Pure Source Minerals Mining Contracting (Pty) Ltd

Pure Source Mine Groundwater Report

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01	01 October 2018	Draft Hydrogeological Report	LS	SM	SM
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DISCLAIMER

LIST OF ABBREVIATIONS

Abbreviation	Description
Bh	Borehole
BPG	Best Practice Guideline
DMR	Department of Mineral Resources
DWAF	Department of Water Affairs and Forestry (now DWS)
DWS	Department of Water and Sanitation
EA	Environmental Authorisations
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GPS	Global Positioning System
ha	Hectares
IWULA	Integrated Water Use Licence Application
km	kilometre
L/s	Litre per second
L/h	Litre per hour
LOM	Life of Mine
m	metre
m^3	cubic metre
m^3/day	cubic metre per day
MAE	Mean Annual Evaporation
m amsl	metres above mean sea level
MAP	Mean Annual Precipitation
m bgl	metres below ground level
meq/L	milli-equivalents per litre
mg/ℓ	milligrams per litre
ml	millilitre
Ml/day	Mega litres per day
mm	millimetre
mm/a	millimetre per annum
MPRDA	Mineral and Petroleum Resources Development Act
MR	Mining Right
MRA	Mining Right Application
mS/m	milli Siemens per metre
NEMA	National Environmental Management Act, 1998
NEM:WA	National Environmental Management: Waste Act, 2008
NWA	National Water Act
Ptn	Portion

Abbreviation	Description
PR	Prospecting Right
SANAS	South African National Accreditation System
SANS	South African National Standards
SWL	Static Water Level
TDS	Total Dissolved Solids
WMA	Water Management Area

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1 Introduction

Monte Cristo Commercial Park (Pty) Ltd (hereafter referred to as Monte Cristo, the Applicant) is proposing to establish an opencast mine which will involve the development of open pits and associated mine infrastructure. The project will be known as Pure Source Mine. Commodities to be mined include sand, aggregate/gravel and diamonds (alluvial).

In order to undertake the proposed mining and associated activities, Monte Cristo requires a Mining Right (MR) in terms of Section 22 of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002, as amended) (MPRDA). In accordance with the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) Environmental Impact Assessment (EIA) and NEMA: Waste Regulations, National Water Act, 1998 (Act 36 of 1998) (NWA) as well as the NEMA: Air Quality Act, 2004 (Act 39 of 2004) and the following environmental permitting and licensing processes are required:

- Undertaking the Public Participation process.
- Compilation of an Integrated Environmental Authorisation Application.
- Compilation of Scoping and Environmental Impact reports.
- Development of an Environmental Management Programme and an Integrated Water and Waste Management Plan.
- Submission of an Integrated Water Use License Application.
- Submission of an Air Emission License Application.

The VLDC Group appointed Shango Solutions as the Environmental Assessment Practitioner (EAP) to manage the required environmental process for the Mining Right Application

A total sand resource of 30.144 million m^3 is estimated for this property. The average depth of the sand deposit is 10.71 metres (m) and for the fresh and oxidised aggregate approximately 7.14 m. Silica sand is present on the Farm Woodlands and has been mined historically on the property. The types of sand present on Portions 1, 3 and the Remaining Extent of the Farm Woodlands 407 vary from light yellow plaster, dark yellow plaster, white plaster, grey plaster, building to red (Erasmus, May 2018). All of the outcropping and underlying sediments on this property could be used for aggregate. From test pits dug on the property the volume of fresh aggregate down to an average depth of 7.5 m is calculated at 28.966 million m^3. Oxidised aggregate is suitable for decorative purposes, but not for use in the civil construction industry.

1.1 Groundwater Study Objectives

The groundwater impact assessment has the following objectives:

1. Define the groundwater characteristics for the Pure Source Mine mining area (the Project area).
2. Define potential receptors in the Project area.
3. Define the aquifers underlying the Project area, including groundwater table depth, groundwater quality, and flow characteristics.
4. Develop a numerical model to define groundwater related impacts and groundwater inflow into the proposed mining areas.
5. Define the radius of influence that will be created by mine dewatering, plus the extent of possible contamination originating from the proposed mining areas and mine

infrastructure.

6. Define the acid rock drainage potential associated with the waste rock.
7. Assess whether decant will occur during the operational phase or post closure.
8. Recommend a groundwater monitoring network that will record the groundwater quality and level changes during the operational and closure phases.

1.2 Compliance Framework

The groundwater impact assessment will be undertaken to South African Best Practice Guidelines, defined by the Department of Water and Sanitation (DWS). A groundwater numerical flow and transport model will support the groundwater impact assessment; defining potential groundwater quality and quantity impacts; including impacts on the local groundwater users, communities and the Vaal River.

The water quality assessment is based on South African National Standard (SANS) 241-1:2015, Drinking Water.

1.3 Groundwater Assessment Team

The following hydrogeologists are involved in the Pure Source Mine groundwater assessment:

1. Stephan Meyer (BSc Hon. Geohydrology) Pr.Sci.Nat:
    a. Project Hydrogeologist.
    b. Data Analysis, Numerical Modelling, Reporting.
2. Lucas Smith (MSc Geohydrology) Pr.Sci.Nat:
    a. Field surveys, interpretations and Scoping Report.

1.4 Report Structure

The report is structured as follows:

1. Section 1 – Introduction.
2. Section 2 – Environmental Setting.
3. Section 3 – Current Groundwater Use.
4. Section 4 – Potential Environmental Impacts.
5. Section 5 – Conclusions.
6. Section 6 – Scope of work proposed for the Impact Assessment Phase.

Appendices:

1. Appendix A: Project maps.
2. Appendix B: Water laboratory certificates.

2 Environmental Setting

The Pure Source Mine Project is situated on the southern banks of the Vaal River, approximately 22 kilometres (km) northeast of Parys, Free State Province and approximately 7 km west of The Barrage (Appendix A: Maps - Figure 8-1). The Pure Source Mine Farm and surrounding properties are located on the inner section of what resembles an oxbow lake, with the flanks approximately 4.3 km apart on the shortest section. Various sand mine operations are in this area with Tja Naledi Beafase Investment Holdings (Pty) Ltdto the east and Sweet Sensations Vaal Sand (Pty) Ltd to the west of Pure Source Mine.

The topography of the Project area and surrounds is relatively with small ridges and depressions to the north and south. The elevation of the project area decreases from 1432 metres above mean sea level (mamsl) in the east to 1417 mamsl in the west. The elevation of the mining area is on average 1440 mamsl. Most of the project area has gentle slopes towards the Vaal River and is located approximately 20 to 30 m higher compared to the Vaal River elevations.

Most of the small ridges and depressions occur along the north of the proposed mining area. There is a hill along the tar road, south of the proposed mining area, with a maximum elevation of approximately 1548 mamsl.

2.1 Catchment

The proposed Pure Source Mine mining area is located within the C23B quaternary catchment of the Upper Vaal Water Management Area (WMA), also referred to as WMA5. The Vaal River flows in a westerly direction.

The main drainage associated with the C23B quaternary catchment is the Kromelmboogspruit, which flows from southeast to northwest across the catchment (Appendix A: Maps - Figure 8-3). This stream is approximately 6 km to the southwest from Pure Source Mine Farm.

2.2 Climate and Rainfall

Climatic conditions can vary considerably from west to east across the Upper Vaal WMA. The mean annual temperature ranges between 16 °C in the west to 12 °C in the east, with an average of approximately 15 °C for the catchment as a whole (DWAF, March 2004).

Maximum temperatures are experienced in January and minimum temperatures usually occur in July. Rainfall is strongly seasonal with most rain occurring in the summer period (October to April). The peak rainfall months are December and January. Rainfall occurs generally as convective thunderstorms and is sometimes accompanied by hail. The overall feature of mean annual rainfall over the Upper Vaal WMA is that it decreases fairly uniformly westwards across the central plateau area. The mean annual precipitation (MAP) for the watershed ranges from a high of 1,000 mm in the east to a low of 500 mm in the west, with an average of about 700 mm. In accordance with the rainfall pattern the relative humidity is higher in summer than in winter.

Average potential gross mean annual evaporation (MAE) (as measured by Class A-pan) ranges from 1,600 mm in the east to a high of 2,200 mm in the dry western parts. The highest gross Class A-pan evaporation is in January (range 180 to 260 mm) and the lowest evaporation is in June (80 to 110 mm).

2.3 Geology

The information presented in this section was obtained from the Pure Source Mine Farm, Mining Right Application, Resource Statement (Erasmus, May 2018).

The proposed Pure Source Mine mining area is situated on the northern rim of the Vredefort Dome, which is a remnant of a meteorite impact event dated at 2020 Ma. The geology consists of very old sedimentary and volcanic sequences, and very young quaternary sediments associated with the Vaal River (Figure 2-1).

The geology on Portions 1, 3 and the Remaining extent of Woodlands 407 dip steeply to the south, at between 50° and 70°, and are all overturned.

In terms of the older sediments on this property, the stratigraphy that have been mapped include the Klipriviersberg Group (Ventersdorp Supergroup), the Black Reef Formation (Transvaal Sequence), the Malmani Subgroup (Transvaal Sequence), the Rooihoogte Formation (Transvaal Sequence), the Timeball Hill Formation (Transvaal Sequence), the Boshoek Formation, the Hekpoort Formation (Transvaal Sequence) and the younger intrusive Lindequesdrift Complex (Figure 2-1).

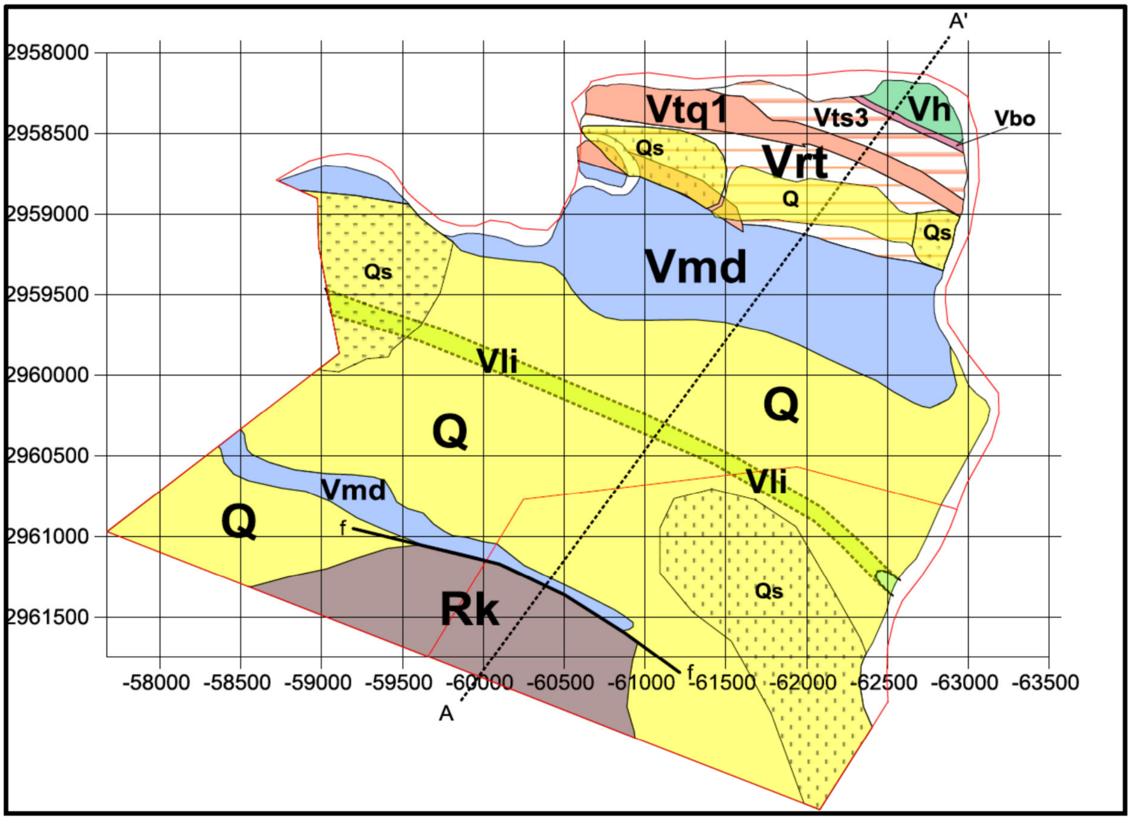

Figure 2-1 Pure Source Mine Geology Map (Erasmus, May 2018)

1. **Klipriviersberg Group (Rk).**
   The Klipriviersberg Group, Ventersdorp Supergroup consists of basaltic lavas, agglomerates and tuffs. This unit unconformably overlies the Witwatersrand Supergroup, and is locally estimated to be between 3,300 and 3,600 m in thickness. The typical lavas for this unit are mostly andesitic in composition and it is amygdaloidal in places.
2. **Black Reef Formation (Mbr).**
   The Black Reef Formation has been displaced by faulting on the Klipriviersberg Group and Malmani Subgroup contact.
3. **Malmani Subgroup (Vmd).**
   This sub-group overlies the Black Reef Formation conformably and consists of dolomite, chert and chert-breccia. This unit is between 1 200 and 1 500 m thick in the vicinity of Woodlands 407. The dolomite of this formation is usually covered by soft sediment, but the more resistant chert and chert-breccia are usually visible as prominent ridges. This unit covers the largest part of the geology on Woodlands.
4. **Lindeques Drift Complex (Vli).**
   This intrusive igneous complex forms an elongated body of 11 km in length and is emplaced within the Malmani dolomite. It consists of lamprophyre, syenodiorite and albite-syenite dykes.
5. **Rooihoogte Formation (Vrt).**
   The Rooihoogte Formation unconformably overlies the Malmani Sub-group, and is on average between 10 and 150 m in thickness. Lower down (basal 30 m) in the succession, this formation consists of breccia and conglomerate, and quartzite. The thicker upper remainder of this formation consists of shale and intercalated quartzite.
6. **The Timeball Hill Formation (Vtq).**
   This formation overlies the Rooihoogte Formation conformably and is made up of the Timeball Hill quartzite. This usually forms prominent ridges. The Vtq2 succession contains an elevated amount of iron when compared to Vtq1.
7. **The Timeball Hill Formation (Vts).**
   This formation overlies the Timeball Hill quartzite and consists of shale horizons.
8. **The Hekpoort Formation (Vh).**
   The main lithologies are finely crystalline andesitic tuffs and lava flows with amygdoloidal zones.
9. **Quaternary Sands (Q).**
   Most of the formations in the area are overlain by unconsolidated quaternary sediments of waterborne and windblown sands. The Vaal River is a very old and mature drainage system, borne out by the course it takes across the rim of the Vredefort dome. There is evidence on Woodlands 407 of a paleo-channel cutting across Portion 4 and the southern parts of the remaining extent, as well as the southern part of the remaining extent of portion 1. Further north in an east-west orientation is additional evidence of separate quaternary sediment deposited on Portion 3 and the remaining extent of Portion 1.
10. **Diamondiferous Gravels (Qs).**
    The mapped diamondiferous gravels are indicated as Qs on Figure 2-1.

The lithologies described above are shown as a cross section (Figure 2-2) across the property along reference line A-A' (Figure 2-1).

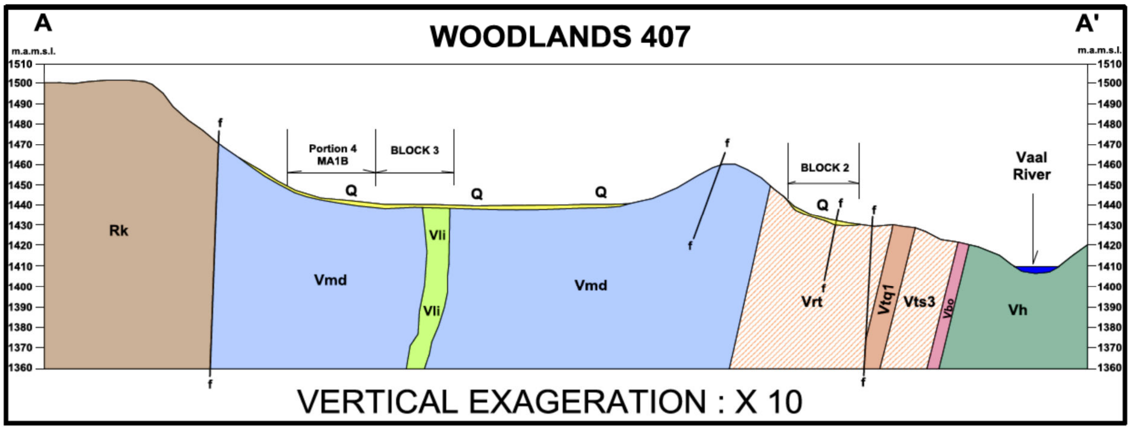

Figure 2-2 Geological Cross Section (Erasmus, May 2018)

3 Current Groundwater Use

A hydrocensus was conducted across the Project area during August 2018. The survey included the proposed mining footprint areas and adjacent properties and concentrated on identifying existing boreholes to enhance the knowledge of the groundwater systems and current groundwater use.

During the 2018 hydrocensus 20 groundwater sites (boreholes) were identified. Groundwater level measurements were possible from 12 boreholes; pumping equipment blocked the rest, and 11 groundwater samples were collected for water quality analysis.

The 20 sites included:

1. 14 boreholes which are in use.
2. 3 blocked boreholes.
3. 1 open / capped borehole – new and to be used soon.
4. 2 old boreholes, not in use.

During the hydrocensus the following information was collected for each site:

1. Borehole position (X, Y, Z-coordinates).
2. Information relating to equipment installed.
3. Borehole construction details.
4. Borehole yield – if known.
5. Groundwater level, if possible.
6. Current use.

A summary of the sites identified during the 2018 hydrocensus is presented in Table 1 and on the Hydrocensus Map (Appendix A).

Water levels were measured by using a dip meter to measure the distance from the mouth of the borehole (borehole collar elevation) to the groundwater table depth in the borehole. The height of the borehole collar was subtracted from the measured water level to define a water level below surface (measured in m bgl).

The boreholes are the only source of water to the community in the study area. Water is drawn from the Vaal River, in places, for irrigation purposes. An assumption has been made that there will be a strong correlation between the groundwater quality and water levels for boreholes GOO5, GOO7, GOO12, GOO18, GOO19 and GOO20 and the Vaal River level and quality. These boreholes are located on the banks of the Vaal River.

Table 1 Hydrocensus summary

Site ID	Farm	Occupant	Latitude (WGS84)	Longitude	Elevation (m amsl)	Water level (m bgl)	Status
GOO1	Woodlands 407, Portion 4	Ian van Rensburg	26,7578	27,62481	1441	pumping	in use
GOO2	Woodlands 407, Portion 4	Ian van Rensburg	26,75866	27,61974	1449	closed	in use
GOO3	Woodlands 407, Portion 4	Ian van Rensburg	26,76435	27,62336	1441	closed	not in use
GOO4	Woodlands 407, Portion 4	Ian van Rensburg	26,75936	27,60881	1457	closed	in use
GOO5	Woodlands 407	Pure Source Mine	26,75176	27,63284	1426	4.44	in use
GOO6	Woodlands 407	Pure Source Mine	26,74971	27,61116	1432	closed	collapsed
GOO7	Woodlands 407	Pure Source Mine	26,75015	27,63216	1419	closed	collapsed
GOO8	Woodlands 407	Pure Source Mine	26,74887	27,60975	1433	closed	in use
GOO9	Woodlands 407	Pure Source Mine	26,7506	27,60743	1438	2.57	collapsed
GOO10	Woodlands 407	Pure Source Mine	26,75805	27,59957	1465	20.56	in use
GOO11	Woodlands 407	Sweet Sensations, Vaal Sand	26,7457	27,5898	1433	7.07	in use
GOO12	De Pont 228	unknown	26,74072	27,58975	1430	closed	not in use
GOO13	Welbedaght 282	Trevor v Heerden	26,77248	27,58512	1417	pumping	in use
GOO14	Welbedaght 282	Vintage Yard Wedding Venue	26,76958	27,58435	1412	1.88	in use
GOO15	Welbedaght 282	Trevor v Heerden	26,76971	27,58866	1435	17.10	in use
GOO16	Welbedaght 282	Trevor v Heerden	26,78416	27,60061	1448	closed	in use
GOO17	Welbedaght 282	Trevor v Heerden	26,7743	27,60671	1469	9.95	in use
GOO18	De Pont 228	Wilhelm Gersteling	26,74398	27,58365	1416	9.85	in use
GOO19	De Pont 228	Athos	26,74484	27,58293	1412	closed	in use
GOO20	De Pont 228	Athos	26,7446	27,58316	1413	closed	in use

3.1 Groundwater Levels

The groundwater levels varied from 2.5 m to 7 m across the proposed mining area, to a maximum depth of 20.5 m bgl along the tar road. To the south of the big hill (south of the tar road and proposed mining area) the average water table depth is 10 m below surface.

Time series groundwater level or quality data are not available to determine seasonal groundwater changes. Detailed information in terms of borehole construction and yields are also not available for the boreholes. The correlation between the topographical elevation and the water table elevation is 91%, confirming that the groundwater table elevation follows the topography. The general groundwater flow direction is in a northerly direction towards the Vaal River. There is a strong possibility of good surface water-groundwater interaction based on the shallow groundwater levels in the proposed mining area and the proximity of the Vaal River. The shallow groundwater table in the proposed Pure Source Mine mining area also indicates the possibility of groundwater inflow into the sand and aggregate excavations.

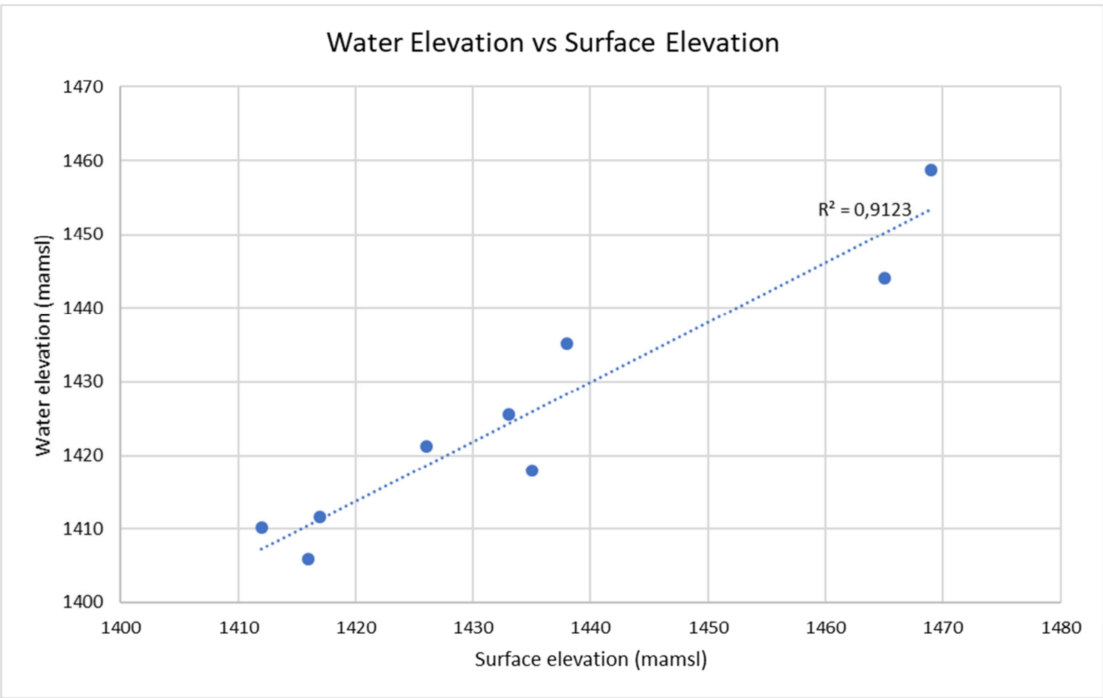

Figure 3-1 Groundwater vs Surface Elevation

3.2 Groundwater Quality

Eleven (11) groundwater samples were collected during the 2018 hydrocensus. The water samples were submitted to Waterlab (Pty) Ltd for analysis; Waterlab is a SANAS accredited laboratory (South African National Accreditation System). The water samples were analysed for basic inorganic parameters and the results were compared against the SANS 241:2015 Drinking Water Standards. It is recommended that all identified boreholes, actively used for domestic and agricultural purposes be sampled again before the construction phase (if successful) to update the baseline assessment and build a water quality database for the area. The database will help the client identify water quality and level trends in the area and will serve as reference to identify and quantify potential impacts on private boreholes.

Samples were collected from boreholes across the project area to ensure a good illustration of current groundwater qualities. Water quality analysis included the following elements:

1. pH – Value at 25°C.
2. Electrical Conductivity in mS/m at 25°C.
3. Total Dissolved Solids.
4. Chloride as Cl.
5. Sulphate as SO_4.
6. Fluoride as F.
7. Nitrate as N.
8. Ortho Phosphate as P.
9. Total Cyanide as CN.
10. E. coli / 100 mℓ.
11. Free & Saline Ammonia as N.
12. ICP-MS Scan.

The water quality results are presented in Table 2. The laboratory certificates are attached in Appendix B. Based on the water quality results, the following conclusions were drawn:

1. Acute Health effects:
   i. E.Coli – The downstream river sample (River 1) yielded a high E.Coli concentration (2 counts per 100 ml); potentially because of anthropogenic activities in the area.
2. Aesthetic effects:
   i. Ammonium – Ammonia is not toxic to human at the concentrations likely to be found in drinking water, but does exert other effects. Elevated concentrations of ammonia can compromise the disinfection of water and give rise to nitrite formation, which may result in taste and odour problems. A high ammonia concentration was measured in the upstream river sample (River 3). Ammonia is also found in runoff from agricultural lands, where ammonium salts have been used for fertilizers.
   ii. Iron – The speciation of iron is also related to the pH and Eh of water. An elevated iron concentration was measured at borehole GOO5 (Table 2). This borehole is on the banks of the Vaal River and the elevated iron concentration could be the results of corroding steel casing or the Transvaal shale formations. The concentration of dissolved iron in water is also dependent on the occurrence of other heavy metals, such as manganese.
   iii. Manganese – Manganese is a relatively abundant element, constituting approximately 0.1% of the earth's crust. The downstream river sample (River 1) measured a manganese concentration that could result in aesthetic issues (Table 2). Manganese tends to precipitate out of solution to form a black hydrated oxide which is responsible for staining problems.
3. Calcium – elevated calcium concentrations were measured in the two river samples and borehole GOO5. Scaling is likely to occur in water heating appliances such as kettles and geysers, and results in low efficiencies and the partial obstruction of pipes. High concentrations of calcium also impair the lathering of soap.

Most of the elevated concentrations are only elevated in one or two sampling points, mostly in the Vaal River and boreholes close to the river. Most of the salts and metals were present in concentrations below the SANS241 guideline limits. Based on the SANS241 drinking water guideline and on the sampled borehole water results, the groundwater sampled from 9 boreholes are fit for human consumption (treatment still recommended).

Groundwater quality in an area can be defined by the groundwater flow rate (residence time), the geological formations, the redox potential and human activities. Good quality groundwater can be expected in the Pure Source Mine area due to the sandy aquifers, dolomite, rainfall, and active groundwater flow. Stagnant groundwater zones are not expected in the area.

The sampled groundwater is currently not showing any negative impacts associated with the historical mining activities on the Farm Pure Source Mine or at the neighbouring sand mine operations.

Table 2 Water quality results (August 2018)

	pH – Value at 25°C	Electrical Conductivity in mS/m at 25°C	Total Dissolved Solids (mS/mx6.7)	Chloride as Cl	Sulphate as SO_4	Fluoride as F	Nitrate as N	Ortho Phosphate as P	E. coli / 100 mℓ	Free & Saline Ammonia as N	Na (mg/L)	Ca (mg/L)	K (mg/L)
SANS241 Standard Limits	≥5 - ≤9.7	Aesthetic ≤170	Aesthetic ≤1200	Aesthetic ≤300	Aesthetic ≤250					Aesthetic ≤1.5	Aesthetic ≤200		
					Acute health ≤500	Chronic health ≤1.5	Acute health ≤11		Acute health - Not detected				
DWS Drinking Standards												No health. Scaling intensifies from 32mg/L	No aesthetic or health effects below 50mg/L
River 1	7.7	78.1	523	49	172	0.2	4.7	0.4	2	1.0	60	57	10,4
River 3	7.7	78.4	525	53	177	0.3	4.0	0.4	0	1.9	61	59	10,5
G001	7.7	19.1	128	2	7	--	3.0	--	0	0.1	4	19	0,8
G002	8.1	26.2	175	3	3	--	4.3	--	0	0.1	4	29	1,6
G005	7.3	99.8	669	48	235	--	0.7	--	0	0.1	43	97	0,7
G008	7.6	22.0	147	8	--	--	0.7	--	0	0.2	5	21	0,7
G010	7.2	17.2	115	2	--	--	4.4	--	0	0.2	5	15	3,3
G011	8.6	12.1	81	2	--	--	1.5	--	0	--	2	15	0,9
G017	6.8	15.7	105	5	2	--	5.4	--	0	--	9	12	3,2
G018	7.8	30.4	204	14	27	--	3.6	--	0	--	6	31	1,0
G020	8.5	11.9	80	2	5	--	1.8	--	0	--	3	15	0,8

	Al (mg/L)	B (mg/L)	Ba (mg/L)	Fe (mg/L)	Li (mg/L)	Mg (mg/L)	Mn (mg/L)	Ni (mg/L)	P (mg/L)	Rb (mg/L)	Si (mg/L)	Sr (mg/L)	Ti (mg/L)
SANS241 Standard Limits	≤0.3			Aesthetic ≤0.3			Aesthetic ≤0.1						
		Chronic health ≤2,4	Chronic health ≤0,7	Chronic health ≤2			Chronic health ≤0.4	Chronic health ≤0.07					
DWS Drinking Standards						Diarrhoea and scaling issues from 70mg/L							
River 1	0,130	0,131	0,046	0,138	0,012	22	0,105	0,012	0,551	0,010	1,6	0,168	0,048
River 3	0,166	0,137	0,045	0,153	0,012	22	0,059	0,012	0,498	--	2,6	0,169	0,044
G001	--	0,041	--	--	--	10	--	--	0,035	--	12,5	0,039	0,014
G002	--	0,040	--	0,028	--	15	--	--	0,106	--	14,2	0,056	0,019
G005	--	0,085	--	0,689	--	63	0,059	--	0,066	--	13,5	0,146	0,062
G008	--	0,032	0,027	0,097	--	13	--	--	0,051	0,013	16,5	0,060	0,016
G010	--	0,031	--	0,029	--	9	--	--	0,090	--	16,1	0,057	0,010
G011	--	0,033	--	0,027	--	5	--	--	0,060	--	11,0	0,029	0,011
G017	--	0,030	--	0,175	--	6	--	--	0,061	--	20	0,055	--
G018	--	0,032	0,025	--	--	14	--	--	0,077	--	17,3	0,081	0,023
G020	--	0,026	--	0,029	--	4	--	--	0,067	--	13,0	0,029	--

4 Geochemical Evaluation

The geological formations in the application area were subjected to geochemical assessments to determine their leach characteristics and acid generation potential. The samples were submitted for static leachate tests and the analysis were performed according to the National Environmental Management: Waste Act, 2008 (NEM:WA) guidelines and regulations for waste classification. The laboratory results have been used to determine the mineral composition of the samples, what elements could potentially leach from the sand or waste material during storage on surface or within the excavations and define the liner requirements for the storage of the material on surface.

Five (5) geological samples were submitted for geochemical laboratory tests. Material samples were taken across the proposed mining area to ensure a representative analysis of the proposed mining zone (Table 3).

Table 3 Geochemistry sample selection

Geochem Sample No.	Deposit	Sample Locality	Longitude (WGS 1984)	Latitude	Leach Test
Z7501	North Sand	Sand North West	27.615625°	-26.737210°	Distilled
Z7502	South Sand	Sand Middle Slime	27.605264°	-26.752521°	Distilled
Z7503	North Aggregate Central	Aggregate Central	27.613431°	-26.747359°	Distilled
Z7504	South Aggregate	Aggregate Central West 2 / Aggregate South East	27.600770° / 27.627160°	-26.744046° / -26.753428°	Distilled
Z7505	North Aggregate	Aggregate North West	27.621645°	-26.735109°	Distilled

4.1 Laboratory Tests

All samples were submitted to Waterlab (Pty) Ltd for analysis. Tests included:

1. XRD analysis.
2. Acid-Base Accounting (ABA).
3. Sulphur Speciation.
4. Aqua regia digestion.

Evaluation of a material's potential to generate or neutralise acid, and leach metals or salts is determined by two types of tests, static and kinetic tests. Static tests enable a basic evaluation of the material in terms of its potential to produce Acid Rock Drainage (ARD) and to identify elements that may leach from the sample. Kinetic testing (not conducted for this project) supports the static test findings, but at a high level of confidence and provides an indication of the time scale associated with the leaching.

Total Concentration values were determined by aqua regia digestion and analysis with Inductively Coupled Plasma (ICP) methods to determine the chemical make-up of the material.

4.1.1 XRD Analysis

X-ray Powder Diffraction (XRD) is used to determine the mineralogical composition of the material.

4.1.2 ABA Analysis

Acid-Base Accounting (ABA) measures the acid and alkaline-producing potential of geological samples to determine if the waste material will produce acid and release metals. It defines the acid-neutralising potential or acid-generating potential of rock samples; the difference is calculated and reported as the Net Neutralising Potential (NNP). The NNP is compared with a predetermined set of values to divide samples into categories that either require, or do not require further laboratory test work.

4.1.3 Leachate Tests and Total Element Analysis

As part of the assessment, leach tests (distilled water extraction) were undertaken by performing a 1:20 (solid-liquid) aqueous extraction with distilled water. The tests are commonly used as a preliminary screening process to identify potential chemicals of concern (CoC).

4.1.4 Sulphur Analysis

Sulphide minerals are the primary sources of acidity and leaching of trace metals, and their measurement is a requirement for acid drainage chemistry prediction. For sustainable long-term acid generation, at least 0.3% Sulphide–S is needed. Values below this can yield acidity.

4.2 Laboratory Results

The laboratory results were assessed against the guidelines as defined in the NEM:WA, to determine the potential environmental risks, as well as to determine the waste type and liner requirements. All laboratory results are presented in Appendix D and are summarised in the following sub-sections.

4.2.1 Sample Mineralogy

Quantitative XRD analysis indicate that the samples consist mainly of quartz, goethite and microcline. The mineral names may not reflect the actual composition of minerals identified, but rather the mineral group. The quartz, iron and feldspar minerals are characteristic of the area.

4.2.2 ABA Analysis

The following guidelines were used to assess the acid or neutralising potential of the samples; the results are presented in Table 6.

Net Neutralising Potential (NNP) is classified according to the following:

1. If NNP (NP – AP) < 0, the sample has the potential to generate acid.
2. If NNP (NP – AP) > 0, the sample has the potential to neutralise acid produced.
3. Any sample with NNP < 20 is potential acid-generating, and any sample with NNP > -20 might not generate acid (Usher et al., 2003).

4. NNP values between –20 and 20 kg/ton $CaCO_3$ are thus in a range of uncertainty; kinetic tests may be needed.
5. If the NNP is greater than 20 kg/ton $CaCO_3$, it is generally accepted that the material is non-acid producing.
6. If the NNP is less than –20 kg/ton $CaCO_3$, it is generally accepted that the material is acid producing.

Table 4 Classification according to the Neutralising Potential Ratio (NPR)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	< 1:1	Likely ARD generating
Possibly	1:1 – 2:1	Possibly ARD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	2:1 – 4:1	Not potentially ARD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	>4:1	No further ARD testing required unless materials are to be used as a source of alkalinity

Classification according to the Sulphur Content (%S) and Neutralising Potential Ratio (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity, but it is likely to be only of short-term significance. From this, and using the NPR values:

1. Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidizable Sulphide-S to sustain acid generation.
2. NPR ratios of >4:1 are considered to have enough neutralising capacity.
3. NPR ratios of 3:1 to 1:1 are consider inconclusive.
4. NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating (Waterlab test certificates, 2018).

Table 5 presents the final classification of the material.

Table 5 Final classification of the material.:

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

Based on the results presented in Table 6, the following were concluded from the ABA tests:

1. Paste pH:
    i. Samples Z7502, Z7503 and Z7504 indicate a paste pH higher than 5.0.
    ii. Samples Z7501 and Z7505 were between 4.0 and 5.0.
    iii. A sample with a pH of < 4.0 is considered potentially acid forming (PAF) and will contain significant acidic sulphate salts that will produce acid upon exposure to water. Samples with a paste pH of 4.0 to 5.0 are also considered PAF, but have a lower stored acidic salt content.
    iv. Paste pH values higher than pH 5.0 indicate a short-term acid neutralizing capacity.
2. Sulphur content:
    i. The sulphur content of all samples is below the 0.3% benchmark and thus unlikely to generate acid sustainably (Table 6). It is also due to the low S-values that the samples have a classification of TYPE II (intermediate) or III (non-acid forming).
3. Nett Neutralization Potential:
    i. 2 of the 5 samples have an NNP value less than zero and is therefore potentially acid generating – samples Z7501 and Z7505.
    ii. Three of the samples have the potential to neutralise acid, if produced.
4. Based on the ABA results presented above the following rock classifications are done (Table 5 and Table 6):
    i. TYPE II – Intermediate risk:
        a. Sample Z7501.
        b. Sample Z7505.
    ii. TYPE III – Non-acid forming:
        a. Samples Z7502, Z7503 and Z7504.

In summary: 2 of the 5 geological formations sampled during the Goosebay groundwater assessment present an intermediate risk; the other 3 samples indicated no risk. The two samples relate to the sand and aggregate located in the northern mining sections. The sand and aggregate material on the rest of the proposed mining area show no risk for acid generation.

Table 6 Acid Base Accounting results

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification				
	Sample Z7501	**Sample Z7502**	**Sample Z7503**	**Sample Z7504**	**Sample Z7505**
Paste pH	4.5	5.6	5.5	5.2	4.7
Total Sulphur (%) (LECO)	0.01	0.01	0.01	0.01	0.01
Acid Potential (AP) (kg/t)	0.453	0.238	0.234	0.188	0.459
Neutralization Potential (NP)	0.250	0.250	0.993	0.993	0.002
Nett Neutralization Potential (NNP)	-0.203	0.013	0.758	0.804	-0.457
Neutralizing Potential Ratio (NPR) (NP:AP)	0.552	1.05	4.23	5.27	0.005
Rock Type	II	III	III	III	II

4.2.3 Leach Tests

From the leach test results the following can be concluded:

1. In terms of Total Concentrations (TC):
   i. Boron concentrations exceed the TCT0 limit in samples Z7501, Z7503 and Z7504.
   ii. Barium exceeded the TCT0 limit for geochem samples Z7501, Z7502 and Z7505.
   iii. Copper, Manganese and Vanadium exceeded the TCT0 limit for geochem samples Z7503 and Z7504.
   iv. Lead exceeded the TCT0 limit for geochem samples Z7501, Z7503 and Z7504.
   v. Total Fluoride exceeded the TCT0 limit for geochem samples Z7501, Z7503, Z7504 and Z7505.
2. In terms of Leachable Concentrations (LC):
   i. No element concentrations exceed the LCT0 limit for all samples.

It is recommended that before construction, additional samples be taken across the project area, focussing on the proposed northern pit areas to provide a more complete understanding of the risks for that area; analysis should include TCLP leach and kinetic testing.

4.3 Waste Classification

According to the NEM:WA, mine waste is listed under Schedule 3, under the category Hazardous Waste; and is considered to be hazardous unless the applicant can prove that the waste is non-hazardous. As waste rock is considered to be waste, it is regulated (August 2013) by:

1. GNR 634 (23 August 2013): Waste Classification and Management Regulations – talks to SANS 10234 and talks to the requirements for disposal, record keeping.
2. GNR 635 (23 August 2013): National Norms and Standards for the assessment of Waste for Landfill Disposal – Assessment of waste prior to landfilling. Prescribes limits relating to chemical composition of wastes from lab testing such as LCT (Leachable Concentration Threshold).
3. GNR 636 (23 August 2013): National Norms and Standards for Disposal of Waste to Landfill –aligns waste classification and character to simplified basal lining systems (containment) being Class A, B, C and D versus Type 0 to 4.

According to these regulations, waste must be classified in accordance with GHS - SANS 10234 "South African National Standard Globally Harmonized System of Classification and Labelling of Chemicals (GHS)"; within 180 days of generation. Classification guidelines are used to determine the waste category, as well as liner design specifications associated with each category.

4.3.1 Waste Assessment Methodology

Total Concentration Threshold (TCT) limits are subdivided into three categories:

1. TCT0 limits based on screening values for the protection of water resources, as contained in the Framework for the Management of Contaminated Land (DEA, March 2010).

2. TCT1 limits derived from land remediation values for commercial/industrial land (DEA, March 2010).
3. TCT2 limits derived by multiplying the TCT1 values by a factor of 4, as used by the Environmental Protection Agency, Australian State of Victoria.

Leachable concentrations were determined by following the Australian Standard Leaching Procedure for Wastes, Sediments and Contaminated Soils (AS 4439,3-1997), as specified in the NEM:WA Regulations (2013). The procedure recommends the use of reagent water for leaching of non-putrescible material that will be mono-filled. A leachate of 1:20 solids per distilled water was used.

Leachable Concentration Threshold (LCT) limits are subdivided into four categories:

1. LCT0 limits derived from human health effect values for drinking water, as published by the Department of Water and Sanitation (DWS), South African National Standards (SANS), World Health Organization (WHO) or the United States Environmental Protection Agency (USEPA).
2. LCT1 limits derived by multiplying LCT0 values by a Dilution Attenuation Factor (DAF) of 50, as proposed by the Australian State of Victoria.
3. LCT2 limits derived by multiplying LCT1 values by a factor of 2.
4. LCT3 limits derived by multiplying the LCT2 values by a factor of 4.

GN R634 identifies waste classes (Waste Types 0 to 4) ranging from high risk to low risk. Waste is classified by comparing the total and leachable concentration of elements and chemical substances in the waste material to TCT and LCT limits as specified in the National Norms and Standards for Waste Classification, and the National Norms and Standards for Disposal to Landfill (Table 7).

Table 7 Waste type and disposal classification*

Type of Waste	Element or chemical substance concentration
Type 0	LC > LCT3 **OR** TC > TCT2
Type 1	LCT2 < LC ≤ LCT3 **OR** TCT1 < TC ≤ TCT2
Type 2	LCT1 < LC ≤ LCT2 **AND** TC ≤ TCT1
Type 3	LCT0 < LC ≤ LCT1 **AND** TC ≤ TCT1
Type 4	LC ≤ LCT0 **AND** TC ≤ TCT0 for metal ions and inorganic anions **AND** all chemical substances are below the total concentration limits provided for organics and pesticides listed

Disposal Requirements

Type 0	Not allowed. The waste must be treated first and then re-tested to determine the risk profile for disposal.
Type 1	Class A or Hh:HH
Type 2	Class B or GLB+
Type 3	Class C or GLB+
Type 4	Class D or GSB-

*DEA. Waste Classification and Management Regulations and Supporting Norms & Standards

Table 8 TCT limits

Total Concentration Thresholds (mg/kg)					Measured Total Concentrations (mg/kg)				
Parameter	**Unit**	**TCT0**	**TCT1**	**TCT2**	**Sample Z7501**	**Sample Z7502**	**Sample Z7503**	**Sample Z7504**	**Sample Z7505**
As, Arsenic	mg/kg	5,8	500	2000	1,60	<0.400	<0.400	<0.400	<0.400
B, Boron	mg/kg	150	15000	6000	270	<10	832	776	<10
Ba, Barium	mg/kg	62,5	6250	25000	67	144	44	13	103
Ca, Calcium	mg/kg				<400	<400	<400	<400	<400
Cd, Cadmium	mg/kg	7,5	260	1040	<1.20	<1.20	<1.20	<1.20	<1.20
Co, Cobalt	mg/kg	50	5000	20000	<10	<10	16	10	<10
$Cr_{Total,}$ Chromium Total	mg/kg	46000	800000	N/A	185	52	1564	310	97
Cu, Copper	mg/kg	16	19500	78000	6,80	<4.00	129	136	<4.00
Fe, Iron	mg/kg				57200	4800	162000	122800	25200
Hg, Mercury	mg/kg	0,93	160	640	<0.400	<0.400	<0.400	<0.400	<0.400
K, Potassium	mg/kg				7560	9600	<200	<200	7000
Mg, Magnesium	mg/kg				800	<400	800	<400	800
Mn, Manganese	mg/kg	1000	25000	100000	212	48	3756	1132	129
Mo, Molybdenum	mg/kg	40	1000	4000	<10	<10	<10	<10	<10
Na, Sodium	mg/kg				1200	1600	<400	<400	1200
Ni, Nickel	mg/kg	91	10600	42400	<10	<10	22	15	<10
Pb, Lead	mg/kg	20	1900	7600	33	9,20	56	48	18
Sb, Antimony	mg/kg	10	75	300	<0.400	<0.400	<0.400	<0.400	<0.400
Se, Selenium	mg/kg	10	50	200	<0.400	<0.400	<0.400	<0.400	<0.400
U, Uranium	mg/kg				4,40	0,800	4,80	2,80	2,80
V, Vanadium	mg/kg	150	2680	10720	84	14	1316	1072	49
Zn, Zinc	mg/kg	240	160000	640000	<10	<10	<10	<10	<10
Cr(VI), Chromium (VI) Total [s]	mg/kg	6,5	500	2000	<5	<5	<5	<5	<5
Total Fluoride [s] mg/kg	mg/kg	100	10000	40000	152	99,3	130	107	171
Total Cyanide as CN mg/kg	mg/kg	14	10500	42000	<0.5	<0.5	<0.5	<0.5	<0.5

Table 9 GPur Source Mine sample results, LCT limits

Leachable concentration threshold (mg/L)						Measured Leachable concentration of samples (mg/L)				
Parameter	**Unit**	**LCT0**	**LCT1**	**LCT2**	**LCT3**	**Sample Z7501**	**Sample Z7502**	**Sample Z7503**	**Sample Z7504**	**Sample Z7505**
As, Arsenic	mg/ℓ	0,01	0,5	1	4	<0.001	<0.001	<0.001	0,002	<0.001
B, Boron	mg/ℓ	0,5	25	50	200	<0.025	<0.025	<0.025	<0.025	<0.025
Ba, Barium	mg/ℓ	0,7	35	70	280	0,052	<0.025	0,044	<0.025	0,076
Ca, Calcium	mg/ℓ					<1	<1	<1	<1	4
Cd, Cadmium	mg/ℓ	0,003	0,15	0,3	1,2	<0.003	<0.003	<0.003	<0.003	<0.003
Co, Cobalt	mg/ℓ	0,5	25	50	200	<0.025	<0.025	<0.025	<0.025	<0.025
$Cr_{Total,}$ Chromium Total	mg/ℓ	0,1	5	10	40	<0.025	<0.025	<0.025	<0.025	<0.025
Cr(VI), Chromium (VI)	mg/ℓ	0,05	2,5	5	20	<0.010	<0.010	<0.010	<0.010	<0.010
Cu, Copper	mg/ℓ	2,0	100	200	800	0,011	<0.010	<0.010	0,022	<0.010
Fe, Iron	mg/ℓ					2,05	0,326	0,570	0,725	1,03
Hg, Mercury	mg/ℓ	0,006	0,3	0,6	2,4	<0.001	<0.001	<0.001	<0.001	<0.001
K, Potassium	mg/ℓ					<0.5	<0.5	0,6	<0.5	5,5
Mg, Magnesium	mg/ℓ					<1	<1	<1	<1	2
Mn, Manganese	mg/ℓ	0,5	25	50	200	<0.025	0,052	0,126	0,044	0,056
Mo, Molybdenum	mg/ℓ	0,07	3,5	7	28	<0.025	<0.025	<0.025	<0.025	<0.025
Na, Soduim	mg/ℓ					<1	<1	<1	<1	<1
Ni, Nickel	mg/ℓ	0,07	3,5	7	28	<0.025	<0.025	<0.025	<0.025	<0.025
Pb, Lead	mg/ℓ	0,01	0,5	1	4	<0.010	<0.010	<0.010	<0.010	<0.010
Sb, Antimony	mg/ℓ	0,02	1,0	2	8	<0.001	<0.001	<0.001	<0.001	<0.001
Se, Selenium	mg/ℓ	0,01	0,5	1	4	<0.001	<0.001	<0.001	<0.001	<0.001
U, Uranium	mg/ℓ					<0.001	<0.001	<0.001	0,001	<0.001
V, Vanadium	mg/ℓ	0,2	10	20	80	<0.025	<0.025	<0.025	<0.025	<0.025
Zn, Zinc	mg/ℓ	5,0	250	500	2000	<0.025	<0.025	<0.025	<0.025	<0.025
Total Dissolved Solids*	mg/ℓ	1000	12 500	25 000	100 000	12	12	15	<10	42
Total Alkalinity as CaCO3	mg/ℓ					12	<5	12	8	8
Chloride as Cl	mg/ℓ	300	15 000	30 000	120 000	11	<2	2	3	11
Sulphate as SO4	mg/ℓ	250	12 500	25 000	100 000	21	<2	4	<2	32
Nitrate as N	mg/ℓ	11	550	1100	4400	0,3	0,6	0,6	0,4	1,7
Fluoride as F	mg/ℓ	1,5	75	150	600	1	<0.2	0,2	0,3	1,2
Ortho-Phosphate as P	mg/ℓ					<0.1	<0.1	<0.1	<0.1	<0.1
Cyanide as CN [s]	mg/ℓ	0,07	3,5	7	28	<0.02	<0.02	<0.02	<0.02	<0.02
pH	mg/ℓ					3,7	3,6	5	4,9	4,6

4.3.2 Assessment Results

Results of the TCT and LCT analysis are shown in Table 8 and Table 9 respectively, and compared to threshold concentrations published in the NEM:WA, Waste Classification and Management Regulations.

4.3.2.1 Total Concentrations

Based on the total concentration analysis (Table 8):

1. Boron concentrations exceed the TCT0 limit in samples Z7501, Z7503 and Z7504.
2. Barium exceeded the TCT0 limit for geochem samples Z7501, Z7502 and Z7505.
3. Copper, Manganese and Vanadium exceeded the TCT0 limit for geochem samples Z7503 and Z7504.
4. Lead exceeded the TCT0 limit for geochem samples Z7501, Z7503 and Z7504.
5. Total Fluoride exceeded the TCT0 limit for geochem samples Z7501, Z7503, Z7504 and Z7505.

4.3.2.2 Leachable Concentrations

In terms of Leachable Concentrations (LC) (Table 9) no element concentrations exceed the LCT0 limits, for all samples.

4.3.2.3 Classification

Based on the total concentration (Table 8) and leachable concentration (Table 9) results, the waste will be classified as a Type 3 waste and the liner design must be according to Class C landfill requirements (Figure 4-1). This is based on TCT0 threshold values exceeded for various parameters. All concentrations were still below TCT1 limits.

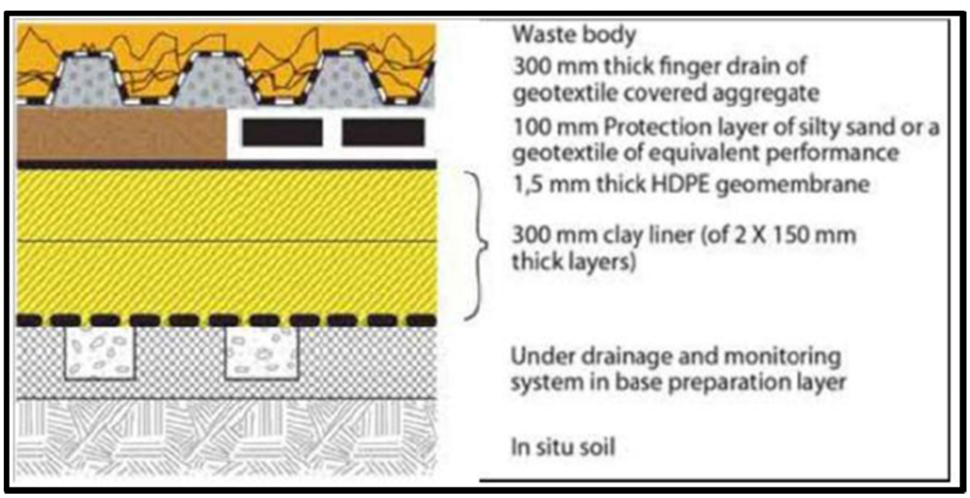

Figure 4-1 Class C landfill site liner requirements (NEM:WA, 2008)

On 21 September 2018 the Minister of Environmental Affairs published amendments to the regulations regarding the Planning and Management of Residue Stockpiles and Residue Deposits, Amendment Regulations. The changes to the existing regulations (Planning and Management of Residue Stockpiles and Residue Deposits, 2015) were made to allow for the pollution control measures required for residue stockpiles and residue deposits, to be determined on a case by case basis, based on a risk assessment conducted by a competent person.

A risk assessment must be conducted to determine pollution control measures suitable for a specific residue stockpile or residue deposit, as part of an application for a waste management licence. Various liner and pollution intercept systems must be simulated and discussed as motivation for the selection of a specific pollution management system. A pollution control barrier system designed in terms of the National Norms and Standards for the Assessment of Waste for Landfill Disposal (GN R635 of 23 August 2013) and the National Norms and Standards for the Disposal of Waste to Landfill (GN R636 of 23 August 2013) is no longer required, if a suitable, effective alternative can be presented.

The pollution assessment documents must include all environmental impacts of a mining operation's residue stockpiles and deposits. All residue stockpiles and residue deposits must still be characterised and classified according to the requirements of the Regulations.

The impact assessment section in the Environmental Impact Assessment report will provide more details in terms of alternatives investigated and solutions proposed.

5 Potential Environmental Impacts

Potential environmental impacts associated with the construction, operational and post-closure phases of the proposed mining project were assessed during the scoping phase. These impacts are only preliminary and were concluded based on baseline data and previous experience in the area. All potential impacts will still be investigated during the groundwater impact assessment phase.

5.1 Construction Phase

The following potential impacts could occur during the construction phase:

5.1.1 Groundwater Quality

During the construction phase little impacts are expected on groundwater quality. Minor impacts on the groundwater can be expected from accidental hydrocarbon spillage from construction vehicles at the service station or diesel bays.

The current groundwater quality is good; depending on distance from the Vaal River.

5.1.2 Groundwater Quantity

The use of groundwater as a potential source of water during construction could potentially have an impact of local water users due to the cone of depression around the production boreholes. The study area is not known for high yielding boreholes.

5.2 Operational Phase

The following impacts can be expected during the operational phase:

5.2.1 Groundwater Quality

Groundwater quality could potentially be negatively affected by the excavation of the sand and around the washing facility.

Hydrocarbon spillage, as well as the incorrect handling and storage of hazardous waste and sewage can potentially contaminate the aquifers.

5.2.2 Groundwater Quantity

Pit dewatering and groundwater abstraction could potentially influence the local groundwater system and may have a negative impact on the local groundwater users.

5.3 Post Closure

The following impacts can be expected after mine closure:

5.3.1 Groundwater Quality

The water quality impacts associated with the excavations and sand washing will reduce and possibly disappear post closure.

5.3.2 Groundwater Quantity

No impact is expected on the water quantity during the post mine phase. The groundwater table will recover during this phase and boreholes in the area previously affected by mine dewatering could start to improve. This will be a function of the recharge to the area.

6 Conclusions

The Pure Source Mine Farm and surrounding properties are located on the inner section of what resembles an oxbow lake, with the flanks approximately 4.3 km apart on the shortest section. Various sand mine operations are in this area with BBS Bulk Sand to the east and Sweet Sensations Vaal Sand to the west of Pure Source Mine. Most of the project area has a gentle slope towards the Vaal River and is located approximately 20 to 30 m higher compared to the Vaal River elevations.

Small ridges and depressions occur along the north of the proposed mining area and there is a hill along the south of the proposed mining area.

The proposed Pure Source Mine mining area is located within the C23B quaternary catchment of the Upper Vaal Water Management Area. The main drainage associated with the C23B quaternary catchment is the Kromelmboogspruit and is approximately 6 km to the southwest from Pure Source Mine Farm.

During the 2018 hydrocensus 20 groundwater sites were identified. The 20 sites included:

6. 14 boreholes which are in use.
7. 3 blocked boreholes.
8. 1 open / capped borehole – new and to be used soon.
9. 2 old boreholes, not in use.

The boreholes are the only source of water to the community in the study area. Water is drawn from the Vaal River, in places, for irrigation purposes. An assumption has been made that there will be a strong correlation between the groundwater quality and water levels for boreholes GOO5, GOO7, GOO12, GOO18, GOO19 and GOO20 and the Vaal River level and quality. These boreholes are located on the banks of the Vaal River.

The groundwater levels varied from 2.5 m to 7 m across the proposed mining area, to a maximum depth of 20.5 m bgl along the tar road. To the south of the big hill (south of the tar road and proposed mining area) the average water table depth is 10 m below surface.

The general groundwater flow direction is in a northerly direction towards the Vaal River. There is a strong possibility of good surface water-groundwater interaction based on the shallow groundwater levels in the proposed mining area and the proximity of the Vaal River.

The shallow groundwater table in the proposed Pure Source Mine mining area also indicates the possibility of groundwater inflow into the sand and aggregate excavations.

Elevated element concentrations recorded in the sampled groundwater are only elevated in one or two sampling points, mostly in the Vaal River and boreholes close to the river. Most of the salts and metals were present in concentrations below the SANS241 guideline limits. Based on the SANS241 drinking water guideline and on the sampled borehole water results, the groundwater sampled from 9 boreholes are fit for human consumption (treatment still recommended).

The sampled groundwater is currently not showing any negative impacts associated with the historical mining activities on the Farm Pure Source Mine or at the neighbouring sand mine operations.

7 References

1. Department of Water and Environmental Affairs & Water Research Commission, First Edition 2000: Quality of Domestic Water Supplies: Volume 2: Sampling Guide.
2. Department of Water Affairs and Forestry, Directorate National Water Resource Planning, March 2004. Internal Strategic Perspective for the Upper Vaal Water Management Area (WMA No 8).
3. Erasmus Johan, May 2018. Goosebay Farm (Pty) Ltd. Mining Right Application No: FS10042 MR. Resource Statement.
4. SABS, 2015. South African National Standards SANS 241-1:2015. SA Drinking Water Standards.

8 Appendix A: Maps

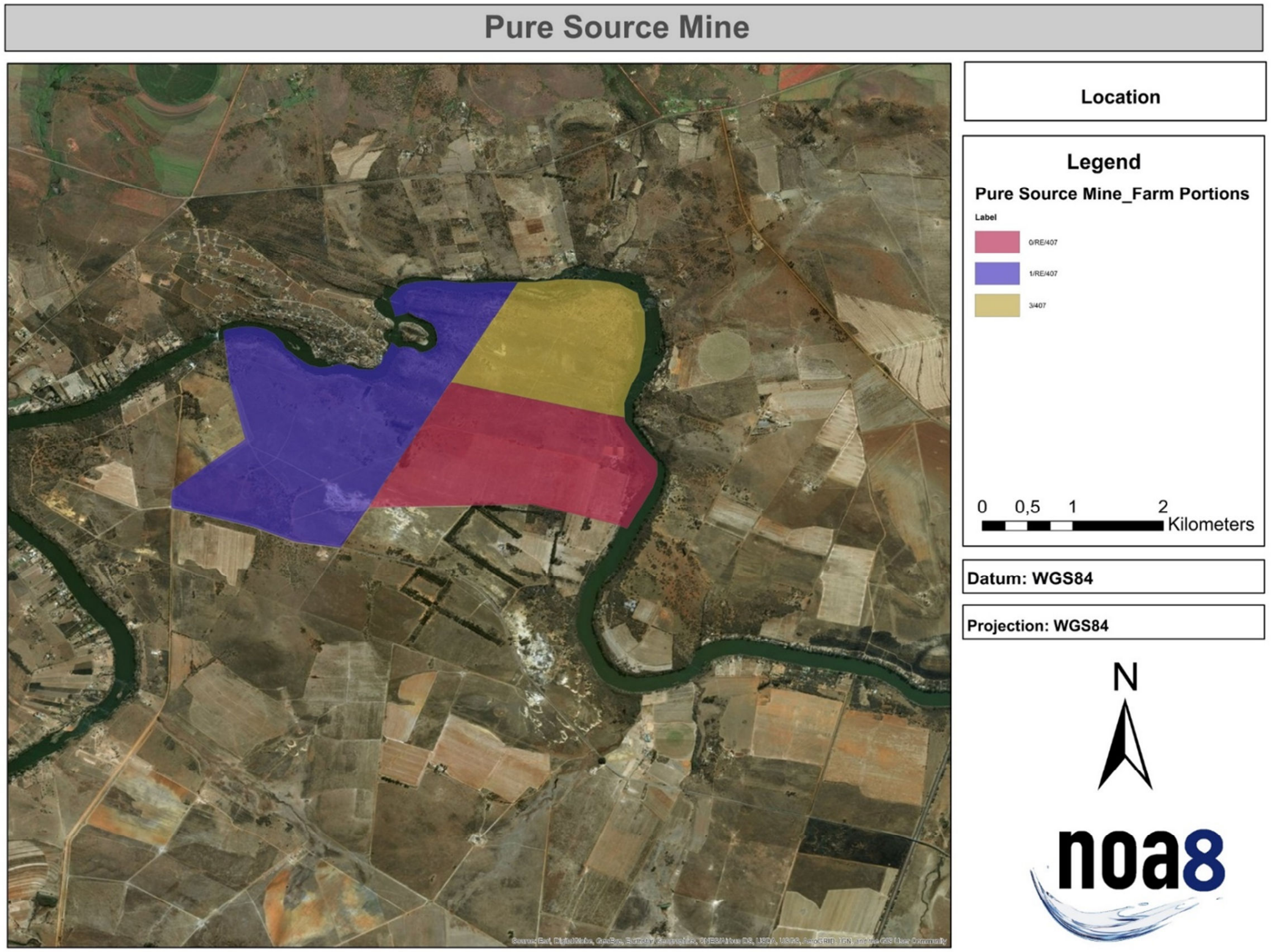

Figure 8-1 Locality

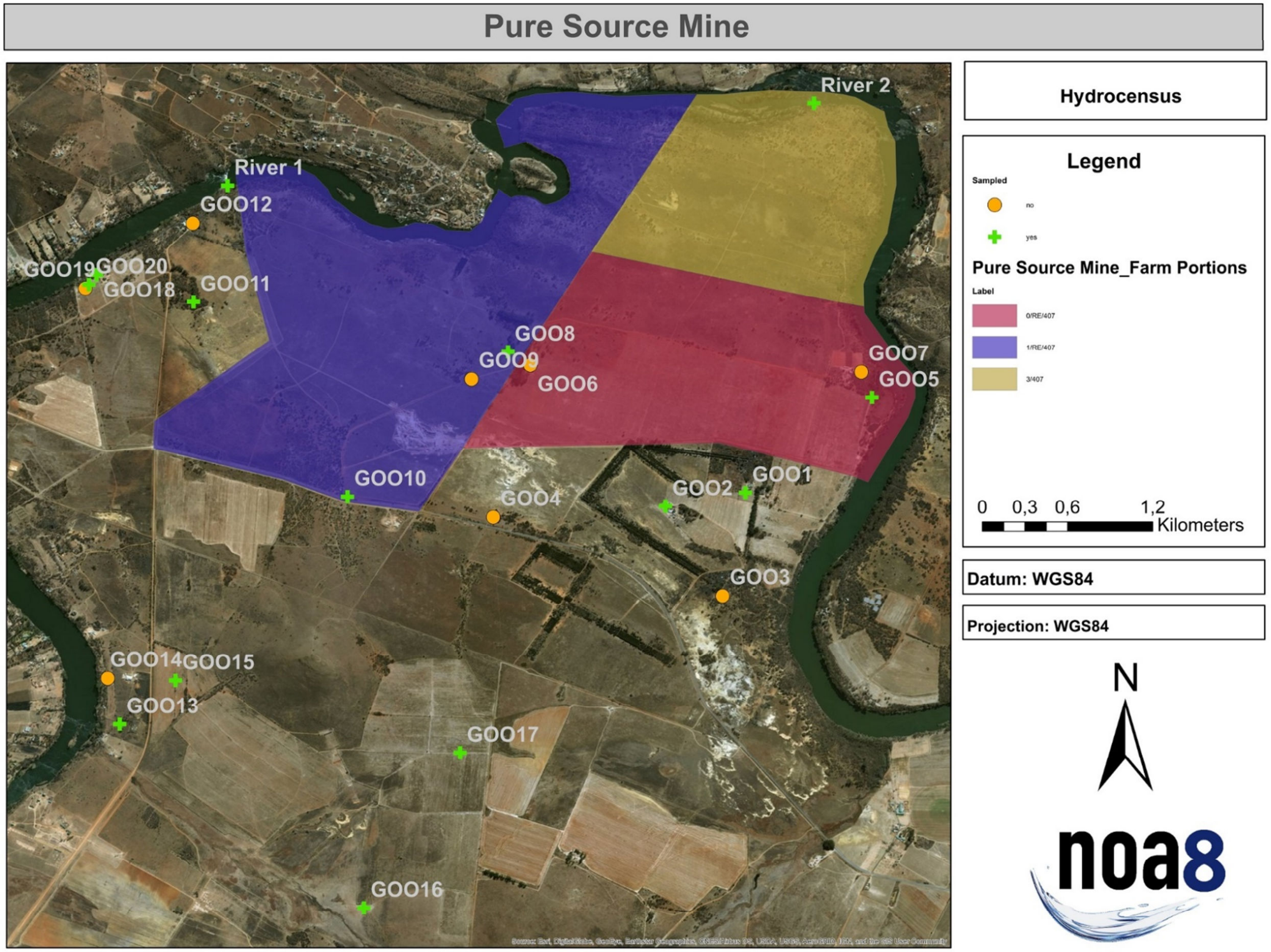

Figure 8-2 **Sites recorded during the hydrocensus survey.**

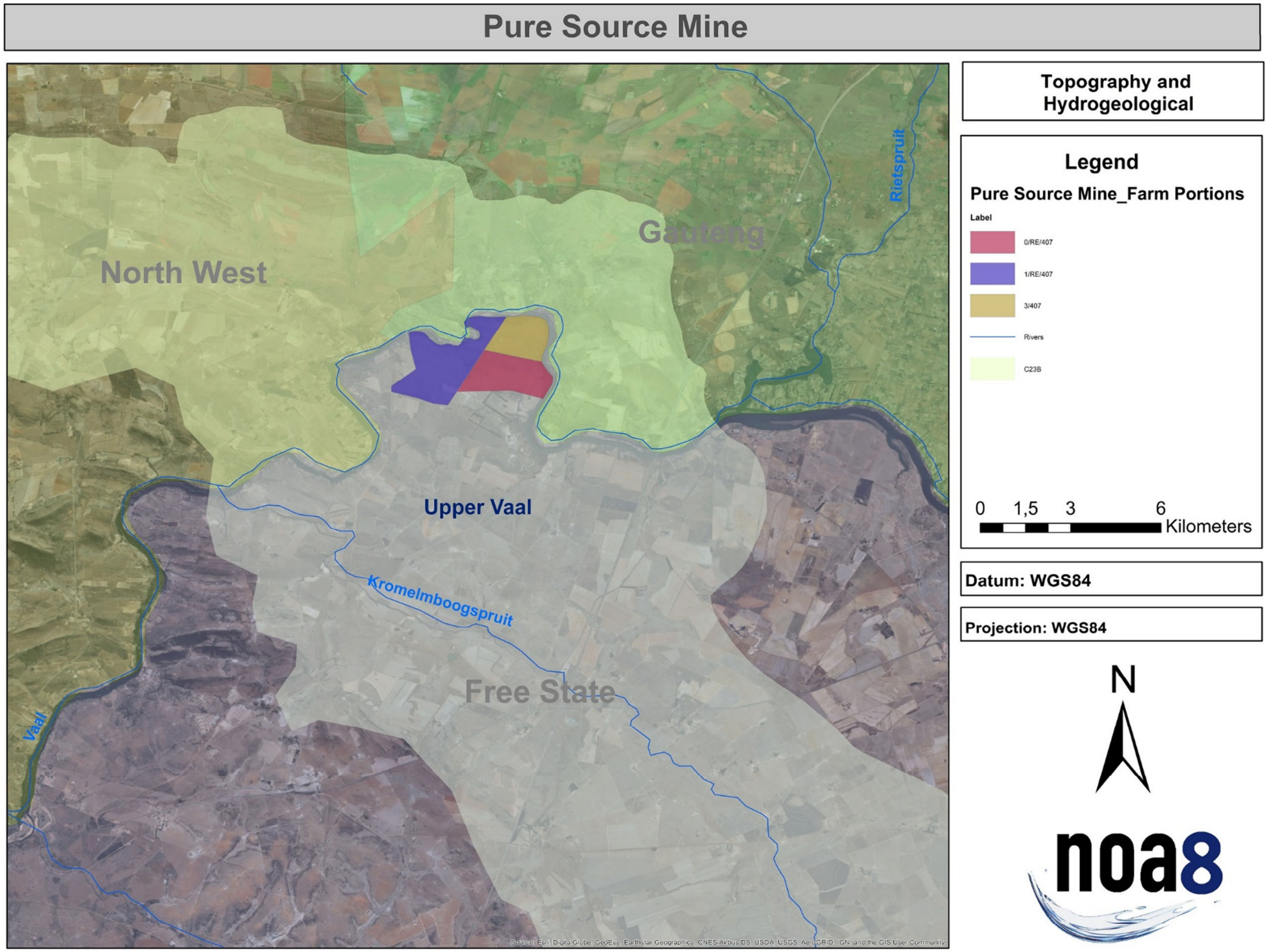

Figure 8-3 Topograhpical map with water management area (WMA) and Quaternay Catchment

9 Appendix B: Water quality results

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification			
		River 1	River 3	G001	G002
Sample Number		40337	40338	40339	40340
pH – Value at 25°C	WLAB065	7.7	7.7	7.7	8.1
Electrical Conductivity in mS/m at 25°C	WLAB002	78.1	78.4	19.1	26.2
Total Dissolved Solids (mS/mx6.7)	WLAB003	523	525	128	175
Chloride as Cl	WLAB046	49	53	2	3
Sulphate as SO_4	WLAB046	172	177	7	3
Fluoride as F	WLAB014	0.2	0.3	<0.2	<0.2
Nitrate as N	WLAB046	4.7	4.0	3.0	4.3
Ortho Phosphate as P	WLAB046	0.4	0.4	<0.1	<0.1
Total Cyanide as CN [s]	---	<0.07	<0.07	<0.07	<0.07
E. coli / 100 mℓ	WLAB021	2	0	0	0
Free & Saline Ammonia as N	WLAB046	1.0	1.9	0.1	0.1
ICP-MS Scan *	WLAB050	See Attached Report: 77091-A			

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification			
		G005	G008	G010	G011
Sample Number		40341	40342	40343	40344
pH – Value at 25°C	WLAB065	7.3	7.6	7.2	8.6
Electrical Conductivity in mS/m at 25°C	WLAB002	99.8	22.0	17.2	12.1
Total Dissolved Solids (mS/mx6.7)	WLAB003	669	147	115	81
Chloride as Cl	WLAB046	48	8	2	2
Sulphate as SO_4	WLAB046	235	7	<2	<2
Fluoride as F	WLAB014	<0.2	<0.2	<0.2	<0.2
Nitrate as N	WLAB046	0.7	0.7	4.4	1.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1	<0.1
Total Cyanide as CN [s]	---	<0.07	<0.07	<0.07	<0.07
E. coli / 100 mℓ	WLAB021	0	0	0	0
Free & Saline Ammonia as N	WLAB046	0.1	0.2	0.2	<0.1
ICP-MS Scan *	WLAB050	See Attached Report: 77091-A			

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**		
		G017	**G018**	**G020**
Sample Number		40345	40346	40347
pH – Value at 25°C	WLAB065	6.8	7.8	8.5
Electrical Conductivity in mS/m at 25°C	WLAB002	15.7	30.4	11.9
Total Dissolved Solids (mS/mx6.7)	WLAB003	105	204	80
Chloride as Cl	WLAB046	5	14	2
Sulphate as SO_4	WLAB046	2	27	5
Fluoride as F	WLAB014	<0.2	<0.2	<0.2
Nitrate as N	WLAB046	5.4	3.6	1.8
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1
Total Cyanide as CN [s]	---	<0.07	<0.07	<0.07
E. coli / 100 mℓ	WLAB021	0	0	0
Free & Saline Ammonia as N	WLAB046	<0.1	<0.1	<0.1
ICP-MS Scan *`	WLAB050	See Attached Report: 77091-A		

*** = Not SANAS Accredited**

Tests marked “Not SANAS Accredited” in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

[s] = Analyses performed by a Sub-Contracted Laboratory

Results marked “Subcontracted Test” in this report are not included in the SANAS Schedule of Accreditation for this Laboratory

Bacteriological parameters analyzed on: 2018-09-06

10 Appendix C: Geochemical assessment results

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Project Number : **1000**
Client : **Noa Agencies**
Report Number : **77091-A**

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
River 1	40337	< 0.010	0.130	< 0.010	< 0.010	0.131	0.046	< 0.010	< 0.010	57	< 0.010	< 0.010	< 0.010
River 3	40338	< 0.010	0.166	< 0.010	< 0.010	0.137	0.045	< 0.010	< 0.010	59	< 0.010	< 0.010	< 0.010
G001	40339	< 0.010	< 0.100	< 0.010	< 0.010	0.041	< 0.010	< 0.010	< 0.010	19	< 0.010	< 0.010	< 0.010
G002	40340	< 0.010	< 0.100	< 0.010	< 0.010	0.040	< 0.010	< 0.010	< 0.010	29	< 0.010	< 0.010	< 0.010
G005	40341	< 0.010	< 0.100	< 0.010	< 0.010	0.085	< 0.010	< 0.010	< 0.010	97	< 0.010	< 0.010	< 0.010
G008	40342	< 0.010	< 0.100	< 0.010	< 0.010	0.032	0.027	< 0.010	< 0.010	21	< 0.010	< 0.010	< 0.010
G010	40343	< 0.010	< 0.100	< 0.010	< 0.010	0.031	< 0.010	< 0.010	< 0.010	15	< 0.010	< 0.010	< 0.010
G011	40344	< 0.010	< 0.100	< 0.010	< 0.010	0.033	< 0.010	< 0.010	< 0.010	15	< 0.010	< 0.010	< 0.010

G017	40345	< 0.010	< 0.100	< 0.010	< 0.010	0.030	< 0.010	< 0.010	< 0.010	12	< 0.010	< 0.010	< 0.010
G018	40346	< 0.010	< 0.100	< 0.010	< 0.010	0.032	0.025	< 0.010	< 0.010	31	< 0.010	< 0.010	< 0.010
G020	40347	< 0.010	< 0.100	< 0.010	< 0.010	0.026	< 0.010	< 0.010	< 0.010	15	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	**Cr (mg/L)**	**Cs (mg/L)**	**Cu (mg/L)**	**Dy (mg/L)**	**Er (mg/L)**	**Eu (mg/L)**	**Fe (mg/L)**	**Ga (mg/L)**	**Gd (mg/L)**	**Ge (mg/L)**	**Hf (mg/L)**	**Hg (mg/L)**
River 1	40337	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.138	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
River 3	40338	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.153	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G001	40339	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.025	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G002	40340	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.028	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G005	40341	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.689	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G008	40342	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.097	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G010	40343	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.029	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G011	40344	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.027	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G017	40345	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.175	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G018	40346	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.025	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G020	40347	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.029	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	**Ho (mg/L)**	**In (mg/L)**	**Ir (mg/L)**	**K (mg/L)**	**La (mg/L)**	**Li (mg/L)**	**Lu (mg/L)**	**Mg (mg/L)**	**Mn (mg/L)**	**Mo (mg/L)**	**Na (mg/L)**	**Nb (mg/L)**
River 1	40337	< 0.010	< 0.010	< 0.010	10.4	< 0.010	0.012	< 0.010	22	0.105	< 0.010	60	< 0.010
River 3	40338	< 0.010	< 0.010	< 0.010	10.5	< 0.010	0.012	< 0.010	22	0.059	< 0.010	61	< 0.010
G001	40339	< 0.010	< 0.010	< 0.010	0.8	< 0.010	< 0.010	< 0.010	10	< 0.025	< 0.010	4	< 0.010
G002	40340	< 0.010	< 0.010	< 0.010	1.6	< 0.010	< 0.010	< 0.010	15	< 0.025	< 0.010	4	< 0.010

G005	40341	< 0.010	< 0.010	< 0.010	0.7	< 0.010	< 0.010	< 0.010	63	0.059	< 0.010	43	< 0.010
G008	40342	< 0.010	< 0.010	< 0.010	0.7	< 0.010	< 0.010	< 0.010	13	< 0.025	< 0.010	5	< 0.010
G010	40343	< 0.010	< 0.010	< 0.010	3.3	< 0.010	< 0.010	< 0.010	9	< 0.025	< 0.010	5	< 0.010
G011	40344	< 0.010	< 0.010	< 0.010	0.9	< 0.010	< 0.010	< 0.010	5	< 0.025	< 0.010	2	< 0.010
G017	40345	< 0.010	< 0.010	< 0.010	3.2	< 0.010	< 0.010	< 0.010	6	< 0.025	< 0.010	9	< 0.010
G018	40346	< 0.010	< 0.010	< 0.010	1.0	< 0.010	< 0.010	< 0.010	14	< 0.025	< 0.010	6	< 0.010
G020	40347	< 0.010	< 0.010	< 0.010	0.8	< 0.010	< 0.010	< 0.010	4	< 0.025	< 0.010	3	< 0.010

Sample Origin	Sample ID	**Nd (mg/L)**	**Ni (mg/L)**	**Os (mg/L)**	**P (mg/L)**	**Pb (mg/L)**	**Pd (mg/L)**	**Pr (mg/L)**	**Pt (mg/L)**	**Rb (mg/L)**	**Rh (mg/L)**	**Ru (mg/L)**	**Sb (mg/L)**
River 1	40337	< 0.010	0.012	< 0.010	0.551	< 0.010	< 0.010	< 0.010	< 0.010	0.010	< 0.010	< 0.010	< 0.010
River 3	40338	< 0.010	0.012	< 0.010	0.498	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G001	40339	< 0.010	< 0.010	< 0.010	0.035	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G002	40340	< 0.010	< 0.010	< 0.010	0.106	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G005	40341	< 0.010	< 0.010	< 0.010	0.066	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G008	40342	< 0.010	< 0.010	< 0.010	0.051	< 0.010	< 0.010	< 0.010	< 0.010	0.013	< 0.010	< 0.010	< 0.010
G010	40343	< 0.010	< 0.010	< 0.010	0.090	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G011	40344	< 0.010	< 0.010	< 0.010	0.060	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G017	40345	< 0.010	< 0.010	< 0.010	0.061	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G018	40346	< 0.010	< 0.010	< 0.010	0.077	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G020	40347	< 0.010	< 0.010	< 0.010	0.067	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	**Sc (mg/L)**	**Se (mg/L)**	**Si (mg/L)**	**Sm (mg/L)**	**Sn (mg/L)**	**Sr (mg/L)**	**Ta (mg/L)**	**Tb (mg/L)**	**Te (mg/L)**	**Th (mg/L)**	**Ti (mg/L)**	**Tl (mg/L)**

River 1	40337	< 0.010	< 0.010	1.6	< 0.010	< 0.010	0.168	< 0.010	< 0.010	< 0.010	< 0.010	0.048	< 0.010
River 3	40338	< 0.010	< 0.010	2.6	< 0.010	< 0.010	0.169	< 0.010	< 0.010	< 0.010	< 0.010	0.044	< 0.010
G001	40339	< 0.010	< 0.010	12.5	< 0.010	< 0.010	0.039	< 0.010	< 0.010	< 0.010	< 0.010	0.014	< 0.010
G002	40340	< 0.010	< 0.010	14.2	< 0.010	< 0.010	0.056	< 0.010	< 0.010	< 0.010	< 0.010	0.019	< 0.010
G005	40341	< 0.010	< 0.010	13.5	< 0.010	< 0.010	0.146	< 0.010	< 0.010	< 0.010	< 0.010	0.062	< 0.010
G008	40342	< 0.010	< 0.010	16.5	< 0.010	< 0.010	0.060	< 0.010	< 0.010	< 0.010	< 0.010	0.016	< 0.010
G010	40343	< 0.010	< 0.010	16.1	< 0.010	< 0.010	0.057	< 0.010	< 0.010	< 0.010	< 0.010	0.010	< 0.010
G011	40344	< 0.010	< 0.010	11.0	< 0.010	< 0.010	0.029	< 0.010	< 0.010	< 0.010	< 0.010	0.011	< 0.010
G017	40345	< 0.010	< 0.010	20	< 0.010	< 0.010	0.055	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
G018	40346	< 0.010	< 0.010	17.3	< 0.010	< 0.010	0.081	< 0.010	< 0.010	< 0.010	< 0.010	0.023	< 0.010
G020	40347	< 0.010	< 0.010	13.0	< 0.010	< 0.010	0.029	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	**Tm (mg/L)**	**U (mg/L)**	**V (mg/L)**	**W (mg/L)**	**Y (mg/L)**	**Yb (mg/L)**	**Zn (mg/L)**	**Zr (mg/L)**
River 1	40337	< 0.010	< 0.010	0.011	< 0.010	< 0.010	< 0.010	0.637	< 0.010
River 3	40338	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.211	< 0.010
G001	40339	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.125	< 0.010
G002	40340	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.191	< 0.010
G005	40341	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.054	< 0.010
G008	40342	< 0.010	< 0.010	0.649	< 0.010	< 0.010	< 0.010	0.052	< 0.010
G010	40343	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.075	< 0.010
G011	40344	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.046	< 0.010
G017	40345	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.046	< 0.010
G018	40346	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.045	< 0.010
G020	40347	< 0.010	< 0.010	0.010	< 0.010	< 0.010	< 0.010	0.063	< 0.010

APPENDIX D
2018 Aquifer test and water quality certificates

WATERLAB (PTY) LTD

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CERTIFICATE OF ANALYSES

Digestion AS 4439.3

Date received:	**9/19/2018**		**Date completed:**	**11/2/2018**
Project number:	**1000**	**Report number: 77516**	**Order number:**	

Client name:	**Noa Agencies**	**Contact person:**	**Stephan Meyer**
Address:	**165 Cent Street, Lynnwood Glen, 0081**	**Email:**	**stephan@noa8.co.za**
Telephone:	**---**	**Cell:**	**072 570 7186**

Analyses	Z7501		Z7502		Z7503		Z7504		Z7505				
Sample Number	41834		41835		41836		41837		41838		TCT0 mg/kg	TCT1 mg/kg	TCT2 mg/kg
Digestion	HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF				
Dry Mass Used (g)	0.25		0.25		0.25		0.25		0.25				
Volume Used (mℓ)	100		100		100		100		100				
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg			
As, Arsenic	0.004	1.60	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	5.8	500	2000
B, Boron	0.675	270	<0.025	<10	2.08	832	1.94	776	<0.025	<10	150	15000	6000
Ba, Barium	0.168	67	0.359	144	0.109	44	0.033	13	0.257	103	62.5	6250	25000
Ca, Calcium	<1	<400	<1	<400	<1	<400	<1	<400	<1	<400			
Cd, Cadmium	<0.003	<1.20	<0.003	<1.20	<0.003	<1.20	<0.003	<1.20	<0.003	<1.20	7.5	260	1040
Co, Cobalt	<0.025	<10	<0.025	<10	0.039	16	0.025	10	<0.025	<10	50	5000	20000
$Cr_{Total,}$ Chromium Total	0.463	185	0.129	52	3.91	1564	0.776	310	0.243	97	46000	800000	N/A
Cu, Copper	0.017	6.80	<0.010	<4.00	0.323	129	0.340	136	<0.010	<4.00	16	19500	78000
Fe, Iron	143	57200	12	4800	405	162000	307	122800	63	25200			
Hg, Mercury	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	0.93	160	640
K, Potassium	18.9	7560	24	9600	<0.5	<200	<0.5	<200	17.5	7000			
Mg, Magnesium	2	800	<1	<400	2	800	<1	<400	2	800			
Mn, Manganese	0.529	212	0.120	48	9.39	3756	2.83	1132	0.322	129	1000	25000	100000
Mo, Molybdenum	<0.025	<10	<0.025	<10	<0.025	<10	<0.025	<10	<0.025	<10	40	1000	4000
Na, Soduim	3	1200	4	1600	<1	<400	<1	<400	3	1200			
Ni, Nickel	<0.025	<10	<0.025	<10	0.056	22	0.037	15	<0.025	<10	91	10600	42400
Pb, Lead	0.083	33	0.023	9.20	0.139	56	0.121	48	0.046	18	20	1900	7600
Sb, Antimony	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	10	75	300
Se, Selenium	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	<0.001	<0.400	10	50	200
U, Uranium	0.011	4.40	0.002	0.800	0.012	4.80	0.007	2.80	0.007	2.80			
V, Vanadium	0.209	84	0.035	14	3.29	1316	2.68	1072	0.123	49	150	2680	10720
Zn, Zinc	<0.025	<10	<0.025	<10	<0.025	<10	<0.025	<10	<0.025	<10	240	160000	640000
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg			
Cr(VI), Chromium (VI) Total [s]	---	<5	---	<5	---	<5	---	<5	---	<5	6.5	500	2000
Total Fluoride [s] mg/kg	---	152	---	99.3	---	130	---	107	---	171	100	10000	40000
Total Cyanide as CN mg/kg	---	<0.5	---	<0.5	---	<0.5	---	<0.5	---	<0.5	14	10500	42000

[s] = subcontracted

UTD = Unable to determine

S. Laubscher______________________

Assistant Geochemistry Project Manager

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CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2018-09-19
Project number: 1000
Report number: 77516
Date completed: 2018-10-30
Order number:

Client name: Noa Agencies
Address: 165 Cent Street, Lynnwood Glen, 0081
Telephone: ---
Contact person: Stephan Meyer
Email: stephan@noa8.co.za
Cell: 072 570 7186

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification		
	Z7501	Z7502	Z7503
Sample Number	**41834**	**41835**	**41836**
Paste pH	4.5	5.6	5.5
Total Sulphur (%) (LECO)	0.01	0.01	0.01
Acid Potential (AP) (kg/t)	0.453	0.238	0.234
Neutralization Potential (NP)	0.250	0.250	0.993
Nett Neutralization Potential (NNP)	-0.203	0.013	0.758
Neutralising Potential Ratio (NPR) (NP : AP)	0.552	1.05	4.23
Rock Type	II	III	III

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification		
	Z7504	Z7505	Z7505
Sample Number	**41837**	**41838**	**41838 D**
Paste pH	5.2	4.7	4.7
Total Sulphur (%) (LECO)	0.01	0.01	0.02
Acid Potential (AP) (kg/t)	0.188	0.459	0.472
Neutralization Potential (NP)	0.993	0.002	0.250
Nett Neutralization Potential (NNP)	0.804	-0.457	-0.222
Neutralising Potential Ratio (NPR) (NP : AP)	5.27	0.005	0.530
Rock Type	III	II	II

*** Negative NP values are obtained when the volume of NaOH (0.1N) titrated (pH: 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 – 2.5 Any negative NP values are corrected to 0.00.**

Please refer to Appendix **(p.2)** for a Terminology of terms and guidelines for rock classification

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CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2018-09-19
Project number: 1000
Report number: 77516
Date completed: 2018-10-30
Order number:

Client name: Noa Agencies
Address: 165 Cent Street, Lynnwood Glen, 0081
Telephone: ---
Contact person: Stephan Meyer
Email: stephan@noa8.co.za
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APPENDIX: TERMINOLOGY AND ROCK CLASSIFICATION

TERMINOLOGY (SYNONYMS)

- Acid Potential (AP) ; *Synonyms*: Maximum Potential Acidity (MPA)
  Method: Total S(%) (Leco Analyzer) x 31.25
- Neutralization Potential (NP) ; *Synonyms:* Gross Neutralization Potential (GNP) ; *Syn*: Acid Neutralization Capacity (ANC) (The capacity of a sample to consume acid)
  Method: Fizz Test ; Acid-Base Titration (Sobek & Modified Sobek (Lawrence) Methods)
- Nett Neutralization Potential (NNP) ; *Synonyms:* Nett Acid Production Potential (NAPP)
  Calculation: NNP = NP – AP ; NAPP = ANC – MPA
- Neutralising Potential Ratio (NPR)
  Calculation: NPR = NP : AP

CLASSIFICATION ACCORDING TO NETT NEUTRALISING POTENTIAL (NNP)

If NNP (NP – AP) < 0, the sample has the potential to generate acid
If NNP (NP – AP) > 0, the sample has the potential to neutralise acid produced

Any sample with NNP < 20 is potentiall acid-generating, and any sample with NNP > -20 might not generate acid (Usher *et al*., 2003)

ROCK CLASSIFICATION

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

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CLASSIFICATION ACCORDING TO NEUTRALISING POTENTIAL RATIO (NPR)

Guidelines for screening criteria based on ABA (Price *et al*., 1997 ; Usher *et al*., 2003)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	**< 1:1**	Likely AMD generating
Possibly	**1:1 – 2:1**	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	**2:1 – 4:1**	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	**>4:1**	No further AMD testing required unless materials are to be used as a source of alkalinity

CLASSIFICATION ACCORDING TO SULPHUR CONTENT (%S) AND NEUTRALISING POTENTIAL RATIO (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity but it is likely to be only of short-term significance. From these facts, and using the NPR values, a number of rules can be derived:

1) Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidisable Sulphide-S to sustain acid generation.
2) NPR ratios of >4:1 are considered to have enough neutralising capacity.
3) NPR ratios of 3:1 to 1:1 are consider inconclusive.
4) NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating. (Soregaroli & Lawrence, 1998 ; Usher *et al*., 2003)

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CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2018-09-19 **Date completed: 2018-10-17**
Project number: 1000 **Report number: 77516** **Order number:**

Client name: Noa Agencies **Contact person: Stephan Meyer**
Address: 165 Cent Street, Lynnwood Glen, 0081 **Email: stephan@noa8.co.za**
Telephone: --- **Cell: 072 570 7186**

Composition (%) [s]					
Z7501		**Z7502**		**Z7503**	
41834		**41835**		**41836**	
Mineral	Amount (weight %)	**Mineral**	Amount (weight %)	**Mineral**	Amount (weight %)
Quartz	88.26	**Quartz**	95.35	**Quartz**	79.62
Goethite	4.07	**Goethite**	0.11	**Goethite**	0.01
Anatase	0	**Anatase**	0	**Anatase**	2.5
Hematite	0	**Hematite**	0	**Hematite**	3.18
Kaolinite	1.95	**Kaolinite**	0.08	**Kaolinite**	0.14
Dolomite	0	**Dolomite**	0.28	**Dolomite**	0.13
Rutile	0.35	**Rutile**	0.6	**Rutile**	0
Plagioclase	0.14	**Plagioclase**	0.18	**Plagioclase**	12.99
Microcline	1.35	**Microcline**	3.32	**Microcline**	1.42
Muscovite	3.89	**Muscovite**	0.07	**Muscovite**	0

Composition (%) [s]			
Z7504		**Z7505**	
41837		**41838**	
Mineral	Amount (weight %)	**Mineral**	Amount (weight %)
Quartz	73.73	**Quartz**	54.21
Goethite	13.24	**Goethite**	31.96
Anatase	1.39	**Anatase**	1.59
Hematite	2.12	**Hematite**	2.25
Kaolinite	1.96	**Kaolinite**	2.4
Dolomite	0	**Dolomite**	0.25
Rutile	0.03	**Rutile**	0.04
Plagioclase	0.36	**Plagioclase**	0.12
Microcline	6.24	**Microcline**	6.67
Muscovite	0.93	**Muscovite**	0.52

[s] Results obtained from sub-contracted laboratory

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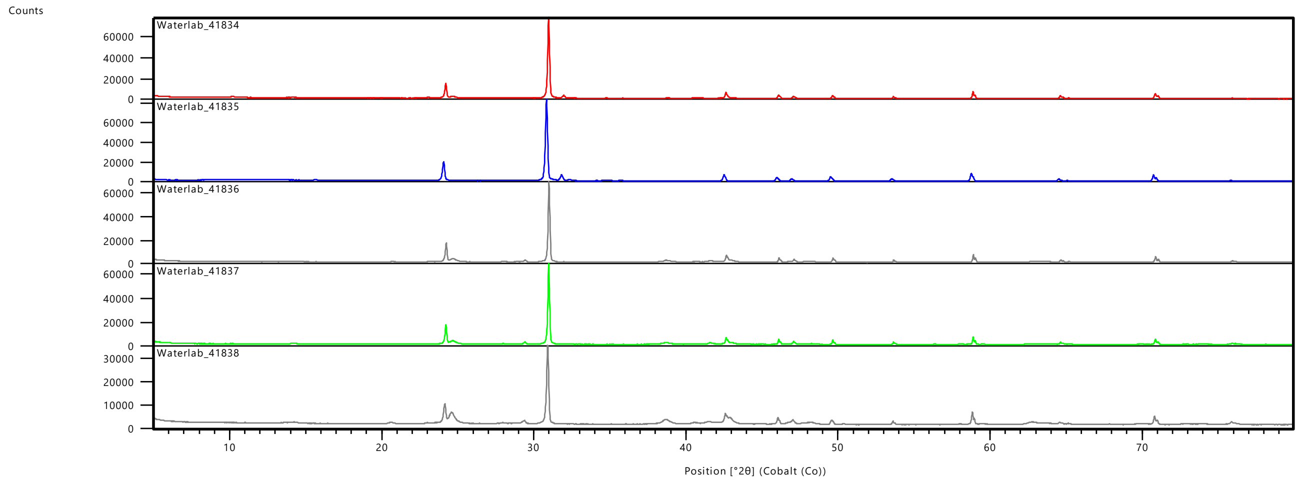

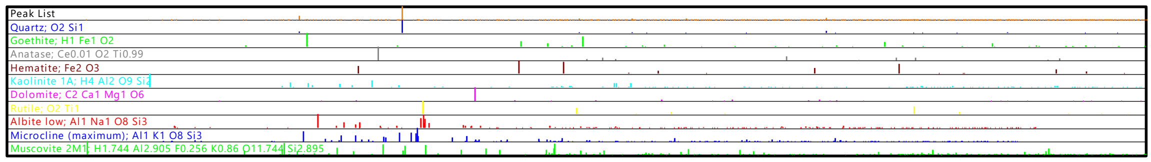

Note:

The material was prepared for XRD analysis using a backloading preparation method.
It was analysed with a PANalytical Aeris diffractometer with PIXcel detector and fixed slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software.
The relative phase amounts (weight %) were estimated using the Rietveld method.

Comment:

- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group.
- Due to preferred orientation and crystallite size effects, results may not be as accurate as shown in the table.
- Traces of additional phases may be present.
- Amorphous phases, if present, were not taken into consideration during quantification

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Ideal Mineral compositions:

Compound Name	Ideal Chemical Formula
Goethite	Fe O OH
Quartz	SiO2
Anatase	TiO2
Kaolinite	Mg3Si2O5(OH)4
Muscovite	K Al2 ((OH)2 Al Si3 O10)
Hematite	Fe2O3
Plagioclase	(Na,Ca)(Si,Al)4O8
Rutile	TiO2
Microcline	K Al Si3 O8

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CERTIFICATE OF ANALYSES
SULPHUR SPECIATION

Methods from: Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1

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Sulphur Speciation*	Sample Identification		
	Z7501	Z7502	Z7503
Sample Number	41834	41835	41836
Total Sulphur (%) (LECO)	0.01	0.01	0.01
Sulphate Sulphur as S (%)	0.01	<0.01	0.01
Sulphide Sulphur (%)	0.01	0.01	<0.01

Sulphur Speciation*	Sample Identification		
	Z7504	Z7505	Z7505
Sample Number	41837	41838	41838 D
Total Sulphur (%) (LECO)	0.01	0.01	0.02
Sulphate Sulphur as S (%)	0.01	0.01	0.01
Sulphide Sulphur (%)	<0.01	<0.01	<0.01

Notes:
- Samples analysed with Pyrolysis at 550°C as per Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1. Multiply Sulphate Sulphur to calculate SO4 % by 2.996. Please see the method for interferences.
- Organic Sulphur is not taken into account and may be included in the results.
- Please let me know if results do not correspond to other data.

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