphate, SO_4.
Acidity/alkalinity, pH.	Manganese, Mn.	Fluoride, F.
Turbidity	Copper, Cu.	Nitrate, NO_3 as N.
Colour	Lead, Pb.	Phosphate, PO_4.
Calcium, Ca.	Zinc, Zn.	Total alkalinity, $CaCO_3$.
Magnesium, Mg.	Cadmium, Cd.	Hydrogen carbonate, HCO_3
Sodium, Na.	Chromium, Cr.	Faecal Coliform.

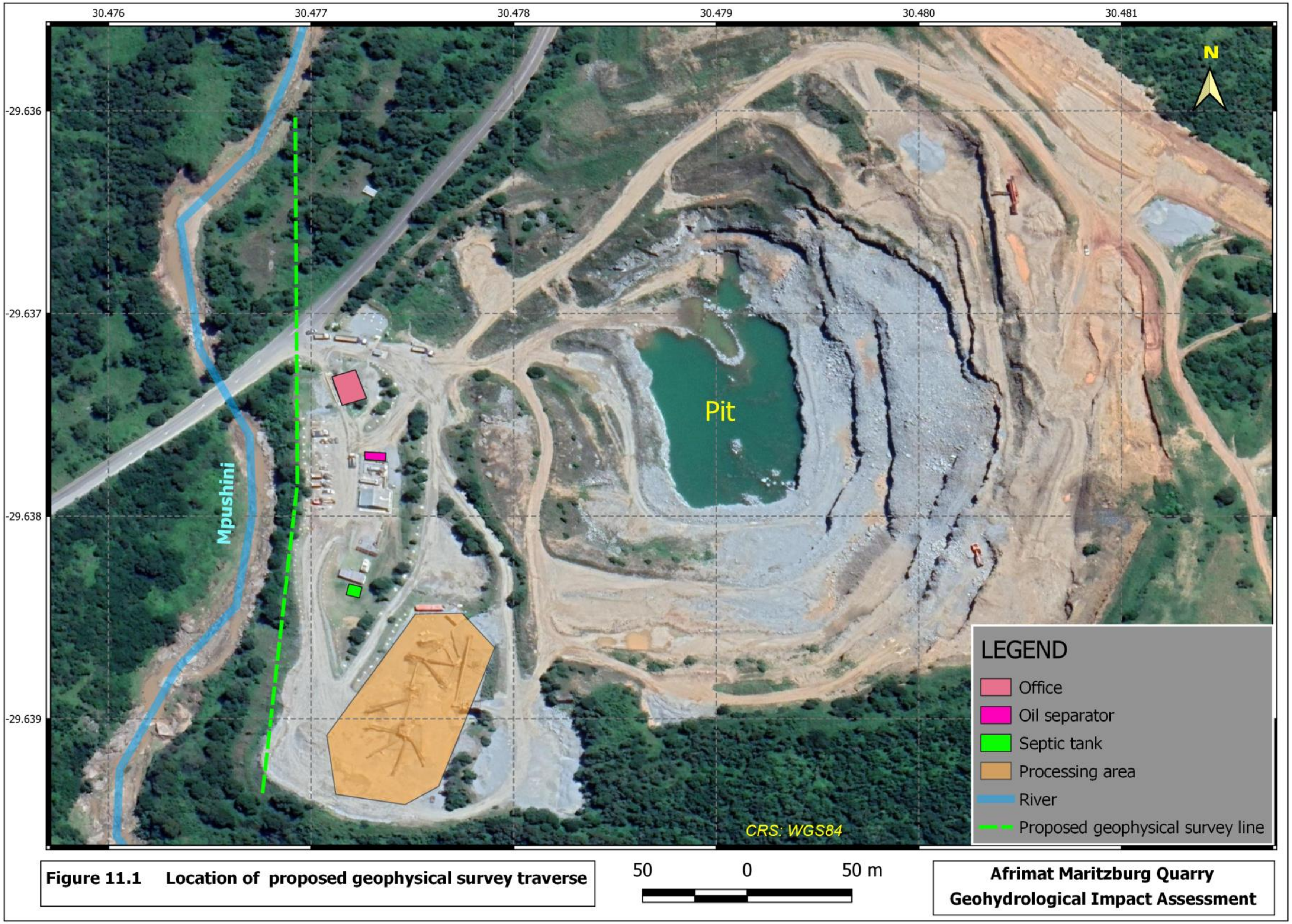


Figure 11.1 Location of proposed geophysical survey traverse

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