Appendix 7:

Geohydrological Specialist Report

Geohydrological assessment of a proposed sand mine, Portion 2 of the Woodlands farm 874, Malmesbury

REPORT:	***PREPARED BY:***
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GEOHYDROLOGICAL AND SPATIAL SOLUTIONS INTERNATIONAL (PTY)LTD
GEOSS

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EXECUTIVE SUMMARY

Afrimat Aggregates Operations (Pty) Ltd has applied for environmental authorization to mine 92 ha of portion 2 of the farm Woodlands (874), which is situated east of the R304 approximately 18.5 km south of Malmesbury in the Western Cape.

During the public participation process (PPP) Cape Nature requested that the opinion of a hydrogeologist be attained to determine if the sand mining process will impact runoff and infiltration to the nearby drainage channel. GEOSS was appointed to provide input and complete a geohydrological assessment.

The proposed activity is the removal of sand from the abovementioned farm portion. Only the upper layer of sand will be removed from the site, to the depth of clay rich / silty sand horizons where excavation will cease. The excavation will take place to a depth of approximately 1.5 m. Rehabilitation will then take place in the form of replacing the topsoil horizon onto the mined strip. Sand mining operations have taken place on the property adjacent to the site in previous years.

The field work took place on 15th March 2014. Five exploration holes were hand augered and piezometers were installed in four of them. Soil profiles (disturbed) were taken for each auger hole.

The following factors have relevance:

- According to the land owner sand mining has previously taken place adjacent to the site. To the south of the site, the land was correctly rehabilitated with topsoil and as a result erosion is negligible. However, to the east of the site rehabilitation was not completed and significant erosion is evident.
- The meeting with the land owner established that during periods of heavy rain, water preferentially flows as surface runoff to the north and to the south of the site.
- On the proposed mining area, three small dams are present which were constructed on the southern part of the site, with the dam base being at the depth of a clay layer. Canals were also dug on site to divert overland flow in to the dams and prevent large volumes of runoff reaching the road at the southern border of the site.
- During the site visit 5 holes were hand augered as deep as possible below the groundwater level and disturbed soil profiles were logged. Three of the auger holes intersected the groundwater level, enabling groundwater level measurement.
- The auger hole in the drainage region was augered to a depth of 2.3 m. No water table was intersected and very little clay was present.
- The groundwater gradient is towards the south of the site.

It is therefore concluded that the removal of the sands will affect the infiltration and therefore the runoff. However, if rehabilitated in the correct manner and timeframe,

erosion can be minimized. The demarked drainage area only flows during/after periods of high rainfall events.

It is recommended that the Department of Water and Sanitation (DWS) assesses the site and the proposed sand mining operations. This would likely require a site investigation during winter months when rainfall and recharge are at a peak. This will establish the rise in the groundwater level which will likely be higher than summer levels measured during this geohydrological assessment.

If the decision to continue with sand mining is made the following measures are recommended to ensure that successful rehabilitation results during and after the sand mining operations in order to minimize erosion.

- The sand mining must not go deeper than the consolidated silt / clay layer.
- The mining must not take place during or just before the rainfall season.
- The strips of soil that are removed should be done so at right angles to the slope, as this will slow down surface runoff and help to prevent erosion.
- Rehabilitation by replacing topsoil on the stripped land should take place before the next strip is opened and mined.
- All machinery must be in excellent condition and there must be NO oil/fuel leaks whatsoever from equipment.
- If a spill does occur, it must be immediately reported to the relevant authorities and immediately remediated.
- A short report (with photographs) should be completed prior to and on completion of the mining to the relevant authorities by an Environmental Control Officer (ECO).

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TABLE OF CONTENTS

LIST OF FIGURES, TABLES AND MAPS

ABBREVIATIONS

ch	collar height
ha	hectare
ℓ/s	litres per second
m	metres
MAE	Mean Annual Evaporation
mamsl	metres above mean sea level
MAP	Mean Annual Precipitation

mbch	metres below collar height
mbgl	metres below ground level
mg/ℓ	milligrams per litre
mm/a	millimetres per annum
mS/m	milliSiemens per meter
NGA	National Groundwater Archive
TMG	Table Mountain Group
WGS84	Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84.

GLOSSARY OF TERMS

Aquifer: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

Borehole: includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].

Fractured aquifer: Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.

Groundwater: water found in the subsurface in the saturated zone below the water table or piezometric surface i.e. the water table marks the upper surface of groundwater systems.

Hydraulic conductivity: measure of the ease with which water will pass through earth material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (in m/d)

Intergranular Aquifer: Generally unconsolidated but occasionally semi-consolidated aquifers. Groundwater occurs within intergranular interstices in porous medium. Typically occur as alluvial deposits along river terraces.

Karst aquifer: is an aquifer within a geological formation shaped by the dissolution of a layer or layers of soluble bedrock, usually carbonate rock such as limestone or dolomite, but also in gypsum.

Piezometer: A piezometer is a device which measures the pressure (more precisely, the piezometric head) of groundwater at a specific point.

Transmissivity: the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d); product of the thickness and average hydraulic conductivity of an aquifer.

Suggested reference for this report:

GEOSS (2014). Geohydrological assessment of a proposed sand mine, Portion 2 of Woodlands Farm 874, Malmesbury. GEOSS Report Number: 2015/03-11. GEOSS - Geohydrological & Spatial Solutions International (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

Surrounding landscape of Woodlands Farm

GEOSS project number:

2015_02-1391

1. INTRODUCTION

Afrimat Aggregates Operations (Pty) Ltd has applied for environmental authorization to mine 92 ha of portion 2 of the farm Woodlands (874), which is situated east of the R304 and approximately 18.5 km south of Malmesbury in the Western Cape **(Map 1, Appendix A).**

Greenminded Environmental appointed GEOSS to conduct a geohydrological assessment on the impact the sand mining process could potentially have on groundwater. Specific items investigated include runoff, infiltration of water on the site, and impacts on the stream channel to the south of the site **(Map 2, Appendix A).**

2. TERMS OF REFERENCE

The project Terms of Reference are to assess the potential impact of sand mining on the nearby channel to the south of the farm portion to be mined, as well as the impacts on runoff and infiltration.

3. REGIONAL SETTING

3.1 General

The study area is located on a farm approximately 18.5 km south of Malmesbury, just east of the R304 road. The proposed activity for the site is the removal of the upper ±1.5 m of soil with an excavator and the transport of the soil off the property with trucks via the R304. According to the land owner sand mining has been conducted in the past to the east and south of the site (**Map 7**).

3.1 Rainfall

Malmesbury receives an average of 237 mm of precipitation per year. The highest amount of rainfall usually occurs in June and July averaging 39 mm each, while the lowest occurs in January and February with an average of 3 mm. The Malmesbury weather station is situated closest to Woodlands Farm.

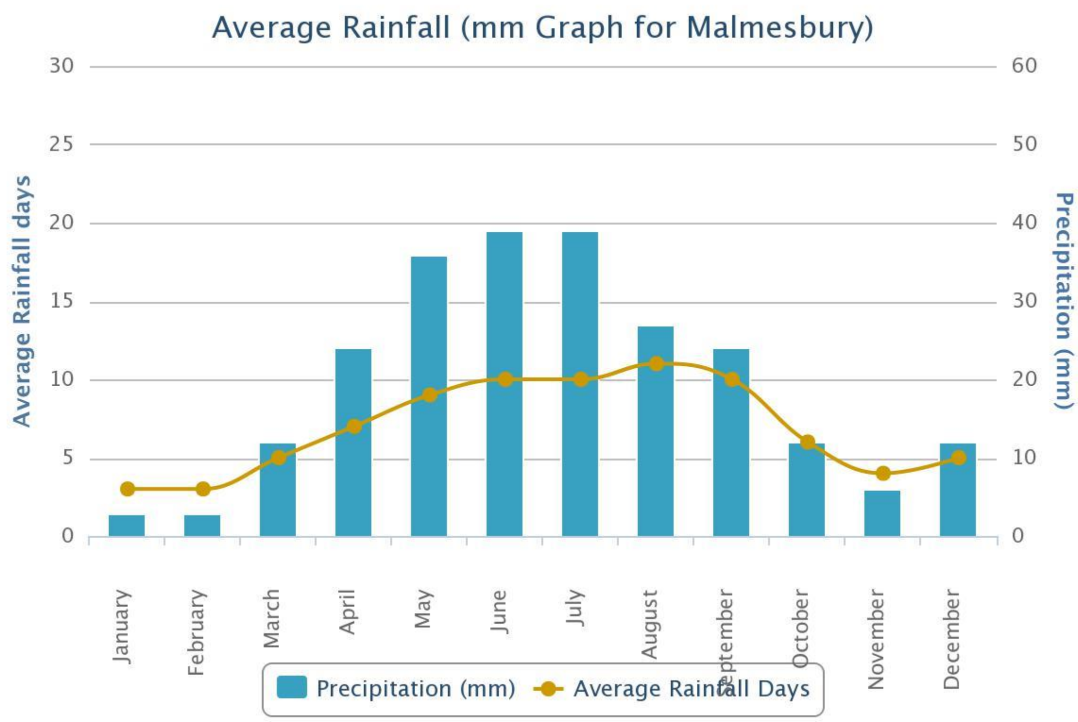


Figure 1: Average monthly rainfall for Malmesbury (worldweatheronline, 2002-2012)

3.1 Regional Geology

The Geological Survey of South Africa (now the Council for Geoscience) has mapped the area at 1:250 000 scale (Map sheet 3318 Cape Town). The geological setting is shown in **Map 3 (Appendix A)**. The main geology of the area is listed as "Qs: light – grey to pale red sandy soil". Approximately 4 km east of the site the Perdeberg Mountains occur, comprising of mainly coarse-grained porphyritic with fine grained leucocratic granite, with fine to medium grained porphyritic and medium grained biotic variants.

3.2 Regional Hydrogeology

During the desktop study it was established that the site predominantly overlies a fractured aquifer with an average expected yield of 0.1 – 0.5 L/s. A small part of the eastern section of the site overlies an intergranular and fractured aquifer of the same average expected yield (**Map 4, Appendix A**). The groundwater quality for the regional aquifer underlying the site has been classified as good to average according to the electrical conductivity, which is in the range of 70 – 300 mS/m (**Map 5, Appendix A**). These classifications are based on a 1:500 000 scale map, and due to this regional scale these classifications are regarded as guidelines only.

No boreholes exist on the proposed mining area. A borehole has been drilled about 1 km away from the site, drilled into granite bedrock.

4. SITE VISIT

The field work took place on 12th March 2015. Site photographs from the field visit are presented in **Appendix C**. Before field work commenced, a meeting was held with the farm owner who kindly provided more details of the proposed mining and expected site conditions. Five holes were then hand augered and the soil profile assessed (presented in **Appendix B**). Piezometers were installed at four of the sites.

4.1 Piezometer installation

Five holes were hand augered, four of them (PZ1, PZ2, PZ3 and PZ4) were equipped with piezometers. An additional fifth one was augered in the nearby drainage channel to the south of the proposed sand mining site. This work was done to determine if groundwater is present and if so, at what depth does it occur. The positions of the piezometers were strategically chosen to provide a good coverage of the study area.

At each site a 27 mm PVC pipe was installed as deep as possible below the water table. The PVC pipe was slotted (i.e. screened) to allow groundwater to infiltrate into the pipe. A gravel pack of 1.2 - 2.4 mm silica grains was used to keep any fine sands from blocking the screens which would slow or prevent inflow of water into the pipe. Such a pipe and screening is referred to as a piezometer (**Figure 2**). On completion of augering, the piezometers were left for a minimum of 2 hours to allow water to stabilise at the level of the local water table. Of the sites augered, three (3) of the five (5) intersected the water table. The positions of the auger sites and piezometers are listed in **Table 1**. The elevations were determined from Google Earth.

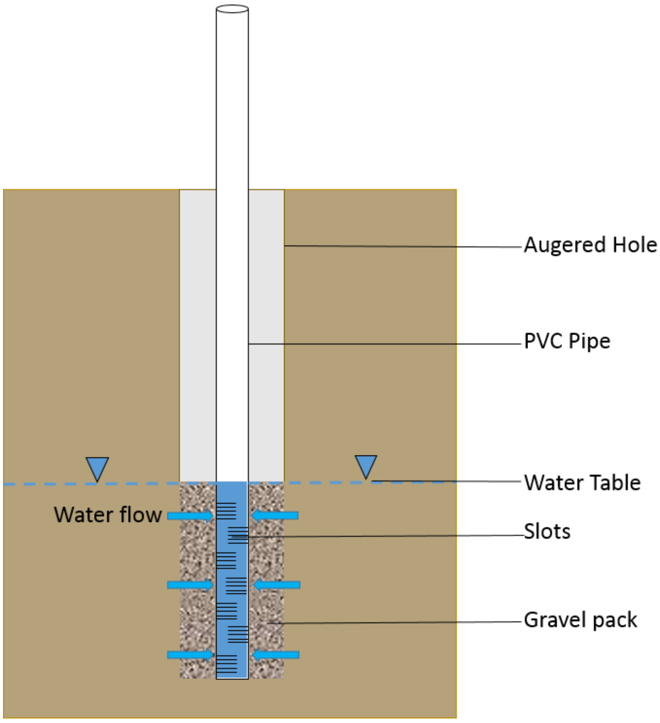


Figure 2: Typical piezometer construction

Table 1*: *Piezometer positions and elevations

Date	Site_ID	Lat_WGS84	Long_WGS84	Elev_mamsl
12-March-15	PZ_1	-33.604310°	18.756130°	171
12-March-15	PZ_2	-33.599748°	18.753760°	172
12-March-15	PZ_3	-33.599250°	18.750951°	166
12-March-15	PZ_4	-33.604900°	18.752830°	162
12-March-15	AH_5	-33.605463°	18.752791°	160

The distribution of the piezometer sites and auger holes are shown in **Map 6, Appendix A**. In **Table 2** the depth of the water levels below surface and piezometer depths is given.

***Table 2*: Water levels**

Site_ID	Elevation (mamsl)	Depth to bottom of auger hole (m)	Water level (mbgl)
PZ_1	171	4.1	2.37
PZ_2	172	2.2	-
PZ_3	166	2.4	1.69
PZ_4	162	4.1	1.97
AH_5	160	2.3	-

5. DATA ANALYSIS

The site consists of unconsolidated sands overlying granite. Groundwater is used in the area, and is usually abstracted from a fractured aquifer, with generally low yields (0.1 – 0.5 L/s). Recharge of the groundwater takes place through infiltration of rainwater through the unconsolidated sand deposits.

The water level in the unconsolidated sands overlying the granite was measured at 3 locations on the site. The deepest measurement was measured in the south east of the site, and was 2.37 mbgl. The water levels at PZ3 and PZ4 were both less than 2 m below ground level. Groundwater levels generally have a seasonal fluctuation, and these measurements were taken in summer. The water levels are expected to increase in winter, and be closer to the surface.

In order to avoid impacting on infiltration, groundwater recharge and flow, the Department of Water and Sanitation (DWS) generally stipulates that sand mining not be allowed within 1.5 m of the shallow groundwater level. Based on the site water level measurements, there is potentially little scope for mining. Additionally, this assessment evaluates summer water levels, and does not give an indication of the winter water level.

The background information document states that due to the sandy geology of the area, rainwater that falls directly on the mining site, will effectively soak away eliminating the risk for soil erosion. However, if mining is undertaken within 1.5 m of the water table, the scope for infiltration to the aquifer is reduced, and the potential for erosion damage is increased.

The groundwater flow on the site is expected to generally follow topography, and flow towards the topographical low points adjacent to the site. If mining is undertaken within 1.5 m of the water table the impacts of evapotranspiration are expected to increase which would reduce groundwater flow toward the nearby channel.

6. DISCUSSION

After completion of the geohydrological investigation, the following relevant points are made regarding the impact of the sand mine on runoff and infiltration, as well as the groundwater depths encountered.

- According to the land owner sand mining has previously taken place adjacent to the site (**Map 7**). To the south of the site, the land was correctly rehabilitated with topsoil and as a result erosion is negligible. However to the east of the site rehabilitation was not completed and erosion is easily evident (photos in **Appendix C**).
- The meeting with the land owner established that during periods of **heavy** rain, water preferentially flows as surface runoff to the north and to the south of the site.
- On the proposed mining area, three small dams are present which were constructed on the southern part of the site, with the dam base being at the depth of a clay layer. Canals were also dug on site to divert overland flow in to the dams and prevent large volumes of runoff reaching the road at the southern border of the site.
- During the site visit there was water present in the abovementioned dams, albeit at a very low level (photos in **Appendix C**).
- The groundwater level measured in the northern part of the site (PZ3) was shallower than that of the southern piezometers (PZ1 and PZ4), whilst no groundwater table was intersected in the auger hole in the drainage area (AH_5). This suggests that the groundwater table depth dips towards the south of the site and correlates with the land owners point that flow of the drainage area only occurs after/during heavy rainfall events.
- The auger hole in the drainage region was hand drilled to a depth of 2.3 m. No water table was intersected and very little clay was present.
- Termite mounds were found throughout the drainage area which correlates with a deeper groundwater table (photos in **Appendix C**)

7. CONCLUSION

From looking at the field evidence and data collected during the geohydrological site investigation, two issues become apparent.

Groundwater levels are relatively shallow, even though measurements were taken at the end of the low rainfall season. Groundwater levels generally have a seasonal fluctuation, and these measurements were taken in summer. The water levels are expected to increase in winter, and be closer to the surface.

Previously mined areas adjacent to the site show what happens when rehabilitation is conducted correctly and in an improper fashion. The sand mining will inevitably change infiltration rates and thus runoff rates, however the negative impact of erosion can be decreased greatly if rehabilitation is successful by conducting both mining and rehabilitation in the summer months before any major rainfall events occur.

In order to avoid impacting on infiltration, groundwater recharge and flow, the Department of Water and Sanitation (DWS) generally stipulates that sand mining not be allowed within 1.5 m of the shallow groundwater level. Based on the site water level measurements, there is potentially little scope for mining.

8. RECOMMENDATIONS

It is recommended that the DWS investigates the site and the proposed sand mining operations. This would likely require a site investigation during winter months when rainfall and recharge are at a peak. This would be able to establish the rise in groundwater table which will likely be higher than summer levels measured during this geohydrological assessment.

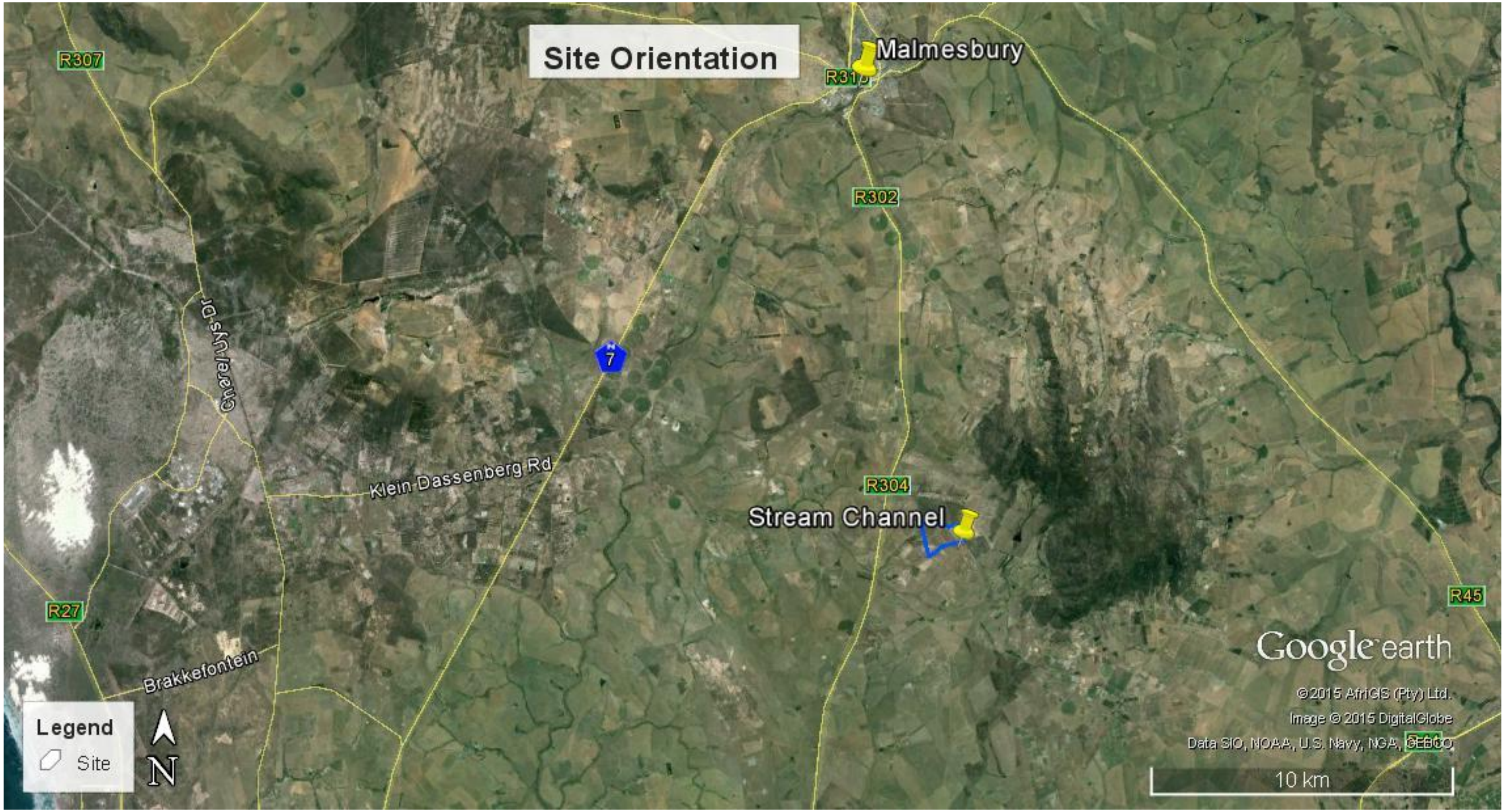
If the decision to continue with sand mining is made the following measures are recommended to ensure that successful rehabilitation results during and after the sand mining operations.

- The sand mining must not go deeper than the consolidated silt / clay layer.
- The mining must not take place during or just before the rainfall season.
- The strips of soil that are removed should be done so at right angles to the slope, as this will slow down surface runoff and help to prevent erosion.
- Rehabilitation by replacing topsoil on the stripped land should take place before the next strip is opened and mined.
- All machinery must be in excellent condition and there must be NO oil/fuel leaks whatsoever from equipment.
- If a spill does occur, it must be immediately reported to the relevant authorities and immediately remediated.
- A short report (with photographs) should be completed prior to and on completion of the mining to the relevant authorities by an Environmental Control Officer (ECO).

9. REFERENCES

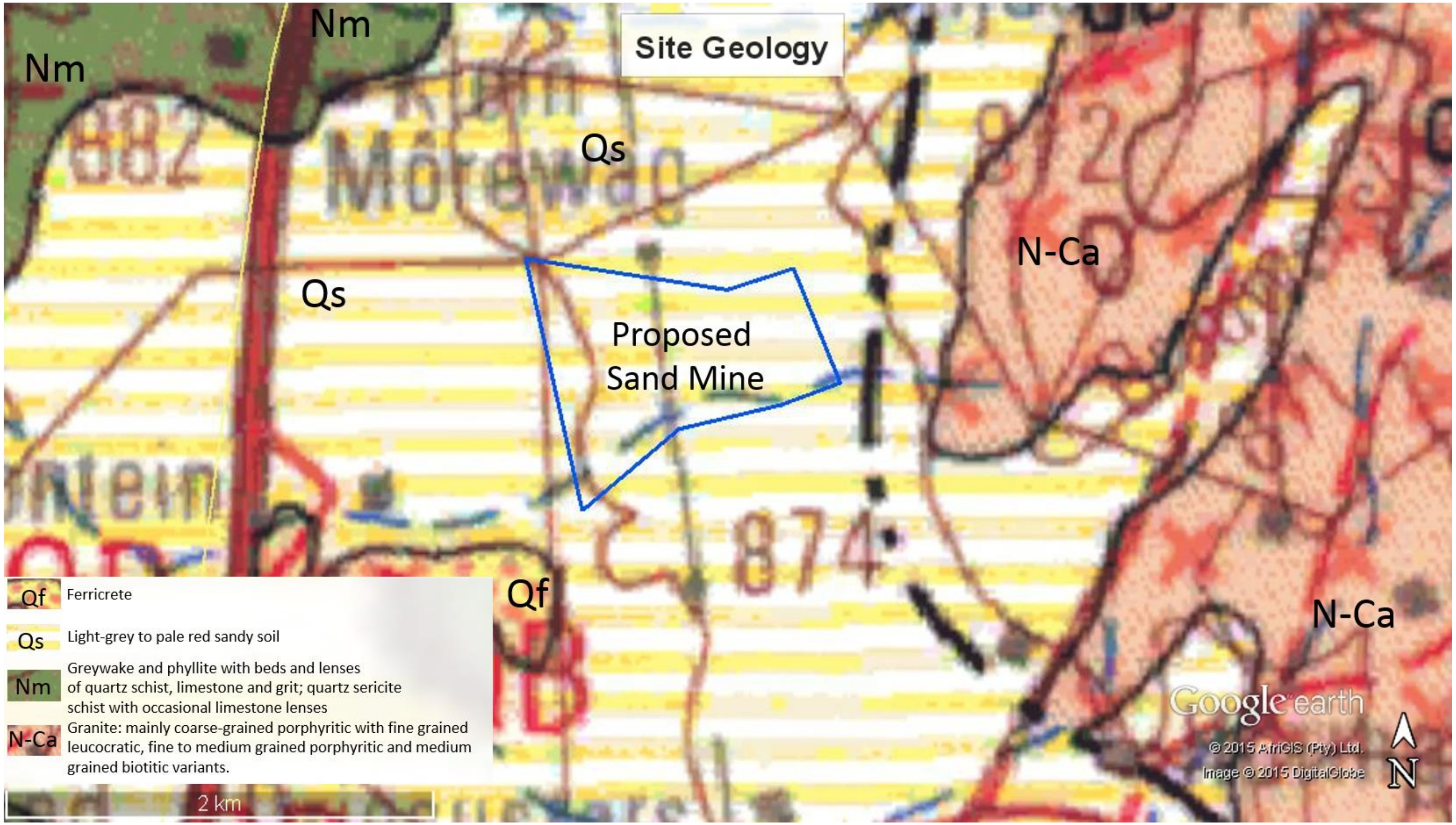
Department of Water Affair and Forestry (1998). The National Water Act, No 36. Pretoria.

10. APPENDIX A: MAPS



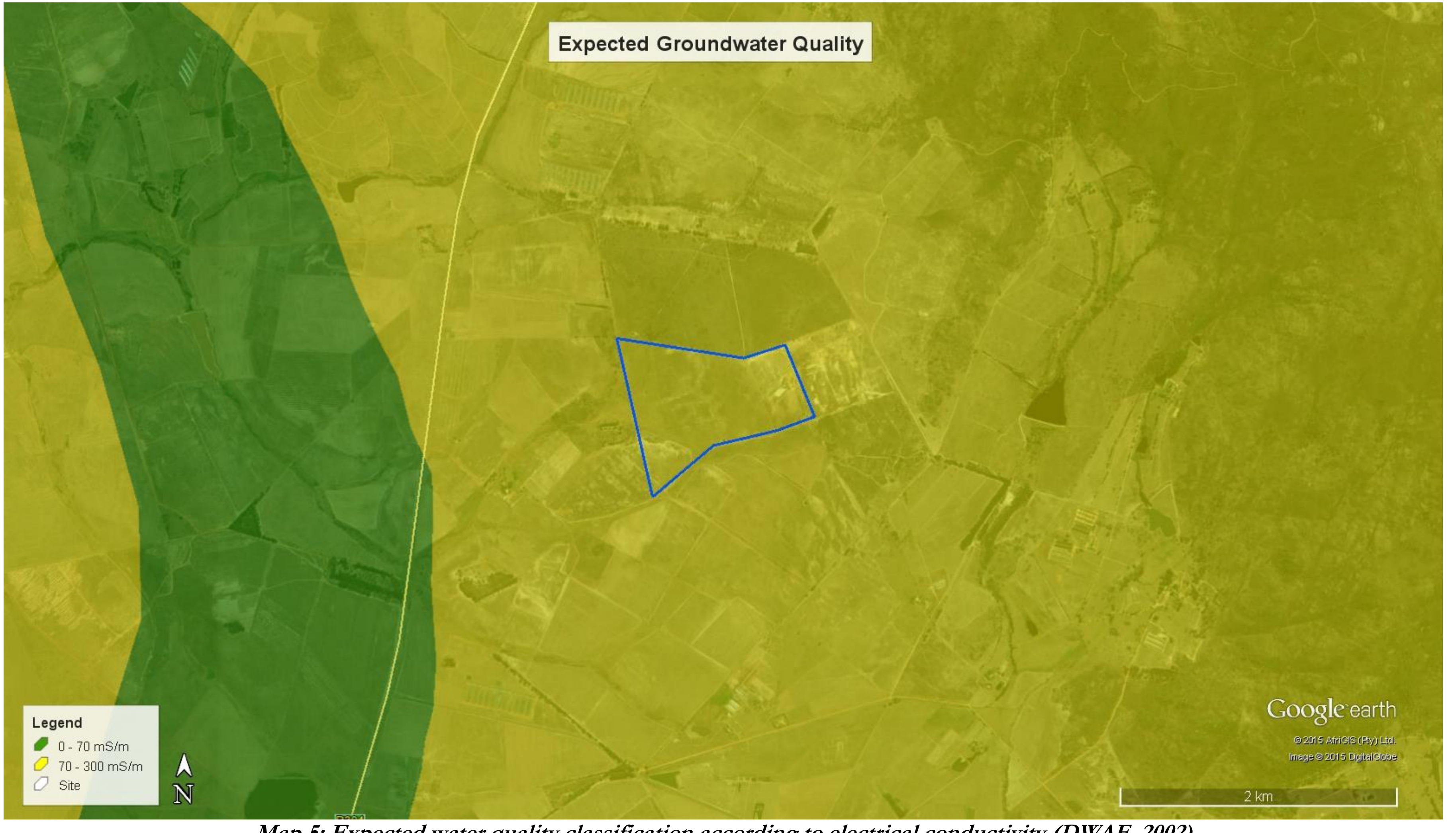
Map 1: Location of the study area within a regional setting

Map 2: The proposed site for sand mining and the location of the stream channel.

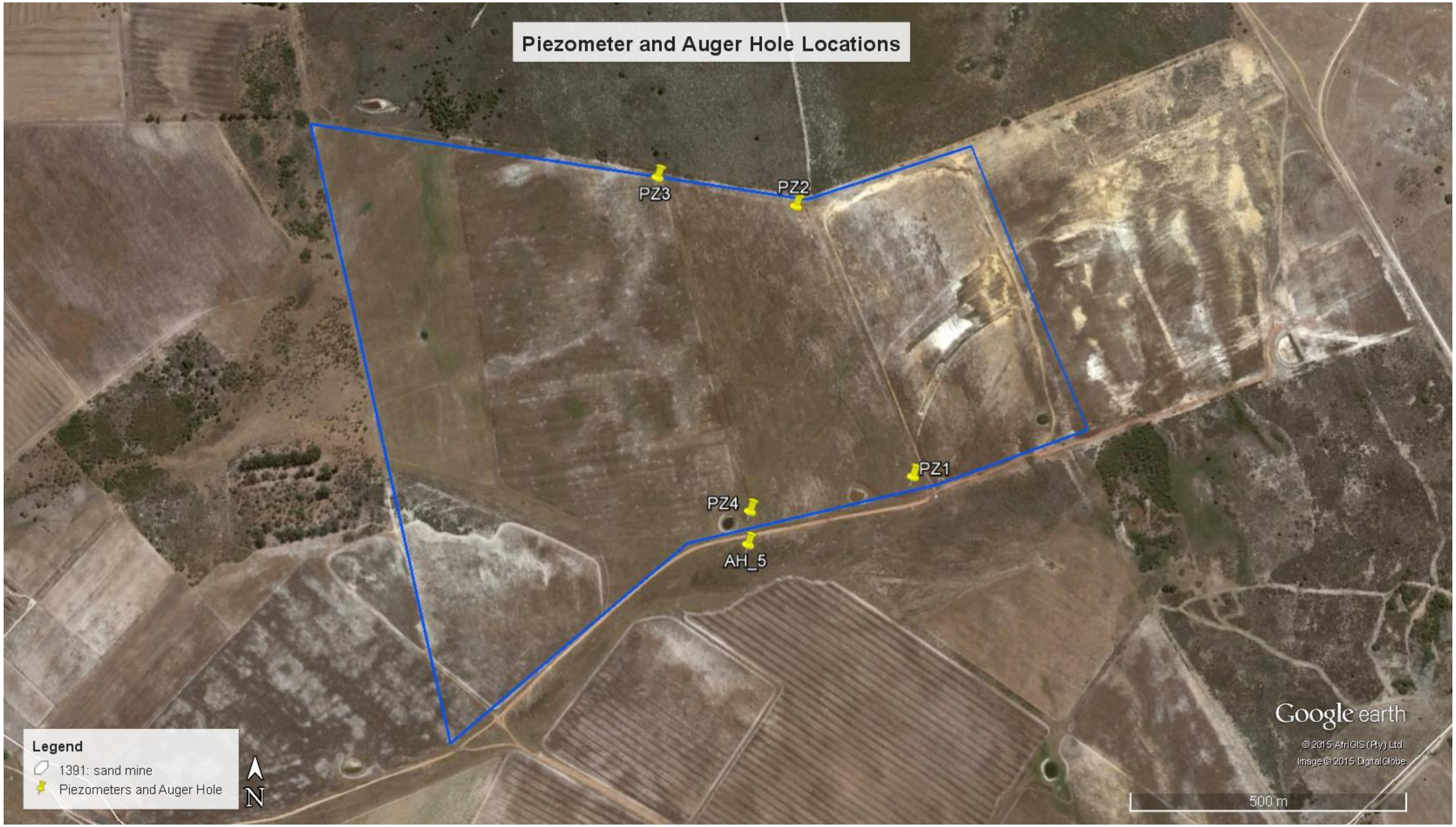


Map 3: Regional and underlying geology of the area (adapted from 3318 Cape Town, Council for Geosceince)

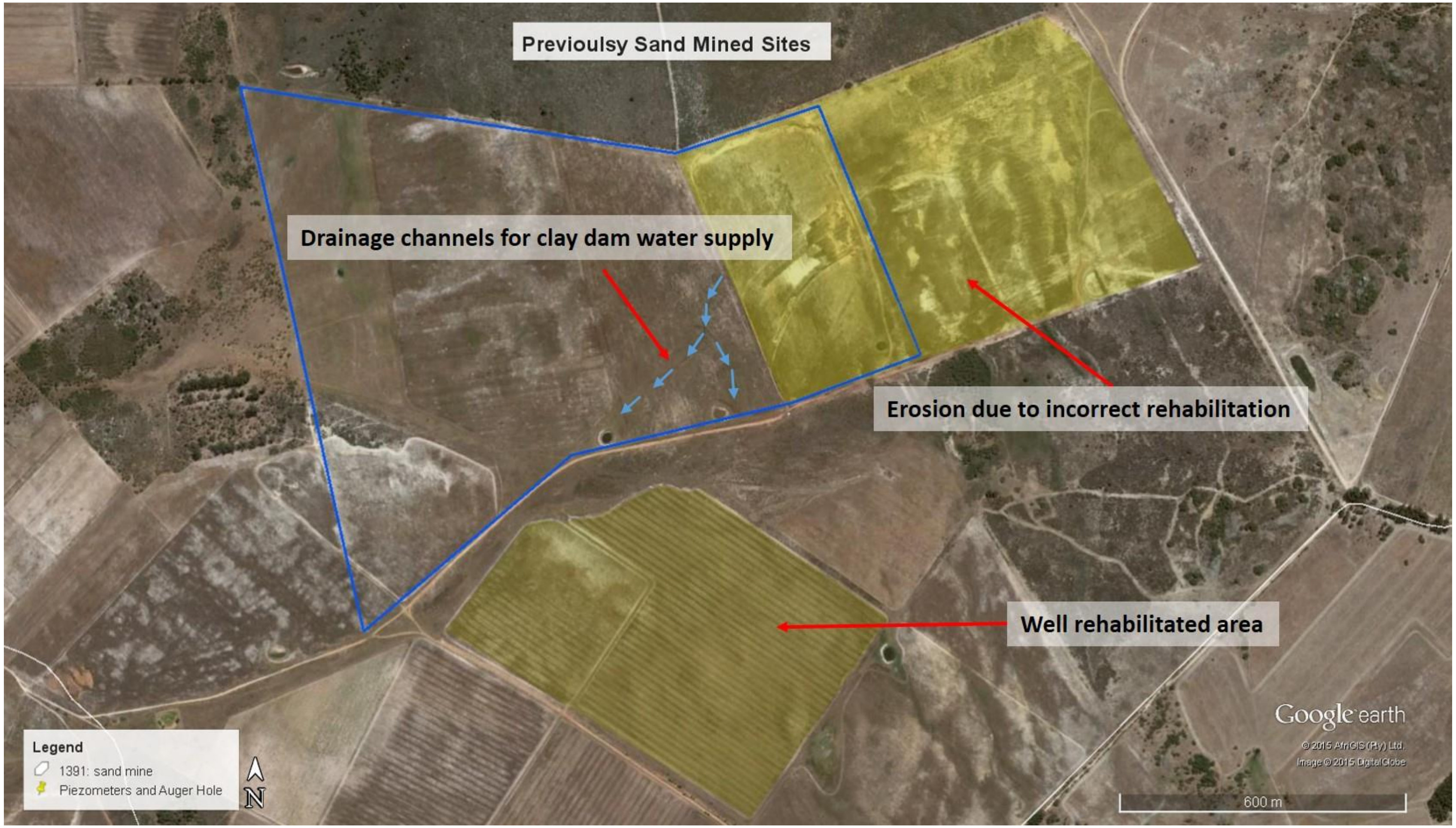
Map 4: Aquifer type and yield for the region (DWAF, 2002)



Map 5: Expected water quality classification according to electrical conductivity (DWAF, 2002)



Map 6: Locations of the four piezometers (PZ1-PZ4) and the auger hole (AH_5)



Map 7: Previously sand mined areas

11. APPENDIX B: SOIL PROFILES (DISTURBED)

Date	Time	Site_ID	Lat_WGS84	Long_WGS84	Elevation (mamsl)
12/3/2015	10:15	PZ1	-33.60431	18.75613	171
Depth (m)		**Description**			
From	**To**				
0	0.2	Dry, brown-grey, loose, silty sand, with roots and root holes.			
0.2	1.1	Very dry, light grey, very loose sand with quartz grains approx. 2 mm in diameter.			
1.1	1.29	Dry, brown white shards of sandy clay, with mottled red and purple brown clay and sand.			
1.29	1.6	Dry, light grey to white, very loose sand with angular quartz grains of up to 2 mm diameter.			
1.6	2.2	Slightly moist, light grey sandy clay, with speckled red and mottled blck sandy clay lenses, as well as root			
2.2	2.73	Moist, light grey, firm clayey sand, with blotches of dark brown and black sandy clay.			
2.73	3.5	Very moist, light grey, clayey sand, with speckled black and red clay snd lenses.			
3.5	4.01	Wet, grey, clayey sand.			

Date	Time	Site_ID	Lat_WGS84	Long_WGS84	Elevation (mamsl)
12/3/2015	12:58	PZ2	-33.59975	18.75376	172
Depth (m)		**Description**			
From	**To**				
0	0.2	Vey dry, brown grey, loose silty sand with roots and organic material.			
0.2	1.1	Dry, brown grey, very loose, silty sand.			
1.1	2.2	Slightly moist, light brown, loose silty sand.			
2.2	Collapse	Moist, light brown, loose silty sand.			
Note: Hole continuously collapsing at this depth due to loose sand in water table					

Date	Time	Site_ID	Lat_WGS84	Long_WGS84	Elevation (mamsl)
12/3/2015	14:05	PZ3	-33.59925	18.75095	166
Depth (m)		Description			
From	To				
0	0.3	Dry, loose, grey brown, silty sand, with roots and organic material.			
0.3	0.5	Dry, loose, grey brown, dense, silty sand.			
0.5	0.8	Slightly moist, red brown, loose silty sand.			
0.8	1.54	Moist, loose, dark brown, silty sand			
1.54	2.1	Very wet, dark brown silty sand.			
2.1	2.4	Wet, brown white, silty sand with lenses of black and yellow silty sand.			

Date	Time	Site_ID	Lat_WGS84	Long_WGS84	Elevation (mamsl)
12/3/2015	15:30		-33.6049	18.75283	162
Depth (m)		Description			
From	To				
0	0.4	Dry, grey brown, loose, silty sand, with roots aand root organc material.			
0.4	1.14	Dry, grey brown, loose, silty sand.			
1.14	1.92	Sightly moist, grey brown, clayey sand, with ottled red clayey sand.			
1.92	3.2	Moist, grey brown, clayey sand, with mottled red clayey sand.			
3.2	4.1	Wet, grey brown, loose silty clay sand with mottled red an white clayey sand.			
4.1	Collapse	Very wet, grey brown silty clay sand. Hole continuously collapsed at this depth.			

Date	Time	Site_ID	Lat_WGS84	Long_WGS84	Elevation (mamsl)
12/3/2015	16:05	AH_5	-33.60546	18.75279	161
Depth (m)		Description			
From	To				
0	0.28	Dry, loose, grey brown silty sand, with roots and organic material.			
0.28	0.8	Dry, loose, grey brown silty sand.			
0.8	1.2	Slightly moist, grey brown silty sand.			
1.2	1.7	Moist, firm, grey brown clayey sand, with red mottles.			
1.7	2.3	Moist, firm grey white clayey sand with red mottles of clayey sand.			
Notes: No water table encountered at the final depth of 2.30 m. Green vegetation of the area likely due to undisturbed natural land, and seasonal preferential flow. The presence of termite mounds throughout the drainage site also suggests a deeper groundwater table					

12. APPENDIX C: PHOTO GALLERY

Piezometer Site 01 (PZ_1)

Piezometer Site 02 (PZ_2)

Piezometer Site 03 (PZ_3)

Piezometer Site 04 (PZ_4)

Termite mound, occuring commonly in drainage area

***Restio sp* plant species that dominates the drainage area**

Erosio on the eastern boundary of site

Erosion on eastern boundry of site

Vegetation of drainage area

Clay dam on site

(last page)