WEST COAST RESOURCES-KOINGNAAS AND SAMSONS BAK COMPLEXES

ENVIRONMENTAL IMPACT ASSESSMENT

REPORT ON GEOHYDROLOGICAL IMPACT ASSESSMENT FOR WEST COAST RESOURCES DIAMOND MINING OPERATIONS ALONG THE WEST COAST AROUND KOINGNAAS, NORTHERN CAPE PROVINCE

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Prepared for

West Coast Resources (Pty) Ltd
P O Box 723
Parow
7499
Capetown

Prepared by

WATERS WITHOUT FRONTIERS
Water & Environmental Consultancy
Water recognises no borders

Andrew Mavurayi: Pr.Sci.Nat; MSc Hydrogeology: UCL- UK,

504 Olivetti House, 241 Schubart Street, Pretoria 0002, Tel: 012 323-0072, Cell: 082 600-2142, Fax: 0867234023
Email: andrew.mavurayi@gmail.com, Website: www.waterfrontiers.co.za

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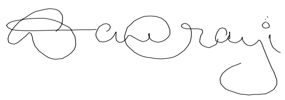

Principal Hydrogeologist
Pr.Sci.Nat, MSc Hydrogeology UCL-UK

EXECUTIVE SUMMARY

1 INTRODUCTION

1.1 BACKGROUND

West Coast Resources (Pty) Ltd (hereafter called WCR) intends to re-visit and mine certain areas on the Namaqualand Coast. WCR is re-establishing diamond-mining operations in the existing mining rights areas on the Namaqualand coast, previously mined by De Beers, and under the existing mining rights of July 2012, i.e. Koingnaas Mining Right (522MRC) and Samsons Bak Mining Right (525MRC. As part of their operations, WCR intend to mine deposits that are located on the beach and extend seaward, potentially for several hundred metres. WCR wants to continue with mining on the areas covered by these rights i.e. areas within the existing mining rights authorization, with immediate target being the Langklip and Koingnaas mining areas. The target areas are those that will not trigger new listed activities in terms of the National Environmental Management Act, Act No. 107 of 1998 (NEMA). The life of mine is anticipated to be about 11 years.

Waters Without Frontiers cc was appointed to conduct a geohydrological impact assessment for the proposed mining activities, as part of a broader **E**nvironmental **I**mpact **A**ssessment (EIA) for the mine. The EIA process is coordinated by Myezo Environmental Services (Pty) Ltd.

1.2 PREVIOUS STUDIES

A groundwater study was previously conducted at the site by M L Francis for De Beers Consolidated Mines Limited - Namaqualand Mines in 2003. The study however, focused on the chemistry of water encountered in the mining excavations which were generally shallow. No boreholes were drilled.

1.3 ASSUMPTIONS AND LIMITATIONS

There were no assumptions made in the study.

The main limitation was that the study was based entirely on existing data, no primary data were generated in the study by way of drilling new boreholes. Heavy reliance was placed on data from the National Groundwater Archive, NGA.

2 OBJECTIVES

The main objective of the study was to assess the potential impact of diamond mining activities on groundwater; and to recommend management options to mitigate or remedy the impacts.

3 METHODOLOGY

The study comprised a desktop study complemented by a hydrocensus.

4 CONCLUSION

The conclusion is based entirely on the evaluation of existing data coupled with a hydrocensus. No new boreholes were drilled in this investigation.

The main conclusion derived from the assessment is that the proposed diamond mining activities will have very small negative impact on groundwater resources for reasons listed below:

- Mining excavations will be limited to shallow depths of less than 20 metres below surface, by most probability above the water-table.
- The natural or ambient groundwater quality in the proposed mining area is of very poor quality; hence further degradation through contamination by sea-quality water will not make a big difference.
- Diamond processing relies on the physical properties of the mineral, no chemically active substances with potential to introduce toxins are added. This means that the process water emerging from the processing plant will have been little altered in chemical composition from its original state. The impact of contaminated groundwater discharging into the sea on the marine ecology is currently a subject of debate, but logically, should be negligible.

The study was not exhaustive and definitive as it was based entirely on existing data. No primary data were generated in this study. The presence or absence of potable groundwater in the proposed mining area needs further investigation by way of siting and drilling exploratory boreholes in the 500 metre wide coastal strip of the mining area.

5 RECOMMENDATIONS

The investigation provided a preliminary understanding of the groundwater situation at the site. The recommendations seek to ensure the mine complies with the relevant government legislation, particularly the National Water Act of 1998. To this end, the following recommendations are made:

- Site and drill at least five exploratory boreholes in the strip of land along the coast, extending 500 metres inland; and at least 100 metres from the sea edge. Siting of the boreholes should employ geophysical survey techniques to increase the chances of locating geological structures that influence groundwater flow such as faults, fracture zones and dykes. Electromagnetic (EM), magnetic, and electro-seismic techniques are recommended in this regards. The approximate positions of the geophysical survey lines are shown in Figure 11.1, and their coordinates are given in Table 11.1. A single borehole will be drilled on the strongest geophysical anomaly on each survey line. In other words, the borehole may be located anywhere along the survey line. The survey positions will be refined in the field based on local conditions encountered during the survey.

- Place some of the boreholes down-stream of the slimes dams so that they can also function as monitoring boreholes, should potable groundwater be found.
- Electrical conductivity of all water strikes should closely be monitored to identify possible pockets of fresh water.
- Water quality parameters to be analysed for should include but not limited to the following: pH, EC, TDS, Ca, Mg, Na, K, Fe, Mn, Cu, Pb, Zn, Cd, Cr, CL, SO_4, F, NO_3, PO_4, CO_3, and HCO_3. Sampling should be carried out quarterly.
- All waste containment facilities must be lined with impermeable or low permeability material. Common lining materials include clay, concrete and HDPE liners; the latter two being expensive.

Should however, no fresh groundwater be found on the properties, then the Department of Water and Sanitation should be engaged to discuss the logic of protecting naturally degraded water quality that does not support both basic human and ecological needs.

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Acronyms

BHN	Basic Human Needs
DWS	Department of Water and Sanitation
EC	Electrical conductivity
EIA	Environmental Impact Assessment
EM	Electro-magnetic
ES	Electro-seismic
HDPE	High density Polyethylene
Mamsl	Metres above mean sea level
WCR	West Coast Resources
WRC	Water Research Commission
WWF	Waters Without Frontiers

GLOSSARY OF TECHNICAL TERMS

Alkalinity: is a measure of the acid-neutralising capacity of water. Ions which commonly contribute to the alkalinity of water are bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), and at high pH values, hydroxide (OH^-. The total alkalinity is the sum of these three ions. Anion: negatively charged ion.

Aquifer: Rock or sediment in a formation or group of formations or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Baseflow: Groundwater contribution to stream-flow during the dry season.

Basic Human Needs (BHN): Minimum quantity and quality of water required to sustain humans.

Bedrock: solid rock underlying loose deposits such as soil or alluvium.

Ecological Requirements (ER): Minimum quantity and quality of water required to sustain an ecological system.

Electrical conductivity (EC): measure of the capacity of water to conduct an electrical current. This capacity is a result of the presence of ions in water, all of which carry an electrical charge. In most waters nearly all the EC is due to the major cations (calcium, magnesium, sodium, potassium and nitrate) and anions (carbonate, bicarbonate, chloride and sulphate). In acidic or basic waters the proton (H_+) or hydroxyl ion (OH_-) contributes extensively to the EC. Most organic compounds dissolved in water do not dissociate into ions, consequently they do not affect the EC. Approximately equivalent to the total dissolved solids.

Overburden: loose earth or rock material overlying solid rock.

Total dissolved solids (TDS): measure of the quantity of various inorganic salts dissolved in water. The TDS concentration is proportional to the electrical conductivity (EC) of water. Since EC is much easier to measure, it is routinely used as an estimate of the TDS concentration.

Water type: Chemical facies are calculated by first converting the milli-equivalents per litre of the major cations (Na_+, Ca^{2+}, Mg^{2+}) and anions (Cl^-, SO_4^{2-}, HCO_3^-) to percentages. The water type expression is formed by listing the ions with concentrations greater than 10% in decreasing order.

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2 OBJECTIVES

The main objective of the study was to assess the potential impact of diamond mining activities on groundwater; and to recommend management options to mitigate or remedy the impacts.

3 LEGAL CONSIDERATIONS

The National Water Act of 1998 recognises the Department of Water Affairs (DWA) as the custodian of all water resources in South Africa; and gives it overall responsibility for and authority over water resource management, including the equitable allocation and beneficial use of water in the public interest. A person can only be entitled to use water if the use is permissible under the Act. The Act recognises the following types of water uses:

21(a):- taking water from a water resource;
21(b):- storing water;
21(c):- impeding or diverting the flow of water in a watercourse;
21(d):- engaging in a stream flow reduction activity contemplated in section 36;
31(e):- engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);
21(f):- discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
21(g):- disposing of waste in a manner which may detrimentally impact on a water resource;
21(h):- disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
21(i):- altering the bed, banks, course or characteristics of a watercourse;
21(j):- removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
21(k):- using water for recreational purposes.

The water uses that have relevance to WCR operation include Sections 21 (a), (b), (g) and (j)

4. SITE DESCRIPTION

4.1 LOCATION

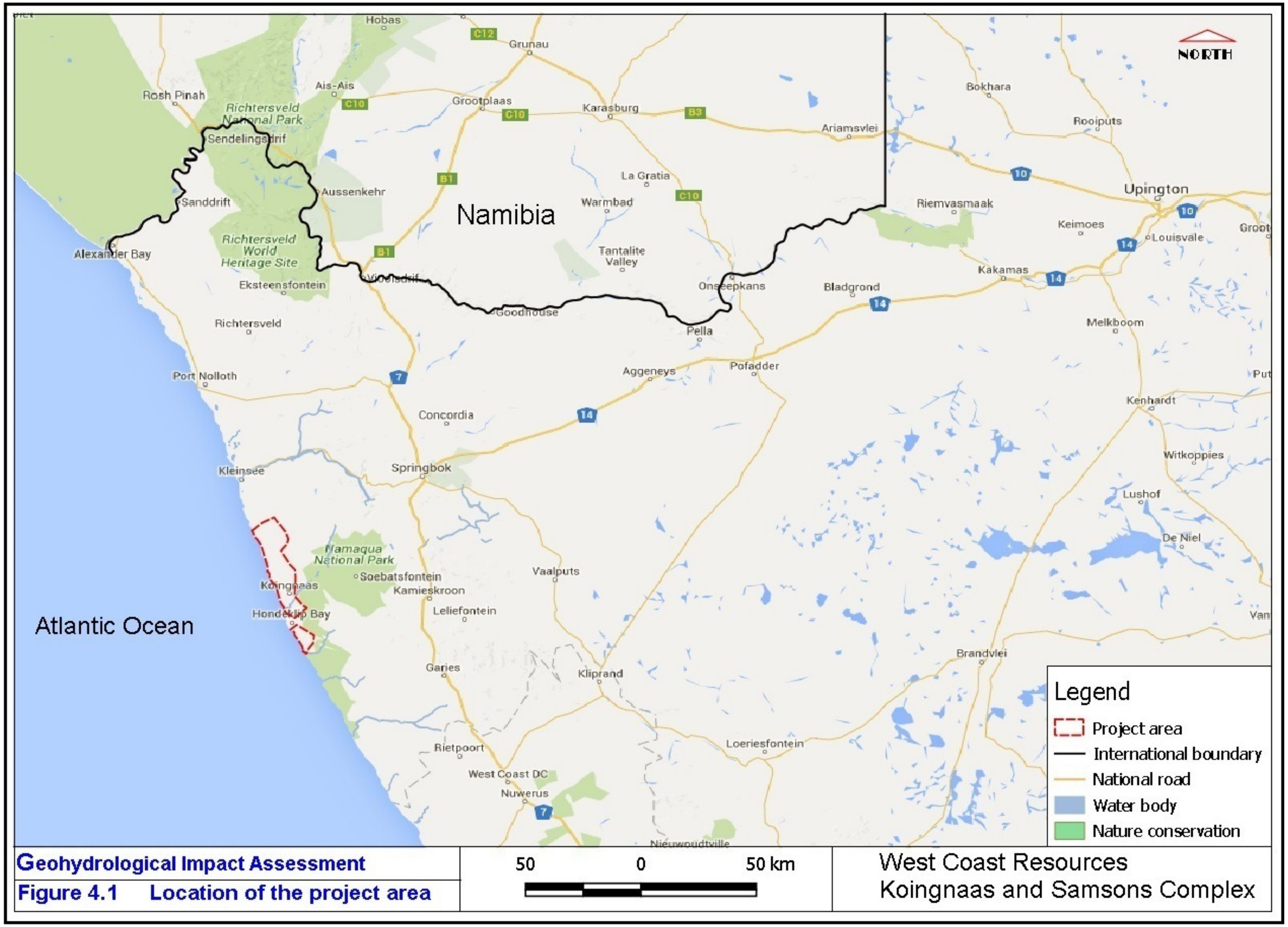
WRC mining area is located along the Namaqualand coastal foreland extending for about 70 km from roughly halfway between Kleinsee and Koingnaas in the north, to Mitchell's Bay in the South. The mining operations extend over portions of seven farms in the Namakwa District, Northern Cape Province. WCR administrative offices are located at Koingnaas. Access to Koingnaas is possible by several routes that include from Springbok via Kleinsee (170 km) or directly from Springbok through Namanqua National Park (105 km), both have sections of gravel. The location of the study area is shown in figure 4.1.

4.2 TOPOGRAPHY AND DRAINAGE

WRC mining area straddles three quaternary catchments which are, from the north to the south; F40A, F40D and F40F; all of which fall within the Lower Orange Water Management Area. The study area is located on a coastal plain, west of the Kamiesburg Mountains. The topography is fairly flat and homogeneous; and for the most part reflects the gently undulating nature of the predominantly sand covered land surface. The topography of the study area is shown in Figure 4.2. Various dune systems provide some topographic variation to the comparatively featureless landscape. Ground elevation in the mine operational areas ranges from 0 to 200 metres above mean sea level (mamsl). The topography becomes very from the sea going inland. Figure 4.3 shows a topographical cross-section from (Point A) in the sea, through Koingnaas to Point B located inland. Several pans occur in the area. The project area is drained by several rivers that rise in the mountains and flow westwards to the Atlantic Ocean. The main rivers include Zwart Lintjes and Spoeg.

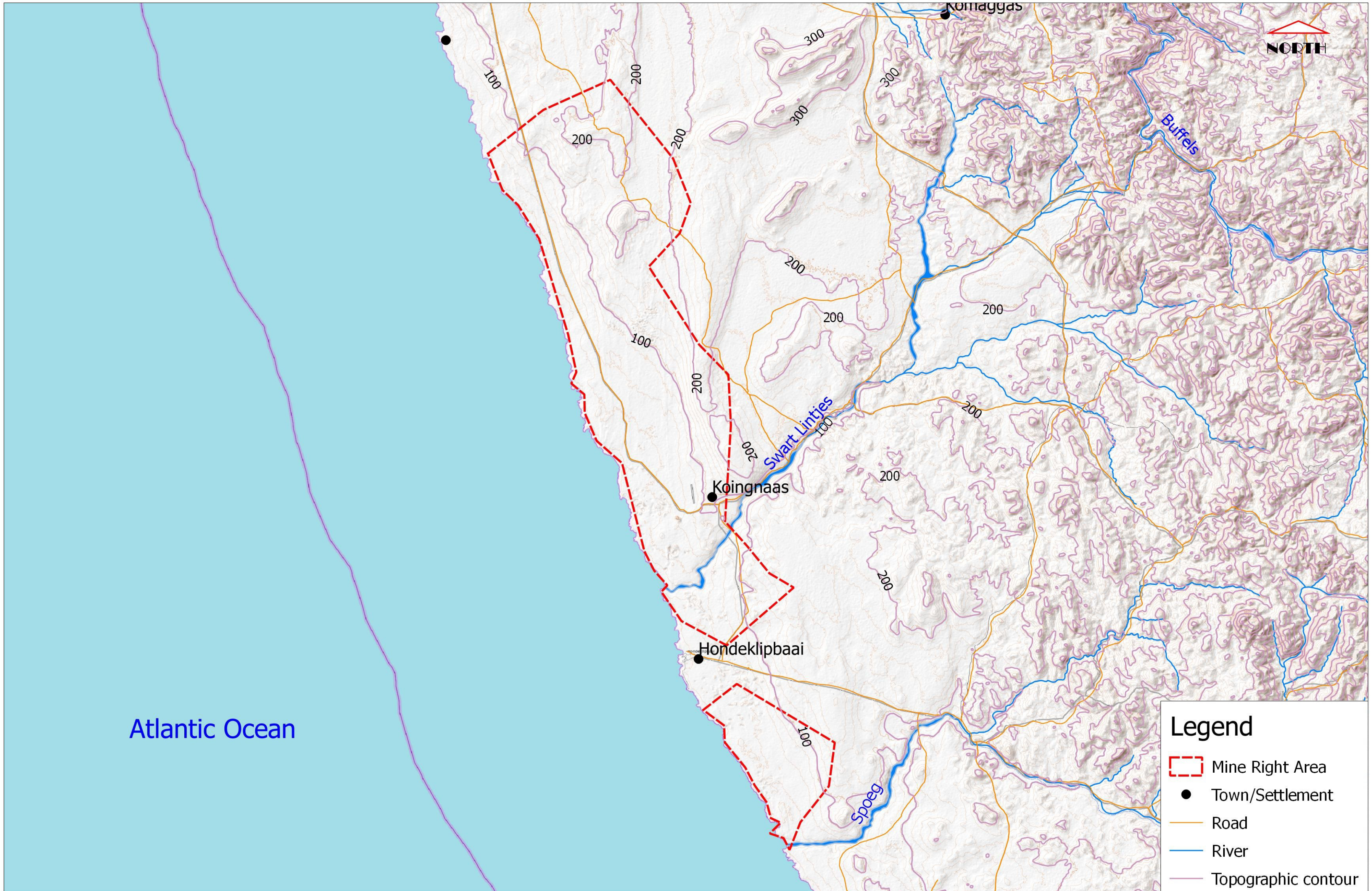
4.3 CLIMATE

Koingnaas is located within an arid region with a climate characterised by relatively cool and dry desert conditions. The low temperatures and low incidence of low rainfall are controlled by the South Atlantic subtropical anticyclone, which maintains an almost isothermal atmosphere over the Namaqualand coast (Nieman, 1981). The predominant southerly winds cause the upwelling of the Benguela system which cools and stabilises the near surface air mass and reduces the potential for rainfall occurrence. Coastal fogs occur year round but are more frequent during the winter period.



Geohydrological Impact Assessment

Figure 4.1 Location of the project area



Geohydrological Impact Assessment		West Coast Resources Koingnaas and Samsons Complex
Figure 4.2 Topography of the project area		

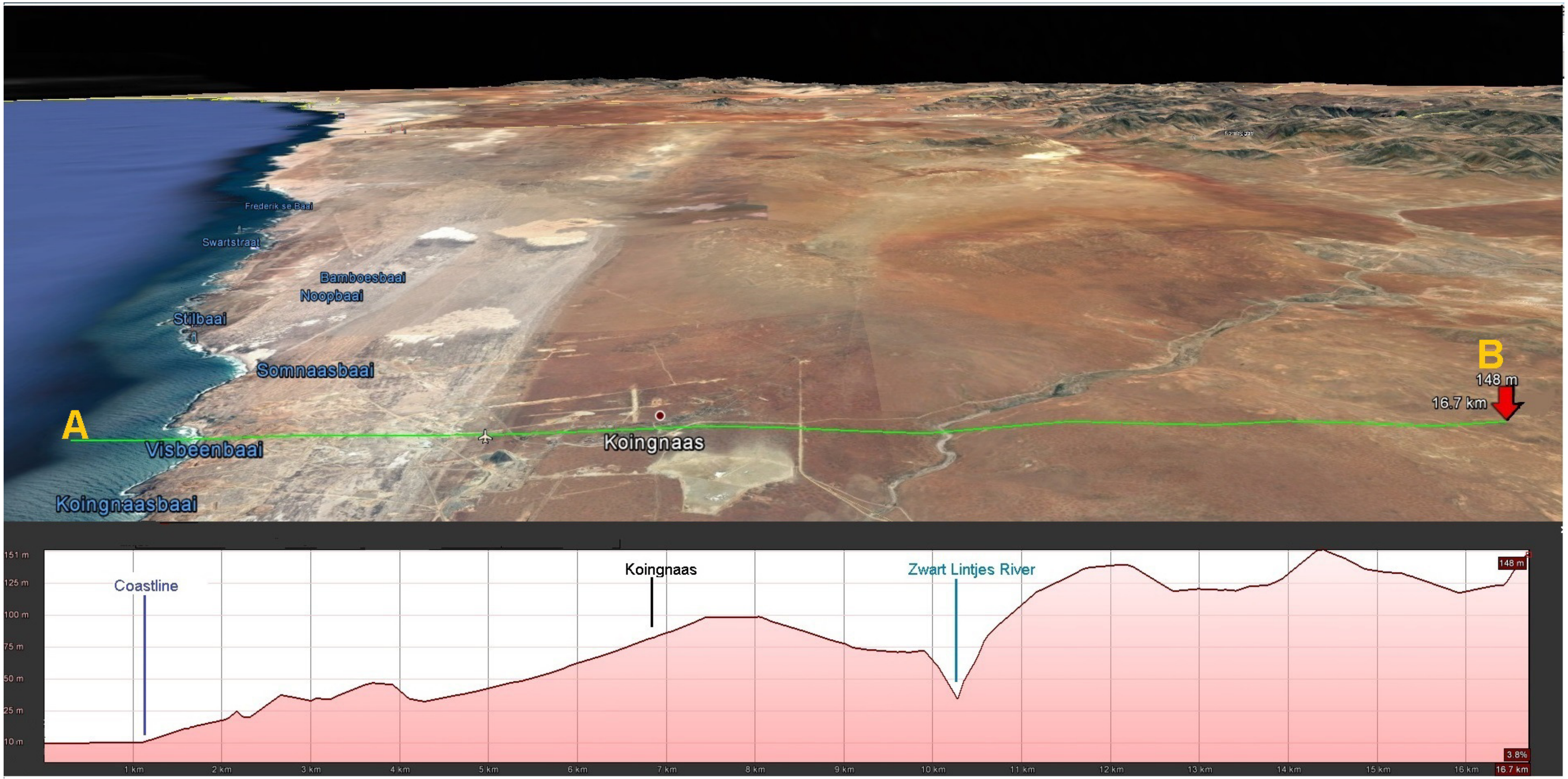


Figure 4.3 **West-East topographical cross-section through Koingnaas**

Koingnaas coastline receives about 100mm of rain per year during winter. Rainfall events are distributed between April and August and peak during May, June and July. It receives the lowest rainfall (0 mm) in January and the highest (6 mm) in June. Fog develops frequently as a result of oceanic surface evaporation which saturates the cool coastal air mass. Fog covers the area 40% of the year. Summer and autumn experience the greatest number of days with fog.

The average midday temperatures range from 20.6°C in July to 27.5°C in January. The region is the coldest during July when the mercury drops to 8.3°C on average during the night. The Atlantic Ocean has a significant moderating effect on the coastal temperature regime. Minimum temperatures are particularly stable and are not subject to large fluctuations. Rainfall and temperature trends are shown in Figures 4.3 and 4.4 respectively.

4.4 LAND USE

The diamond mining and fishing industries are the economic mainstay and largest employment source on the West Coast. Small-scale recreation and tourism are additional growth industries generating an increasing source of revenue for West Coast towns.

4.5 WATER SUPPLY

Groundwater represents the main source of water for domestic supply in the region. The settlements of Koingnaas, Hondeklip Bay and Samson Bak derive water from the Somnaas Noup aquifer located about 20 km north of Koingnaas. Two boreholes, BH 12 and BH 14, are currently in use. A third borehole, BH15 adjacent to BH 12, is equipped and used as a standby borehole.

4.6 SANITATION

Koingnaas is serviced by a water borne sewage system. Temporary ablution facilities are used at the mining and processing sites.

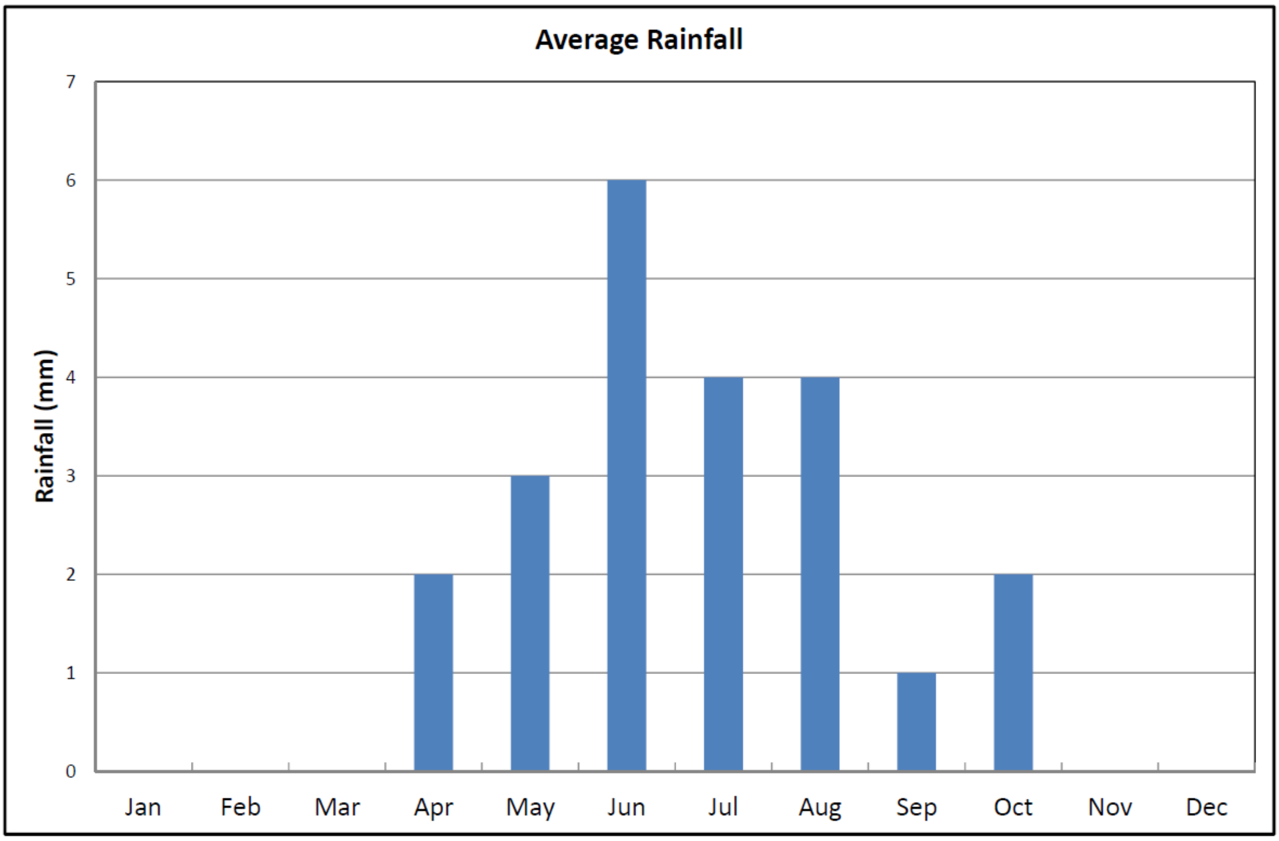


Figure 4.4 Rainfall pattern at Port Nolloth/Alexander Bay

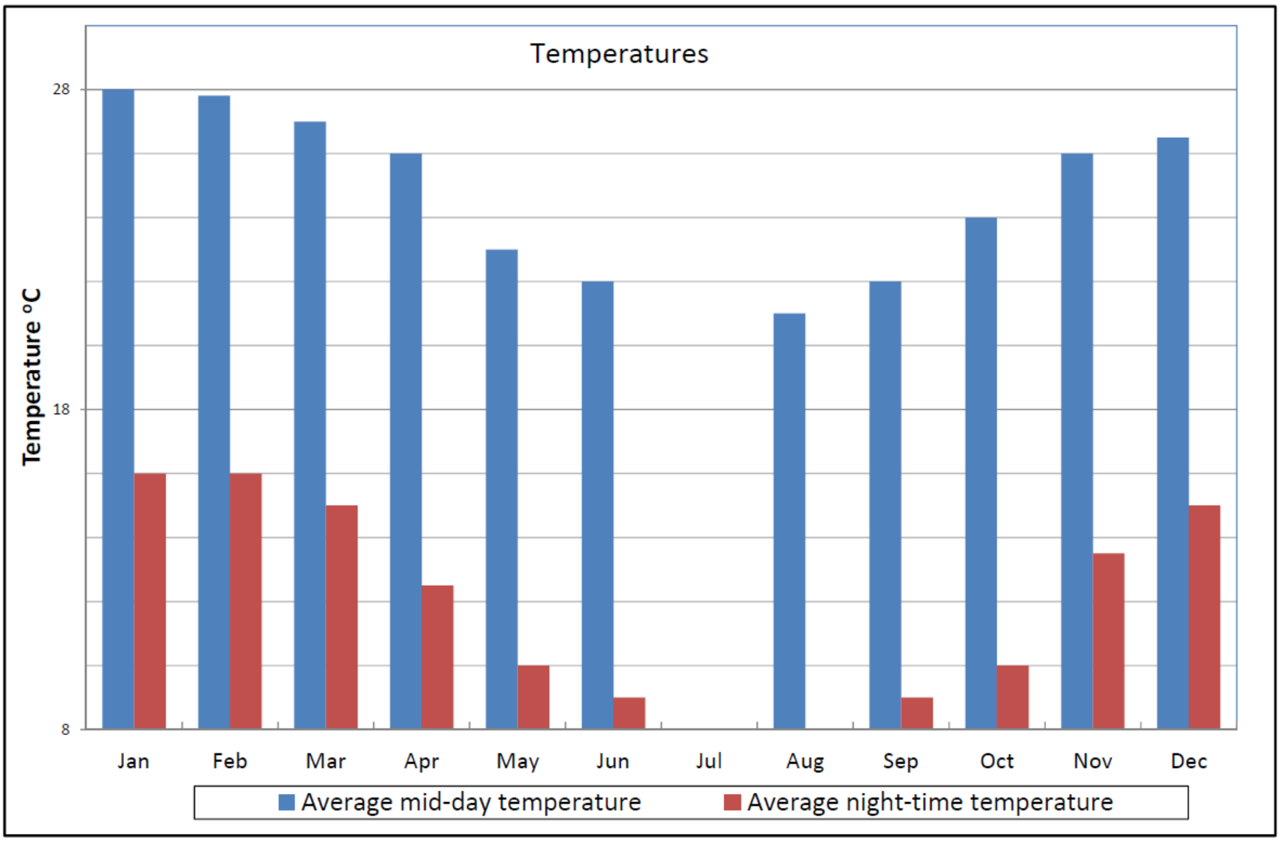


Figure 4.5 Temperature patterns at Port Nolloth/Alexander Bay

5 GEOLOGICAL SETTING

5.1 REGIONAL GEOLOGY

The study area is located in the Namaqua Metamorphic province, characterised by metamorphosed Precambrian basement rocks overlain by Cenozoic to Recent sediments. Figure 5.1 shows the simplified geology of the study area.

The basement consists predominantly of the Little Namaqualand Suite and; to a lesser extent, the Garries biotite gneiss and the Spektakel granite. The Little Namaqualand Suite occurs in an area bounded by the Orange River in the north and the Buffels River in the east, the Sandveld Coastal Plain in the west and the Bushmanland Peneplain in the east. It consists of a series of quartz-feldspar-biotite orthogneisses which have intrusive relations with one another and with the country rocks. Eight varieties of the gneisses are recognised. Rocks of the Namaqua Metamorphic Province were formed contemporaneously with the Natal metamorphic rocks in KwaZulu Natal. Remnants of the original Precambrian granites include the Spektakel granite.

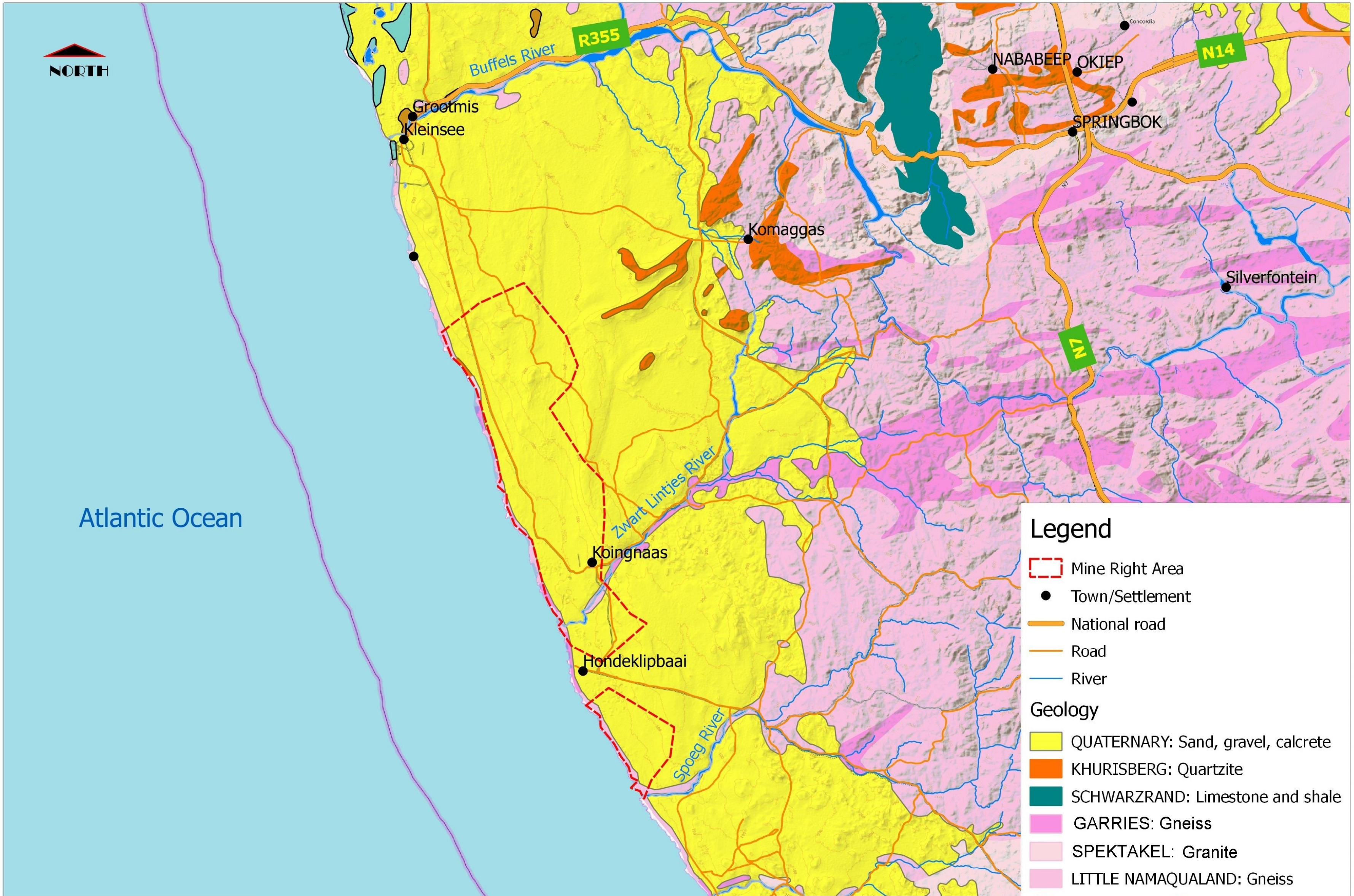
The metamorphic origin of the basement rocks implies that the rock masses were subjected to tectonic activities. East- west trending weaknesses are inferred to be related to transform faults generated by tectonism associated with the creation of the African plate. These weaknesses were exploited by the rivers to cut out the palaeo-channels targeted for diamond extraction. The diamonds were originally derived from intrusive kimberlites inland and were transported to the sea by erosion and fluvial processes.

5.2 LOCAL GEOLOGY

The study area is covered by a thin veneer of Cenozoic sediments comprising coastal dunes, which overlie fluviatile, beach and near-shore sediments. Sandy gravels occur on marine terraces most of the way along the western coastline from the Olifants River to to Hondeklip Bay, and overlie older channel deposits.

In general, the coastal sediments are sands of Pleistocene origin, grading upwards into silty sands. These are overlain by a calcrete layer varying in depth and consistency from hard rock to unconsolidated lime-rich sands. The surface sands are of eolian origin, and increase in depth from the north to the south.

The palaeo-channel at Koingnaas measures approximately 150 metres wide and in excess of 6 km long, trending north-east to south-west. The basal deposits consist of angular to sub-rounded quartz rubble lying on basements rocks. Late sediments consist of well sorted medium-grained sands and clays with peat layers.



Geohydrological Impact Assessment

Figure 5:1 Simplified geology of the project area

West Coast Resources
Koingnaas and Samsons Complex

6 GEOHYDROLOGICAL SETTING

6.1 REGIONAL SETTING

Groundwater utilisation is of major importance across wide areas in the study area and often constitutes the only source of water. It is mainly used for rural domestic supplies, stock watering and water supplies to towns. As a result of the low rainfall, recharge of groundwater is limited and only small quantities can be abstracted on a sustainable basis. Artificial recharge of groundwater is practiced in some areas where water from small dams is transferred through pipes into boreholes. Aquifer characteristics (borehole yields and storage of groundwater) are also typically unfavorable because of the hard geological formation underlying most of the area. Groundwater availability in the coastal region is extremely limited as a result of the lack of rainfall. Close to the sea there is a strong risk of seawater intrusion into coastal aquifers

6.2 LOCAL SETTING

The study area is characterised by both primary and secondary aquifers.

6.2.1 Primary Aquifer

Primary aquifers are associated with the unconsolidated deposits comprising sand and gravel in paleao drainage channels and associated valleys. They vary in thickness from 0 m (bedrock outcrops) to about 30 metres below surface.

6.2.2 Secondary Aquifer

The secondary aquifers are associated with fractures and fissures in the bedrock of Little Namaqualand gneiss and the Garries Complex. These rocks typically possess extremely small primary porosity and hydraulic conductivity when formed, and consequently have little to offer in terms of groundwater resources. Secondary process, however, improve their groundwater potential through fracturing and weathering.

Several different modes of groundwater occurrence have been recognised as follows:

- Jointing and fracturing associated with faulting,
- Weathering in lavas and gneisses,
- Fracturing at contacts between lithologies,
- Partings between bedding planes.
- Solution cavities in limestone and dolomite.

The groundwater yield potential in the study area is low with borehole yield generally less than 0.1 L/s.

The region receives very little groundwater recharge. Vegter's groundwater recharge map estimates recharge at 2 mm per annum, whilst the groundwater water harvest map indicates that 2

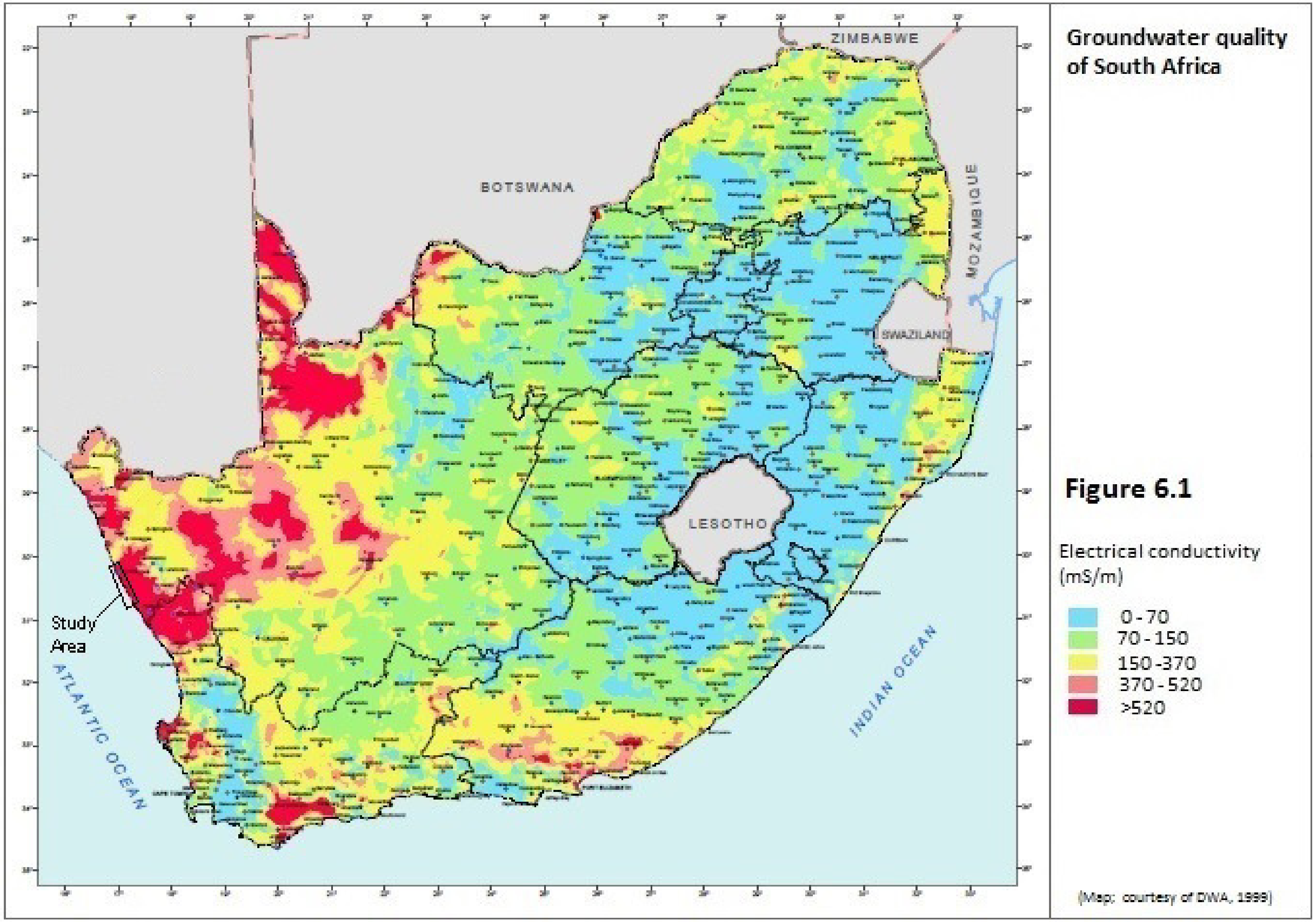
500 m^3 of groundwater can be sustainably abstracted per square kilometre per annum in the region.

6.2.3 Groundwater Quality

Groundwater quality is typical of arid regions, which is generally poor and characterised by high salinity. Electrical conductivity generally exceeds 500 mS/m. Groundwater is predominantly of the Na-Cl affinity. The poor water quality is attributed to several factors that include:

- Very low groundwater recharge (estimated at 0 to 2mm per annum), hence limited flushing out of old water.
- Marine origin of gravels described earlier in Geology Section forming terraces extending about 2 km inland and rising to about 90 m above mean sea level.
- Leaching and dissolution of terrestrial salts emanating from salt outfall from the sea.
- Ancient (old) water in paleao-drainage channels, recharged during periods of less arid regional climate in the past.
- Excessive surface water evaporation relative to rainfall, resulting in the concentration of salts in the water infiltrating the ground.

Figure 6.1 shows the groundwater electrical conductivity distribution in South Africa.


Groundwater quality
of South Africa
Figure 6.1
Electrical conductivity
(mS/m)
0 - 70
70 - 150
150 -370
370 - 520
>520
(Map: courtesy of DWA, 1999)
ZIMBABWE
BOTSWANA
MOZAMBIQUE
SWAZILAND
LESOTHO
Study
Area
ATLANTIC OCEAN
INDIAN OCEAN

7 INVESTIGATION

The objective of the study was to determine the potential impacts of mining activities on water resources in the vicinity of the mine. In order to appreciate the task at hand, it is worthwhile discussing the potential impacts emanating from mining activities:

Depletion of groundwater resources due to mine dewatering to create safe working conditions for the miners. Pumping of water from a mine pit results in the development of a cone of depression around the pumping source. The cone represents a zone of dewatered or emptied rock. Any borehole, spring, wetland or river section within the cone of influence will lose water to the cone, and my eventually dry up. Figure 7.1 shows a typical cone of influence.

Contamination of groundwater from mineral processing and waste containment facilities. Groundwater contamination occurs when contaminants seep from unlined containment facilities into groundwater resources and transported in the direction of groundwater flow. The contaminants will daylight in abstraction boreholes, springs, wetlands and rivers located down-gradient of the sources.

Acid rock drainage: Acid rock drainage is an inherent problem associated with mining of mineral associated with sulphides, and a huge threat to groundwater quality. Pyrite, an iron sulphide is oxidised when exposed to the atmosphere and water to form sulphuric acid. The acid increases the capacity of groundwater to dissolve and mobilise salts. This results in higher levels of dissolved solids in groundwater. Acid rock drainage is unlikely to occur at the site due to the absence.

The approach adopted for the investigation recognised that the impacts of mining activities on groundwater resources are very closely tied to the prevailing groundwater flow patterns and hydraulic head distribution at the site, as dictated by stresses imposed by mining and other activities in the area. To this end the investigation focused on:

- Development of an accurate piezometric surface map of the site,
- Identification of potential sources of contamination and establishment of the spatial water quality distribution at the site,
- Identification of potential groundwater preferential flow pathways,
- Correlation of groundwater flow patterns with the spatial water quality distribution.

The current study was based entirely on existing information. The findings of the study would determine additional field work that would be required to achieve the objectives of the investigation.

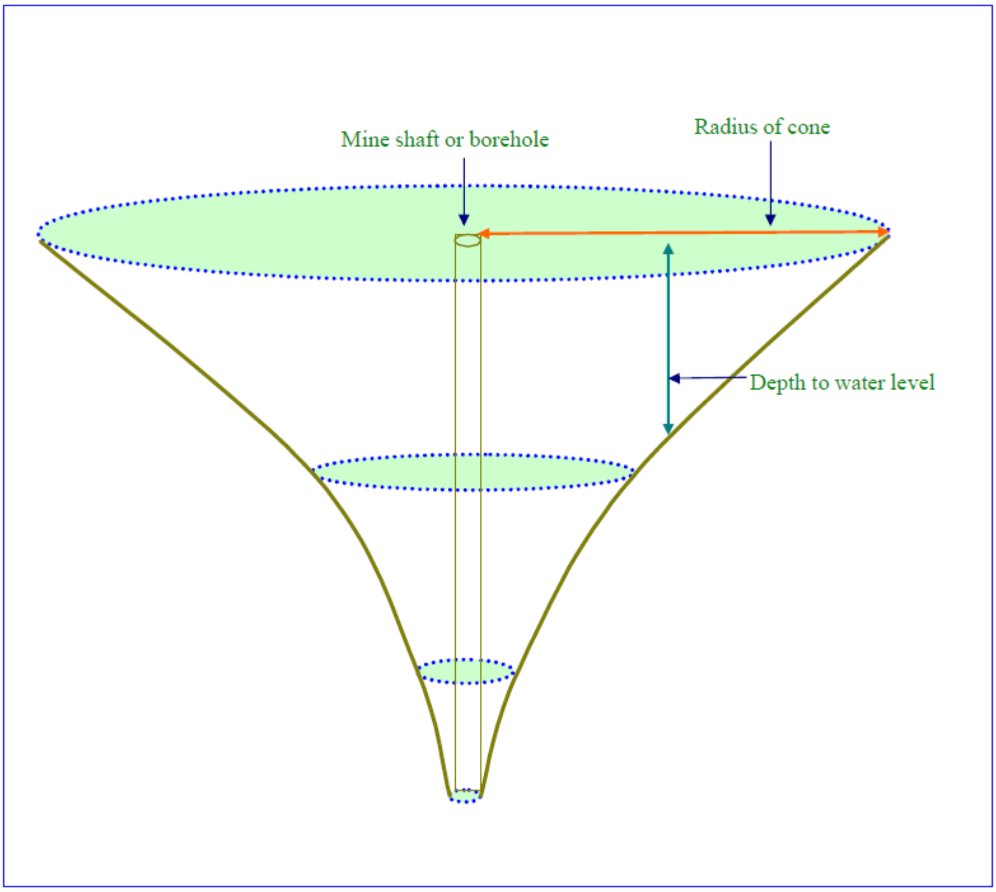


Figure 7.1 Typical cone of depression due to groundwater abstraction

The following activities were undertaken:

7.1 DESKTOP STUDY

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

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

7.2 HYDROCENSUS

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

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

7.3 INTERVIEWS

During the desktop study and the hydrocensus, interviews were conducted with groundwater users around the mine to establish issues relating to their groundwater resources.

7.4 GROUNDWATER MODELLING

The spatial distribution of electrical conductivity and groundwater levels were modelled. Groundwater flow patterns were determined.

8 DISCUSSION OF FINDINGS

8.1 DATA EVALUATION

Groundwater characterisation was based on the evaluation of existing boreholes mainly from the **N**ational **G**roundwater **A**rchive (NGA) of the **D**epartment of **W**ater and **S**anitation (DWS). A total of 27 boreholes were identified in the study area. The two boreholes that supply domestic water to Koingnaas (BH 12 and BH 14) plot at the same positions as boreholes 3017AA00003 and 3017AA00001 in the NGA respectively. The location of the boreholes is shown in Figure 8.1. Information on the boreholes is patchy and is summarized in Table 8.1.

8.2 GROUNDWATER QUANTITY

Data from the existing boreholes in the area indicate borehole yields ranging from 0.1 to 7 L/s, with an average yield of 0.7 L/s as analysed from 25 boreholes. Water strike depth ranges from 10m to 160m blow surface, with an average depth of 62m, as analysed from 25 boreholes. High yields are associated with well-developed fractures and fissures in the bedrock.

8.2 GROUNDWATER LEVEL

Groundwater levels data in the study area were evaluated from 25 boreholes from the NGA. The water level data were contoured to depict the distribution of the depth to the water-table, Figure 8.2. The groundwater levels occur between 0 and 123 metres below surface, with an average of 39 metres below surface.

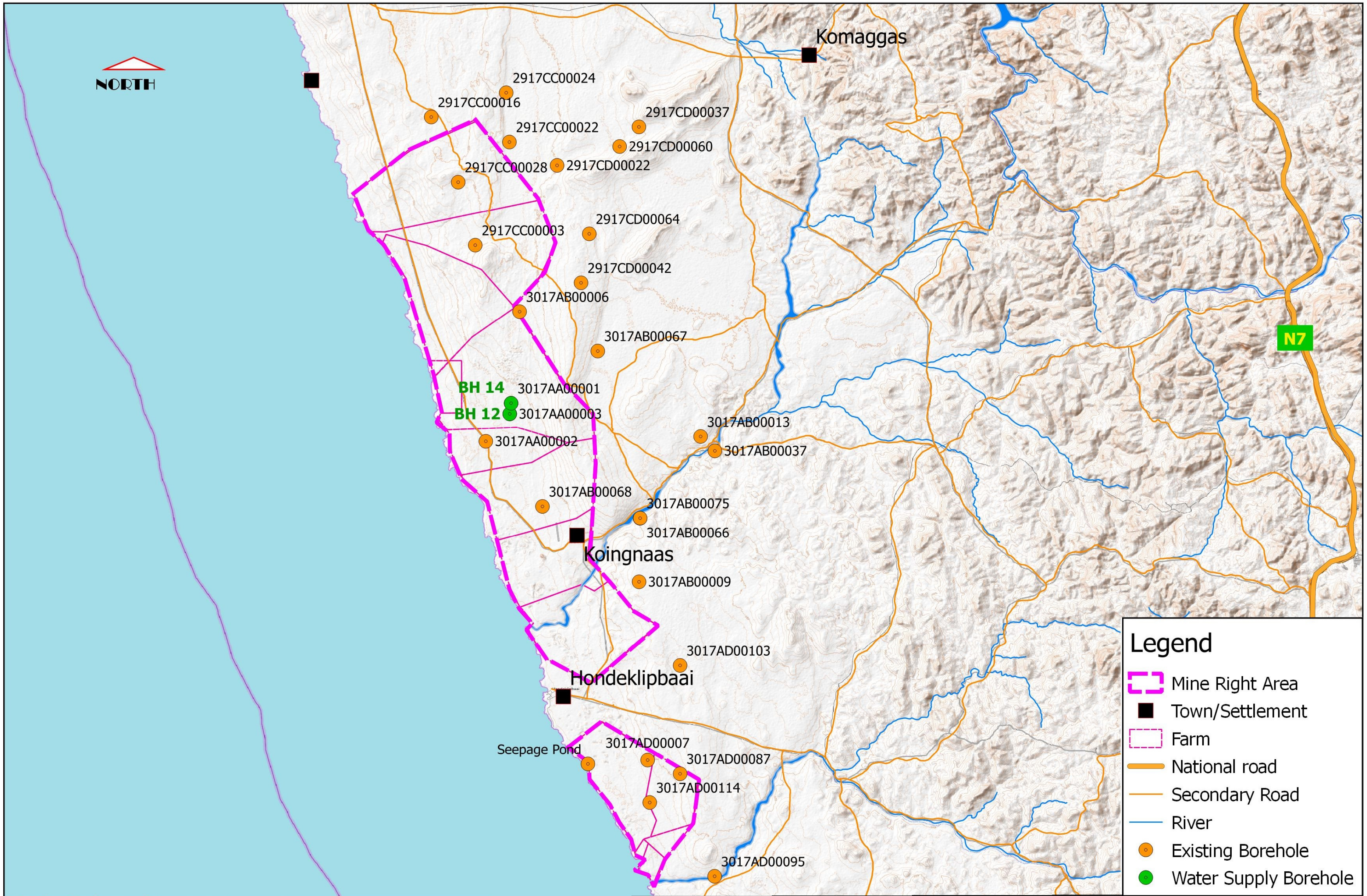
8.3 GROUNDWATER FLOW

A piezometric surface map for the study area was created to determine groundwater flow patterns at the site. Figure 8.3 shows the piezometric surface map around the site. Groundwater flows predominantly in a westerly direction towards the sea.

Table 8.1 Information on existing boreholes

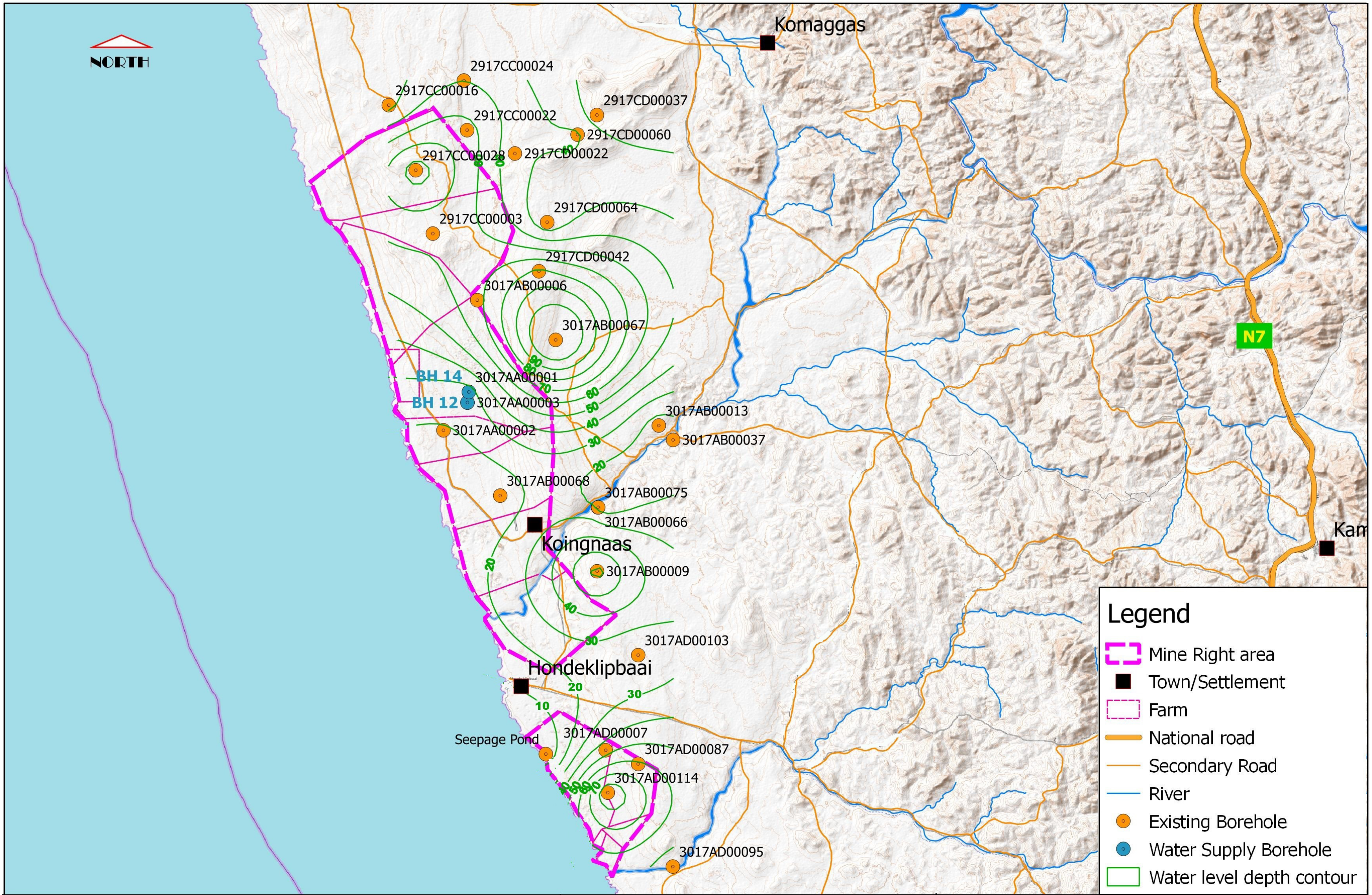
Borehole ID	Latitude	Longitude	Borehole depth (m)	Water Level (m)	Water Strike (m)	Yield (L/s)	Bedrock Lithology
3017AD00095	-30.46704	17.41056	72	15	57	0.6	Granite
3017AD00114	-30.40704	17.35775	175	15	160	0.3	Granite
3017AD00087	-30.38373	17.38249	24		12	0.4	Granite
Seepage Pond	-30.37565	17.30747	10	0	10		
3017AD00007	-30.37259	17.35608		45			
3017AD00103	-30.29537	17.38248	40	20	22	0.2	Granite
3017AB00009	-30.22733	17.34914	110	64	70		Granite
3017AB00066	-30.17547	17.34987	20	23	31		Limestone
3017AB00075	-30.17538	17.34996	86	9	73	0.2	Granite
3017AB00068	-30.16593	17.27053	31	14	20		Granite
3017AB00037	-30.12066	17.41081	56	18	70		Granite
3017AA00002	-30.11287	17.22442	20	19	19		
3017AB00013	-30.10901	17.39916	81	14	73	0.2	Granite
3017AA00003 (BH12)	**-30.09037**	**17.24386**		**25**			
3017AA00001 (BH14)	**-30.08176**	**17.24497**	**45**	**25**	**25**	**7.0**	
3017AB00067	-30.03953	17.31553	137	123	125		Gneiss
3017AB00006	-30.00731	17.25192	30	67	73		Sandstone
2917CD00042	-29.98379	17.30189	125	82	91	0.3	Limestone
2917CC00003	-29.95319	17.21578	94	62	64		Granite
2917CD00064	-29.94402	17.30856	98	31	88	0.3	Quartzite
2917CC00028	-29.90178	17.20188	57	86	90	0.2	
2917CD00022	-29.88817	17.28244	85	43	46	0.1	
2917CC00022	-29.86929	17.24355	103	64	66	0.1	
2917CD00060	-29.87288	17.33329	90	42	72	0.1	Granite
2917CD00037	-29.85710	17.34911	24	24	41		Granite
2917CC00016	-29.84895	17.18028	84	36	82	0.2	Quartzite
2917CC00024	-29.82901	17.24133	62	50	58	0.2	
Statistical analysis	**Number of boreholes**		**25**	**26**	**25**	**15**	
	Minimum value		**10**	**0**	**10**	**0.1**	
	Maximum value		**175**	**123**	**160**	**7.0**	
	Mean value		**70**	**39**	**62**	**0.7**	

BH 12 and BH 14 currently supply water to Koingnaas



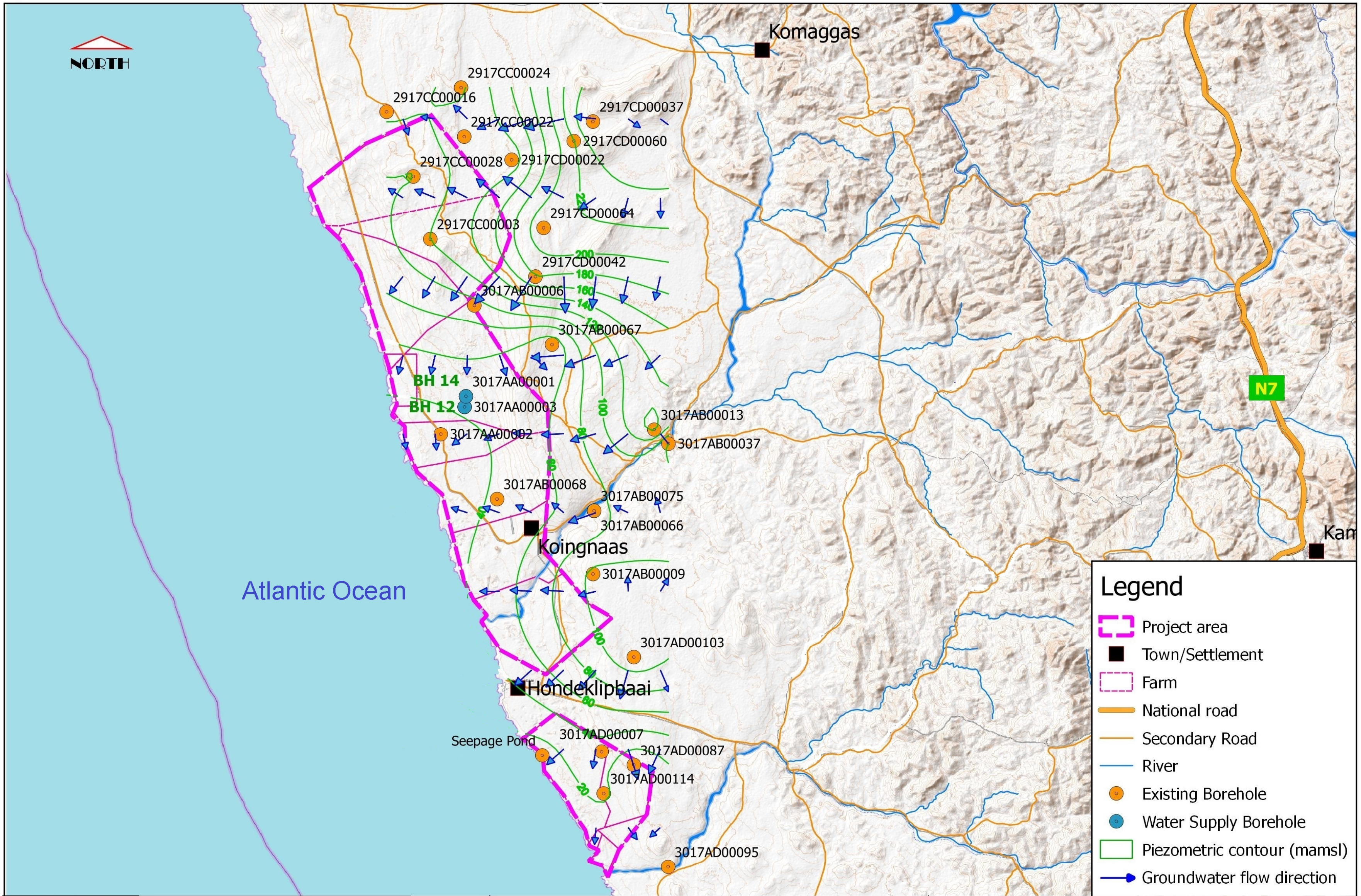
Geohydrological Impact Assessment

Figure 8.1 Location of existing boreholes



Geohydrological Impact Assessment

Figure 8.2 Depth to the water-table contour map



Geohydrological Impact Assessment	7.5 0 7.5 km	West Coast Resources
Figure 8.3 Piezometric surface map		Koingnaas and Samsons Complex

8.4 GROUNDWATER QUALITY

Groundwater quality was evaluated from 19 existing boreholes from the NGA, with a view to establishing the baseline groundwater quality against which potential impacts of mining will be monitored. Table 8.2 gives water quality data for boreholes in and around the study area. The data were evaluated against water quality guidelines for domestic use prescribed by the Department of Water Sanitation. Analysis of the data indicates that electrical conductivity ranges from 35 mS/m to 7 612 mS/m, with an average value of 1 253 mS/m based on data from 19 boreholes. Electrical conductivity is a very useful parameter for characterising water quality as it relates to the total amount of dissolved solids in the water. The spatial distribution of electrical conductivity is shown in Figure 8.4.

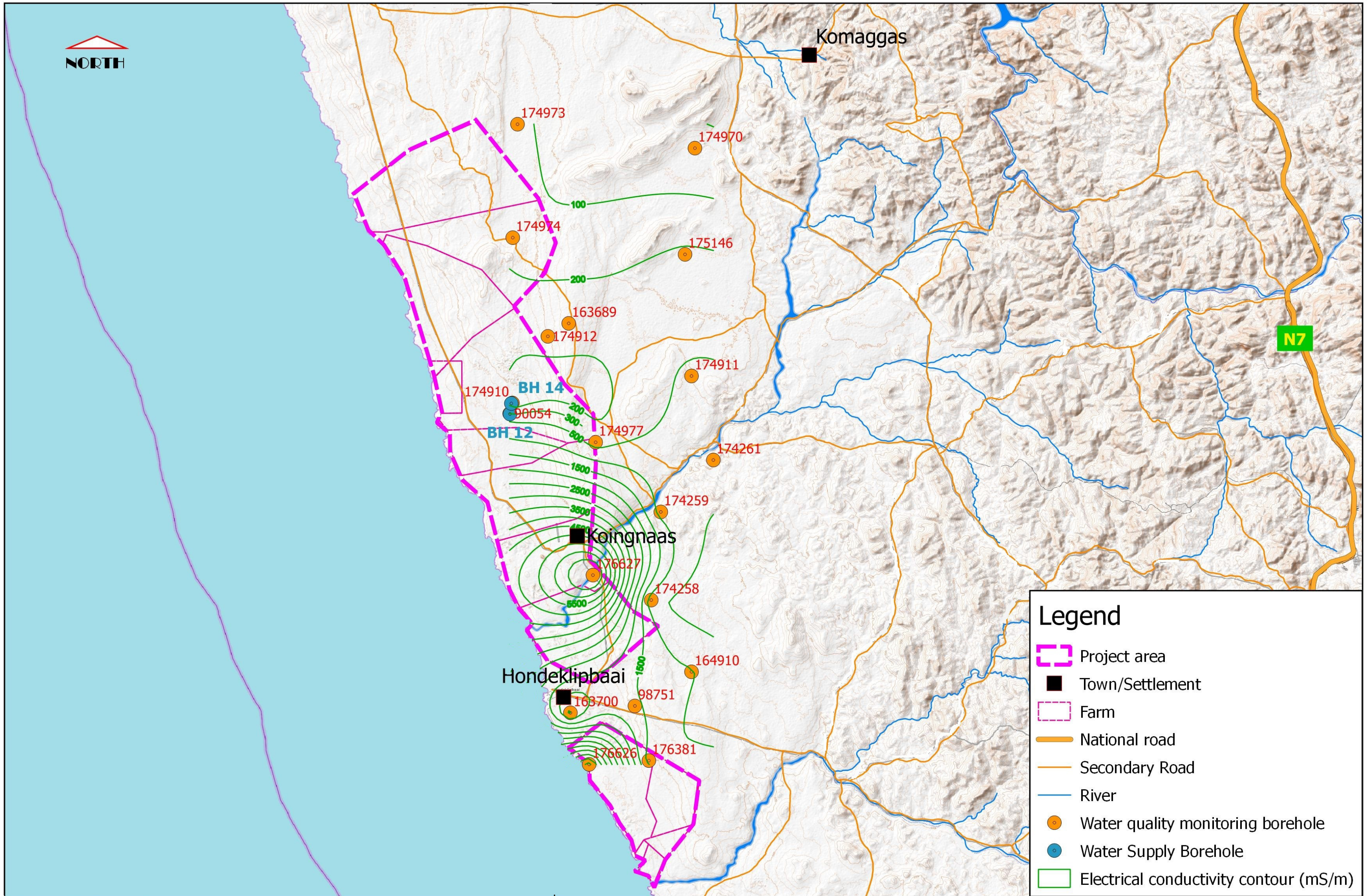
The study area is characterised by saline groundwater, with the majority of boreholes falling in Class III of DWS water quality guidelines. Groundwater quality generally deteriorates from the north to the south of the study area. The boreholes that supply water to Koingnaas have marginal water quality with electrical conductivity of between 150 mS/m and 277 mS/m. No fresh groundwater has been reported in the proposed mining areas. Fresh water is currently sourced from an aquifer located about 20 kilometres north of Koingnaas. Please note that the positions of the water supply boreholes BH12 and BH14 coincide with monitoring boreholes 90054 and 174910 respectively, Figure 8.4.

Evaluation of the water quality data for the study area using a Piper diagram shows that the groundwater type is predominantly of the Na-Cl affinity, Figure 8.5. Boreholes Bh14 and 174970 display Na-HCO_3 water type, which is indicative of recent groundwater recharge.

Table 8.2 Groundwater quality data

Monitoring Point ID	Latitude	Longitude	pH	EC (mS/m)	Ca (mg/l)	Cl (mg/l)	F (mg/l)	K (mg/l)	Mg (mg/l)	NO_3 (mg/l)	Na (mg/l)	SO_4 (mg/l)	PO_4 (mg/l)	Total Alkalinity (mg/l)
90054 **(BH12)**	-30.09000	17.24361	7.42	277	77.8	772.5	0.38	13.7	59.9	2.67	396.6	105.7	0.03	65.7
98751	-30.32778	17.34556	7.68	1620	646.0	5708.8	2.39	98.2	413.8	0.29	2532.5	570.7	0.00	83.8
163689	-30.01667	17.29167	7.05	286.1	29.6	766.0	2.05	9.8	11.3	0.21	504.5	105.6	0.01	57.8
163700	-30.33333	17.29306	6.4	842.8	165.8	2416.7	2.44	49.9	99.5	0.40	1410.8	330.9	0.02	41.9
164910	-30.30000	17.39167	7.23	1040	177.0	3297.1	2.07	43.4	189.9	0.09	1866.7	455.9	0.08	34.9
174258	-30.24167	17.35889	8.47	645	43.5	1913.9	1.93	40.4	63.0	0.19	1282.3	287.1	0.01	292.9
174259	-30.17000	17.36667	7.94	816	140.3	2774.0	1.17	55.9	199.3	0.61	1403.4	287.2	0.01	194.7
174261	-30.12778	17.40944	7.93	843	210.1	2831.4	2.08	59.9	226.2	1.44	1341.4	417.5	0.02	152.3
174910 **(BH14)**	-30.08139	17.24583	8.18	150	31.5	258.3	0.61	6.8	16.3	22.00	274.0	57.3	0.15	226.7
174911	-30.05944	17.39167	8.03	584	66.1	1877.6	0.81	40.8	79.6	2.02	1131.0	220.0	0.02	169.2
174912	-30.02722	17.27472	8.27	290	82.2	614.8	1.39	17.8	42.2	38.67	496.2	112.0	0.09	332.8
174970	-29.87417	17.39444	7.68	34.7	16.5	58.4	0.59	4.0	3.1	8.02	41.9	8.6	0.02	29.7
174973	-29.85472	17.25000	7.77	123.4	13.5	347.2	0.49	9.7	16.9	1.14	213.8	27.5	0.02	50.0
174974	-29.94694	17.24611	7.76	129.8	17.8	360.6	0.37	10.9	26.8	0.02	202.3	43.4	0.01	69.2
174977	-30.11333	17.31361	8.31	302	35.5	913.2	1.53	27.1	42.7	0.07	545.4	118.3	0.02	143.8
175146	-29.96056	17.38639	7.56	219	25.4	648.8	0.74	17.1	41.4	2.59	305.2	6.4	0.00	33.5
176381	-30.37222	17.35694	7.74	1258	922.3	4106.3	0.37	110.4	137.6	0.30	1342.1	307.7	0.02	81.9
176626	-30.37528	17.30833	8.16	6728	1938.8	23644.1	1.45	260.5	2167.2	0.02	10621.9	3245.3	0.02	219.4
176627	-30.22139	17.31139	7.94	7612	5408.1	35580.6	1.22	384.6	1441.3	0.05	14239.4	1878.4	0.04	220.2
Average value				1253	528.8	4678.4	1.27	66.4	277.8	4.25	2113.2	451.9	0.03	131.6
Guidelines														
Class O			6 - 9	70	80	100	1	25	30	6	100	200		
Class I			5-6 & 9-9.5	150	150	200	1.5	50	70	10	200	400		
Class II			4-5 & 9.5-10	370	300	600	3.5	100	100	20	400	600		
Class III			<4 & >10	>370	>300	>600	>3.5	>100	>100	>20	>400	>600		

BH 12 and BH 14 currently supply water to Koingnaas



Geohydrological Impact Assessment

Figure 8.4 Electrical conductivity contour map

7.5 0 7.5 km

West Coast Resources
Koingnaas and Samsons Complex

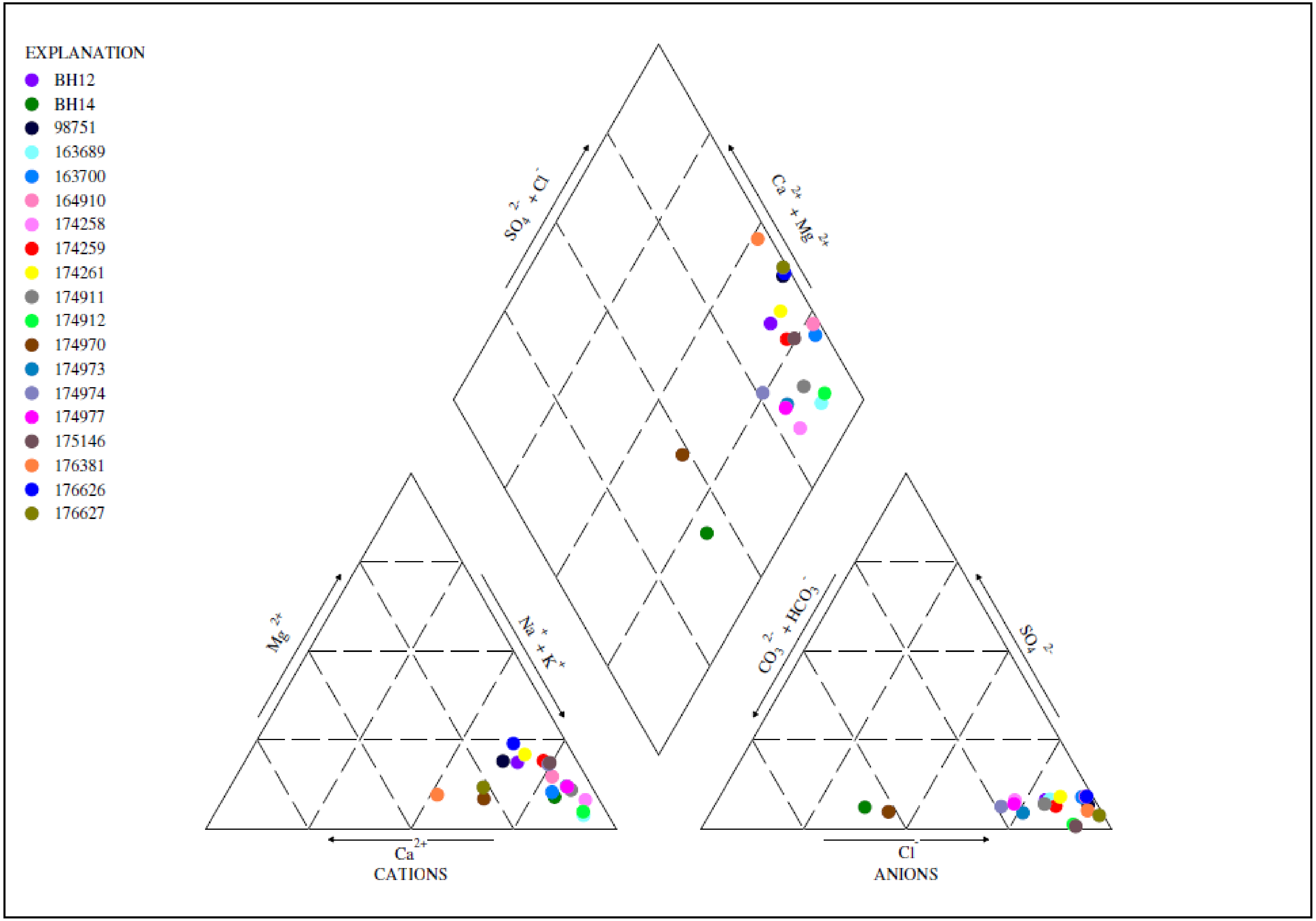


Figure 8.5 Piper diagram for the study area

9 ASSESSMENT OF IMPACT OF MINING ACTIVITIES ON GROUNDWATER RESOURCES

The potential impacts posed by the proposed mining activities on the integrity of groundwater resources at the site were evaluated according to DWS guidelines on water management for mines. The guidelines require that the impacts be evaluated for all the different phases of the mine life cycle, which comprise the following:

- Feasibility
- Construction phase
- Operational phase
- Decommissioning and closure phase
- Post closure phase (management of post closure residual and latent impacts)

For WCR the feasibility has passed. Construction and operation phases are under way.

9.1 DESCRIPTION OF MINING ACTIVITIES

9.1.1 Mining

The Koingnaas area has been extensively mined over the last 60 years. WRC is re-establishing diamond mining operations in the area previously mined by De Beers. WRC intends to mine deposits that are located on land as well as deposits that extend seawards for several hundred metres. The following mining techniques will be employed:

Land Mining Operations

This is essentially an opencast mining technique involving the stripping off of the overburden to expose the diamond bearing gravels, and excavating the gravels. The depth of excavation varies from shallow to about 20 metres below surface. Land operations will be confined to about 200 metres of the coastline. Figure 9.1 shows mining operations on the beach. Figure 9.2 shows schematic illustration of mining operations on the beach.

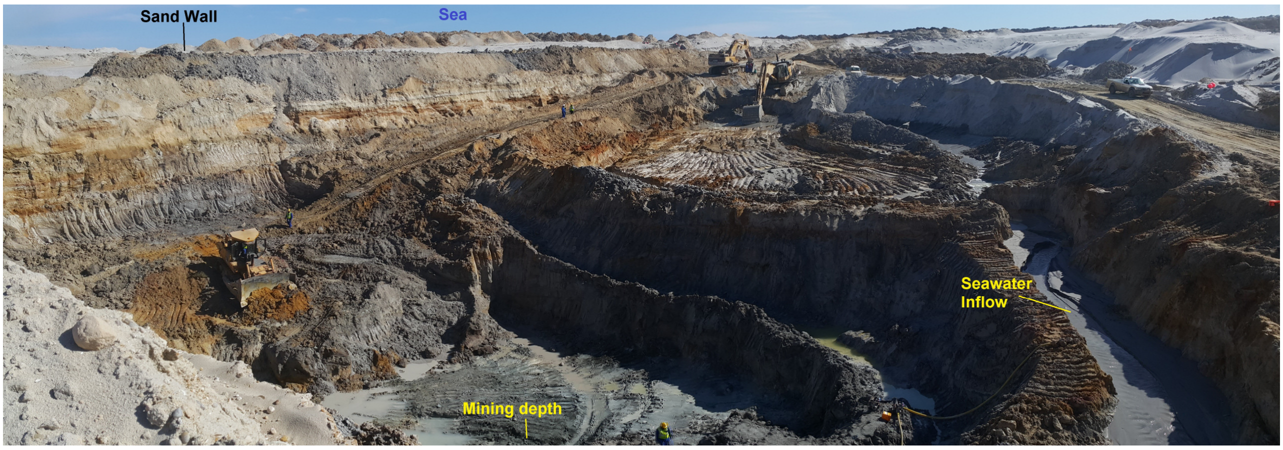


Figure 9.1 Mining operation on the beach (23/06/16)

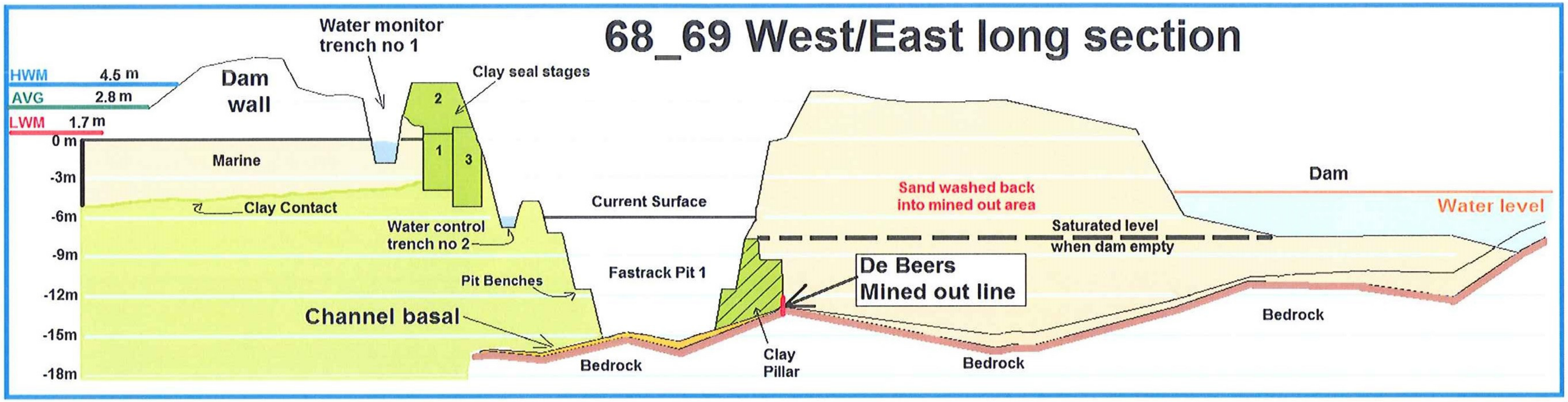


Figure 9.2 Schematic illustration of mining on the beach (Courtesy of WCR)

Marine operations.

These techniques involve pumping of diamond bearing gravels under sea water and processing them on land.

9.1.2 Processing

The diamond bearing gravels are screened and scrubbed on site to limit the volume of material hauled to the Dense Medium Separation (DMS) plants. Figure 9.3 shows a screening plant near Koingnaas. The screened fraction is transferred to the DMS plant were the diamonds are concentrated. The concentrate is then ferried to Kleinsee plant for final recovery. Seawater is used for processing and the residue from processing is disposed of in slimes dams where the solids settle out and water is returned to the sea or recycled to the plant.

Figure 9.3 WCR screening and scrubbing plant near Koingnaas.

9.2 POTENTIAL IMPACTS ON GROUNDWATER

9.2.1 Impact on groundwater Levels

Of all the mining operations, land mining has the biggest potential to impact on groundwater levels. Theoretically, as soon as mining excavation breaches the water-table, groundwater will flow into the pit thereby necessitating dewatering of the pit to facilitate mining. This in turn will have potential to deplete groundwater resources in the area, as well as trigger seawater intrusion into aquifers adjacent to the mining operations.

The risk of this happening is, however, considered negligible due to the fact that mining operations will be taking place at relatively shallow depth, generally less than 20 metres below surface; thus above the water-table. To date, no potable groundwater has been encountered within the proposed mining area. At the time of the site visit on 22 June 2016, one of the excavations was about 17 metres deep and only seawater was seeping into the pit, Plate 9.1.

9.2.2 Impact on groundwater quality

Potential negative impact on groundwater quality emanating from the mining operations relate to possible contamination of groundwater through leakage from waste containment facilities such as slimes dams and rock dumps; and from petroleum products at the workshops. The slimes dams contain seawater used during diamond processing.

Available water quality data indicate that the entire area proposed for mining is characterised by highly saline groundwater with electrical conductivity of above 1000 mS/m. This is supported by the fact that there are no water supply boreholes around, and south of Koingnaas. Potable groundwater is currently sourced from the Somnaas Noup aquifer located about 20 kilometres north of Koingnaas.

The natural groundwater quality in the proposed mining area is very poor and is not suitable for basic human needs (BHN). There is no evidence that groundwater contributes to land-based ecological systems in the proposed mining area; in the form of springs, wetlands or river baseflow in dry seasons. Contamination from the slimes dams, which contain sea-quality type water, will further degrade groundwater quality that is already very poor. As shown in Figure 8.3, groundwater ultimately discharges into the sea.

Diamond processing relies on the physical properties (mainly density and hardness) of the mineral for extraction, no chemically active substances are added, which may potentially introduce toxins. This means that the process water emerging from the process plant will have been little altered in chemical composition from its original state. The impact of such water discharging back into the sea on the marine ecology is a subject of debate, but logically, should be negligible.

The question that arises is whether it is prudent to protect a naturally degraded water resource that does not provide any benefit to both humans and ecological systems.

9.3 RISK QUANTIFICATION

An attempt was made to quantify the risk posed by mining activities on groundwater resources at the site. The significance level of the risk was determined through a synthesis of the probability of occurrence and consequence of occurrence. The assessment was based on the following factors:

- **Probability** of occurrence which describes the likelihood of the impact actually occurring and is indicated as:
    - Improbable, where the likelihood of the impact is very low;
    - Probable, where there is a distinct possibility of the impact to occur;
    - Highly probable, where it very likely that the impact will occur;
    - Definite, where the impact will occur regardless any management measure.

- **Consequence** of occurrence in terms of:
    - Nature of the impact;
    - Extent of the impact, either local, regional, national or across international borders;
    - Duration of the impact, either short term (0-5 years), medium term (6-15 years) or long-term (the impact will cease after the operational life of the activity) or permanent, where mitigation measures by natural processes or human intervention will not occur;
    - Intensity of the impact, either being low, medium or high effect on the natural, cultural and social functions and processes.

The environmental risk level is defined by a parameter called **significance points (SP),** which is calculated as follows:

SP = (magnitude + duration + scale) x **probability**

Table 9.1 shows the ranking of the factors used in the calculation of environmental risk assessment.

The maximum value of significance points (SP) is 100. Environmental effects could therefore be rated as either high (H), moderate (M), or low (L) significance on the following basis:

- More than **60** points indicates high (H) environmental significance.
- Between **30 – 60** points indicate moderate (M) environmental significance.
- Less than **30** points indicates low (L) environmental significance.

Table 9.1: Ranking of factors for the quantitative environmental risk assessments

PROBABILITY = P 5 – Definite / don't know 4 – High probable 3 – Medium probability 2 – low probability 1 – Improbable 0 – None	**DURATION = D** 5 – Permanent 4 – Long-term ceases with operational life) 3 – Medium-term (5 – 15 years) 2 – Short-term (0-5 years) 1 – Immediate
SCALE = S 5 – International 4 – National 3 – Regional 2 – Local 1 – Site 0 – None	**MAGNITUDE = M** 10 – Very high / Don't know 8 – High 6 – Moderate 4 – Low 2 – Minor

9.3.1 Risk on groundwater levels and groundwater quantity

The significance of risk of mining activities impacting negatively on groundwater levels, consequently quantity, was determined from the following factors:

Probability	=	2 (low)
Scale	=	2 (local)
Duration	=	2 (short term)
Magnitude	=	4 (low)

The **SP** was calculated as follows: **SP = (4+ 2+ 2) x 2 = 16**

The SP of 16 points indicates very low risk.

9.3.2 Risk of groundwater contamination

The same factors used for groundwater levels above also apply to the risk of groundwater contamination. The risk of groundwater contamination is therefore very low too.

10 CONCLUSION

The conclusion is based entirely on the evaluation of existing data coupled with a hydrocensus. No new boreholes were drilled in this investigation.

The main conclusion derived from the assessment is that the proposed diamond mining activities will very small negative impact on groundwater resources for reasons listed below:

- Mining excavations will be limited to shallow depths of less than 20 metres below surface, by most probability above the water-table.
- The natural or ambient groundwater quality in the proposed mining area is of very poor quality; hence further degradation through contamination by sea-quality water will not make a big difference.
- Diamond processing relies on the physical properties of the mineral, no active chemicals with potential to introduce toxins are added. This means that the process water emerging from the plant will have been little altered in chemical composition from its original state. The impact of contaminated groundwater discharging into the sea on the marine ecology is currently a subject of debate, but logically, should be negligible.

The study was not exhaustive and definitive as it was based entirely on existing data. No primary data were generated in this study. The presence or absence of potable groundwater in the proposed mining area needs further investigation by way of siting and drilling exploratory boreholes in the 500 metre wide coastal strip of the mining area.

11 RECOMMENDATIONS

The investigation provided a preliminary understanding of the groundwater situation at the site. The recommendations seek to ensure the mine complies with the relevant government legislation, particularly the National Water Act of 1998. To this end, the following recommendations are made:

- Site and drill at least five exploratory boreholes in the strip of land along the coast, extending 500 metres inland; and at least 100 metres from the sea edge. Siting of the boreholes should employ geophysical survey techniques to increase the chances of locating geological structures that influence groundwater flow such as faults, fracture zones and dykes. Electromagnetic (EM), magnetic, and electro-seismic techniques are recommended in this regards. The approximate positions of the geophysical survey lines are shown in Figure 11.1, and their coordinates are given in Table 11.1. A single borehole will be drilled on the strongest geophysical anomaly on each survey line. In other words, the borehole may be located anywhere along the survey line. The survey positions will be refined in the field based on local conditions encountered during the survey.
- Place some of the boreholes down-stream of the slimes dams so that they can also function as monitoring boreholes, should potable groundwater be found.
- Electrical conductivity of all water strikes should closely be monitored to identify possible pockets of fresh water.
- Water quality parameters to be analysed for should include but not limited to the following: pH, EC, TDS, Ca, Mg, Na, K, Fe, Mn, Cu, Pb, Zn, Cd, Cr, CL, SO_4, F, NO_3, PO_4, CO_3, and HCO_3. Sampling should be carried out quarterly.
- All waste containment facilities must be lined with impermeable or low permeability material. Common lining materials include clay, concrete and HDPE liners; the latter two being expensive

Table 11.1 Coordinates of the geophysical survey lines

Description	Survey Line Start		Survey Line End	
	Latitude	Longitude	Latitude	Longitude
Line 1	-30.17798	17.22652	-30.20684	17.23736
Line 2	-30.22997	17.25068	-30.25405	17.26331
Line 3	-30.26643	17.26878	-30.29375	17.28099
Line 4	-30.36572	17.30711	-30.39005	17.32077
Line 5	-30.40687	17.33802	-30.43624	17.35458

Should however, no fresh groundwater be found on the properties, then the Department of Water and Sanitation should be engaged to discuss the logic of protecting naturally degraded water quality that does not support both basic human and ecological needs.

Geohydrological Impact Assessment

Figure 11.1 Location of geophysical survey lines

West Coast Resources
Koingnaas and Samsons Complex

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APPENDIX (I)

CV for Andrew Mavurayi

CURRICULUM VITAE
for

ANDREW MAVURAYI

TITLE:	Principal Hydrogeologist
EDUCATION:	MSc Hydrogeology (University College London, England) 1989 BSc Chemistry & Geology (University of Zimbabwe) 1984
TRAINING:	Groundwater flow and transport modelling, 2007
SPECIALISATION:	☐ Groundwater Resource Assessment and Development, ☐ Groundwater Contamination Assessment ☐ Groundwater Protocols ☐ Implementation of Resource Directed Measures (RSA Water Act) ☐ Groundwater seepage studies and Mine Dewatering ☐ Land stability studies in dolomites ☐ Groundwater Flow and Transport Modelling ☐ Water related disaster risk assessment ☐ Hydrogeological input in Environmental Impact Assessments ☐ Project Management

EMPLOYMENT HISTORY

2010 – Present	**Waters Without Frontiers** Principal Hydrogeologist
2002 – 2010	**Department of Water Affairs and Forestry; Chief Directorate: Resource Directed Measures.** Internal Consultant: Hydrogeologist
2000 – 2002	**Jeffares Green and Parkman Consulting Engineers** Senior Hydrogeologist
1995 – 2000	**Steffen Robertson and Kirsten Consulting Engineers** Senior Hydrogeologist
1991 – 1995	**Geoflux Groundwater Consultants (Botswana)** Senior Hydrogeologist
1885 – 1991	**Department of Water Affairs (Zimbabwe)** Junior to Senior Hydrogeologist

Department of Water Affairs and Forestry, RDM Directorate - Groundwater water Resource management; - Implementation of Resource Directed Measures (RDM).

- RDM assessment and determinations in support of groundwater use licence evaluations.
- Technical support to the Directorate: RDM on groundwater related matters.
- Provision of training in Resource Directed Measures perspectives and processes.
- Review of high confidence level RDM studies

Associated tasks:

- Assessment of groundwater resources in quaternary catchments'
- Determination of groundwater recharge in quaternary catchments
- Estimation of baseflow from streamflow hydrographs
- Determination of ecological requirements of rivers dependent on groundwater
- Determination of ambient groundwater quality in quaternary catchments, and consequently Reserve Requirements.

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Etruscan Diamond Mine Geohydrological Study, 2008: Geohydrological study in support of an intergrated water use licence application by Etruscan Diamond Mine in the North west Province.

Metsweding Municipality Geohydrological Study, 2008: Geohydrological study for the establishment of a regional cemetery for Metsweding Municipality near Ekandustria in Gautent Province.

Orascom Cement Plant Geohydrological Study, 2007 : Geohydrological study to assess the availability of groundwater for use in the proposed cement plant by Orascom Construction near Mafikeng, North West Province.

Hillendale Mine Groundwater Modelling Study, 2008 Groundwater flow model for the Department of Agriculture (RSA) to investigate the possibility of sand-dune mining for heavy metals using water blasting by Hillendale Mine inducing seepage observed in houses located downstream of the mine.

Zululand District Municipality, 2006: Geohydrological assessment for the water supply to the villages of Ntababomvu and Strathcona in the Emondlo regional area, northern KwaZulu-Natal.

Thembisile Local Municipality, 2005 : Water related disaster management plan for Thembisile Local Municipality, Mpumalanga.

Machadodorp Municipality, 2004: Geohydrological assessment for the closure of a waste disposal site at Machadodorp for Machadodorp Municipality.

Mopane District Municipality, 2005: - Limpopo Province - Rural Village Water Supply: - Location and development of groundwater resources to feed into proposed water supply schemes for Mbawula, Mnghonghoma, Hlaneki and Gon'on'o Villages.

Umgeni Water Rural Schools Water Supply, 2004: - Interpretation of pumping test data from boreholes earmarked for equipment with play pumps.

2001 – 2002 **Aquamanzi Developments**
Senior Hydrogeologist

Zululand Rudimentary Rural Water Supply sub-contracted to AquAmanzi: Development of groundwater resources for basic water supply to rural communities in Zululand.
Managed and coordinated the following activities:

- Identification of existing water sources (boreholes and springs) and supervision of their rehabilitation
- Siting of new boreholes
- Drilling and pumping test supervision
- Spring protection design and supervision
- Water quality sampling and evaluation
- Capture of field data, processing and report writing
- Rural Sanitation: Groundwater protocols – Groundwater contamination risk assessment.
- Indaleni Phase II Water Supply project: Comprehensive hydrogeological investigation with a view to providing a standby water supply borehole for Indaleni Village and new water supply boreholes for Simozomeni.
- Mandlakazi and Hlahlindlela Sanitation - Groundwater Protocols

2000 - 2001 **KLM Consulting Services**
Senior Hydrogeologist

Finsch Mine and Jwaneng Mine dewatering investigation. Hydrogeological investigations for the design of effective mine dewatering systems. Groundwater modelling codes Visual Modflow and Minedew were employed.

1998 - 2000 **SRK Consulting Engineers - Johannesburg**
Senior Hydrogeologist

Karbochem, New Castle. Evaluation of potential ground water inflow into a cut-off trench intended to intercept ground water flow and lower the water table to facilitate construction of waste disposal dams.

AECI Umbogintwini Slimes Dam Dewatering Project, Durban: Establishment of a network of boreholes in slimes dams to facilitate vertical drainage in the dams and speed up dewatering of the slimes dams. Ground water sampling and hydrochemical analysis.

Ga-Pila Relocation Project, Potgietersrus: Evaluation of ground water resources with a view to supplying water to the relocated residents of Gapila Village on Farm 229KR Sterkwater. The relocation was necessitated by the planned expansion of Potgietersrus Platinum Mine, a division of Anglo American Corporation Limited.

Due diligence and environmental audits for Northam Platinum Mine, St Helena Gold Mine and President Steyn Mine. Emphasis was placed on liabilities arising from ground water problems such as mine flooding, effects of mine dewatering on the regional groundwater resources and potential ground water contamination due to mining activities.

Messina Platinum Mine, Zebediela: - Hydrogeological input for Environmental Impact Assessment (EIA) and feasibility study. Scope of work included estimation of potential groundwater inflows; evaluation of potential effects of dewatering on regional ground water resources; evaluation of potential contamination of ground water by mining activities.

Doe Run Exploration, Grikwatown: Hydrogeological investigation as part of a feasibility study to open a lead and zinc mine. Scope of work as above and included an evaluation of potential water supply from ground water.

Impala Platinum Mine, Rustenburg. Precementation evaluation of three shafts, No 1, No 11B and No 11C to minimize ground water inflow into the shafts. Investigations included water injection (packer) tests to determine permeability of formations; grouting around the proposed shaft to reduce ground water inflow to the shaft.
Gheita Mine, Tanzania. Estimation of potential ground water inflow into proposed open mining pits using appropriate ground water flow analytical methods.

Mondi Kraft, Piet Retief. Ground water investigation as part of an application for the closure of a waste disposal site. Characterisation of aquifers and delineation of the extend of contaminant migration.

Dwaalboom Venture. Ground water resource assessment for water supply to the proposed new gold mine for Cluff Minerals. Evaluation of the ground water contamination potential from mining activities. Prediction of potential groundwater inflow into the proposed mine.

AFFILIATIONS

Registered Professional Natural Scientist with SACNS (PrSciNat).
Member of International Association of Hydrogeologist
Member of Ground Water Division of the Geological Survey of South Africa.
Member of the Borehole Association of Southern Africa.

PUBLICATIONS

Evaluation of geophysical survey techniques for borehole siting over crystalline hard rocks in Masvingo Province, Zimbabwe, as thesis submission for an MSc Degree in Hydrogeology at University of London, 1989.

"**Groundwater Assessement from the Resources Directed Measures Perspective"** presented at the Biennial Groundwater Conference on 7th to 9th of March 2005 at the CSIR in Pretoria, RSA, organized by the Groundwater Division of the Geological Society of South Africa.

"Unpacking The Groundwater Reserve" **Presented at the International Conference On Groundwater under the theme: Our Source Of Security In An Uncertain Future. 19 – 21 September 2011 : CSIR International Convention Centre, Pretoria, South Africa.**

Groundwater Resource Directed Measures, 2012. I Dennis, K Witthusser, K Vivier,R Dennis and A.Mavurayi Water Research Commission project :K8/891, Pretoria.

EXPERIENCE

DATE	PROJECT	C
July 2015	Geohydrological Impact Assessment for the Proposed New Tailings Dam and Extension of the Rock Dump at Millsell Section, in Terms of the National Water Act of 1998 (Act N0. 36 of 1998)	Samanc Chrome Ltd
May 2015	Geohydrological Impact Assessment For the Proposed Gold Mine on the Farm Batavia 176 KP in the Thabazimbi Local Municipality, Limpopo Province.	Myezo Environ Services
April 2015	Water Use Licence Conditions Compliance Audit For Mining Operations At Millsell And Waterkloof Sections, In Terms Of The National Water Act Of 1998 (Act N0.36 Of 1998)	Samanc Chrome Ltd
November 2014	Report On Compliance With Gn-704 Of The National Water Act, 1998 (Act N0.36 Of 1998) for SamancorCr Mooinooi Section.	Samanc Chrome Ltd
September 2014	Geohydrological Impact Assessment For The Proposed Oogiesfontein Colliery near Ogies, Malahleni District, Mpumalanga Province	Headwa Envirom Consulti
August 2014	Geohydrological Impact Assessment for the rehabilitation of the Hernic Open Cast Pit at Samancor Mooinooi Section, Northwest Province	Samanc Chrome Ltd
May 2014	Geohydrological, hydrological and wetland impact assessment for the proposed Panfontein Coal Mine near Vereeniging, Gauteng Province	TTH Env Consulti
April 2014	Geohydrological impact assessment for Elexkor Diamond Mine in support of an integrated water use licence application.	Alexkor Mine
May 2013	Geohydrological Impact Assessment for the Koi Koi Crushers Project near Mafikeng for Enermin Africa (Pty) Ltd. Mafikeng Local Municipality, North West Province. Report No: min/2013/006	Myezo Environ Services

DATE	PROJECT	CLIENT	CONTACT
March 2013	Geohydrological impact assessment for the proposed Mafikeng Cement, Northwest Province. Ref: ENV/2011/010	Myezo Environmental Services	Babalwa Fatyi 0827722418
March 2012	A Groundwater Protocol For On-Site Sanitation Programme - Mmakaunyane village, Northwest Province	Desema Consulting Engineers on behalf of DWA	Piet Sepoloane 0795071712
February 2013	Geohydrological Impact Assessment for the Coal Processing Plant near Ogies for Just Coal cc. Mpumalanga Province	Kimopax (Pty) Ltd	Charles Chigurah 0790626318
January-12	Review of the Intermediate Groundwater Reserve determination for the Limpopo Water Management Area	DWA	Nancy Motebe 0123368073
July 2011	Geohydrological Impact Assessment on the site for the Chrome Beneficiation Plant on the remaining Portion of Portion 181 {a Portion of Portion 2} of the Farm Zandfontetn 447 JQ, Madibeng Local Municipality	Elgagen Chrome	Grant 0822945621
June 2011	Geohydrological Impact Assessment on the site for the Chrome Beneficiation Plant on Portion 86 of the Farm Hartebeestfontein 445 JQ, within Madibeng Local Municipality. EIA/2011/006	Rockstar Trading/CDF Chrome	Philip Stander 0845100997
April 2011	Report on the Geohydrological Impact Assessment conducted at the site of the proposed Remhoogte Diamond Mine. Report No: Min/2011/008	Transhex (Pty) Ltd	Babalwa Fatyi 0827722418
Óctober 2010	Impact Assessment conducted at De Punt Mine, Western Cape. Report No: Min/2010/005	Transhex (Pty) Ltd	Babalwa Fatyi 0827722418
September 2010	Report on the Geohydrological Impact Assessment conducted for the Mooinooi Section of Samancor Western Chrome Mines. Report No: Min/2010/004	Samancor Western Chrome Mines, Via Vuka Africa Consulting Engineers.	Mpho Mokone 0733522256

DATE	PROJECT	CLIENT	CONTACT
Áugust 2010	Report on the Geohydrological Impact Assessment conducted for the Millsell Section of Samancor Western Chrome Mines. Report No: Min/2010/003	Samancor Western Chrome Mines, Via Vuka Africa Consulting Engineers.	Mpho Mokone 0733522256
July 2010	A Groundwater Protocol For On-Site Sanitation Programme: Upper Setlagole And Thutlwane Villages. Report GWP/2010/001	RE A Aga Progects	Tendai Manasani 0836327960
June 2010	Preliminary Geohydrological Investigation for the Proposed Kwa-Ceza Mountain Colliery near Vryheid in KwaZulu-Natal Province. G & C Shelf 141 (Pty) Limited. Report No: min/2010/002. REPORT No: MIN/2010/001	Bembani Sustainability Training (Pty) Ltd	Victor Siphugu 0844608001
May 2010	Preliminary Geohydrological Investigation For The Proposed Van Ouds Colliery At Ermelo In Mpumalanga Province. Phase 1. Report No: Min/2010/001	Mazolo Holdings (Pty) Ltd	Victor Siphugu 0844608001
April 2010	Groundwater Investigation. Bulk Water Supply To Dithakong Village, North West Province. Pumping Test Report. Report No: WAT/2010/001	Mafikeng Municipality	Tendai Manasani 0836327960
December 2009	Preliminary Groundwater Assessment For Wards 1, 2 & 3 Of Albert Luthuli Municipality For The Augmentation Of Water Supply To The Methula Water Treatment Works. Report No: Min/2010/001.	Lebea & Maduna Civil Engineering Consultants	Lebea 0711306942
October 2009	A Groundwater Protocol For On-Site Sanitation Programme. Rysmierbult Village. Report No: Carlt/001	Vuka Africa Consulting Engineers	Hary Mtshweni 0833062139
July 2009	Geohydrological Study For The Proposed Filling Station At Molatedi Village, Northwest Of Rustenburg, North West Province. Report No: Env/003	Lesheka Environmental Consulting	Lesego Senna 0837637854 0186421680
April 2009	Geohydrological Study For Water Supply To Six Villages In The Area Of Jurisdiction Of Moses Kotane Local Municipality, North West Province. Report No: Wat/2009/02.	Re A Aga Projects	Tendai Manasani 0836327960
March 2009	Geohydrological Study For Integrated Water And Waste Management Plan (Iwwmp) For Sishen Mine. Report No: min/2009/001	Bembani Sustainability Training (Pty) Ltd	Lekau Hlabolwa 0716753196
February 2009	Assessment Of Water Availability In Selected Villages In Ward 1. Local Municipality Of Madibeng. Report No: WAT/2009/01	Vuka Africa Desema Joint Venture	Piet Sepoloane 0795071712

DATE	PROJECT	CLIENT	CONTACT
October 2008	Geohydrological Study For The 'Proposed Expansion Of Cemeteries At Lehurutshe 'And Ikageleng Near Zeerust, 'North West Province 'Report No: ENV/002	Lesheka Environmental Consulting	Lesego Senna 0837637854 0186421680
September 2008	Geohydrological Study For The Proposed Filling Station On Stand Jo 301 Of Mmabatho Town & Townlands, West Of Mmabatho, North West Province. Report No: ENV/001	NIAGARA PROPERTY DEVELOPMENT	Lesego Senna 0837637854 0186421680
September 2008	Groundwater Flow Modelling. Hillendale Mine Groundwater Seepage Problem. Department Of Agriculture, Empangeni.	DEPARTMENT OF AGRICULTURE	Joseph Mukumba 0333433581
June 2008	Geohydrological Study For The Proposed Cemetery On Portions 63, 68 And 70 Of The Farm Leewfontein 487 Jr Near Ekandustria, Gauteng Province. Metsweding District Municipality. Report No: ENV/001.	Metsweding District Municipality	Hary Mtshweni 0833062139
February 2008	Siting Of The Proposed Water Supply Boreholes For The Villages Of Olifantsfontein, Dryden And Brakfontein In The Delnmas Area. Delmas Local Municipality. Report No: 2008/003	P Square Consulting Engineers	Hamilton 0725627824
January 2008	A Groundwater Protocol For On-Site Sanitation Programme. Kanana Village. Rustenburg Local Municipality. Report No: RUST/001.	Vuka Africa Consulting Engineers	Hary Mtshweni 0833062139
October 2008	Geohydrological Study For The 'Proposed Expansion Of Cemeteries At Lehurutshe 'And Ikageleng Near Zeerust, 'North West Province 'Report No: ENV/002	Lesheka Environmental Consulting	Lesego Senna 0837637854 0186421680
September 2008	Geohydrological Study For The Proposed Filling Station On Stand Jo 301 Of Mmabatho Town & Townlands, West Of Mmabatho, North West Province. Report No: ENV/001	NIAGARA PROPERTY DEVELOPMENT	Lesego Senna 0837637854 0186421680
June 2008	Geohydrological Study For The Proposed Cemetery On Portions 63, 68 And 70 Of The Farm Leewfontein 487 Jr Near Ekandustria, Gauteng Province. Metsweding District Municipality. Report No: ENV/001.	Vuka Africa Consulting Engineers	Hary Mtshweni 0833062139

DATE	PROJECT	CLIENT	CONTACT
March 2008	Review Of The Groundwater Situation At Etruscan Diamond Mine North Of Ventersdorp. Report No: 2008/002	Etruscan Diamonds Mine	Simon Netshiozwi 0834532809
February 2008	Siting Of The Proposed Water Supply Boreholes For The Villages Of Olifantsfontein, Dryden And Brakfontein In The Delnmas Area. Delmas Local Municipality. Report No: 2008/003	P Square Consulting Engineers	Hamilton 0725627824
August 2007	Geohydrological Investigation. Eloff Waste Transfer Station. Report No: Eloff/001/07	Delmas Local Municipality	Daniel Kalombo 0824587294
July 2007	Evaluation of the stability of the site for a Filling Station with respect to features assosciated with dolomite at Moleleki Extension 2	Pule Mogwane	Pule Mogwane 0731622517
May 2007	Holfontein Coal Project. Preliminary Geohydrological Investigation - Phase 1. Report No: GW/GVM/001.	GVM Metals Limited	Cliff Lewis 0845598007
November 2006	Mutale Local Municipality Emergency Rural Village Water Supply. Preliminary Report On Geopysical Survey For Borehole Siting At The Villages Of Tshifume, Dzamba, Tshaanda And Mukondeni.	Chidaya Consulting Engineers	Phaskani Msiska 0721966562
March 2005	Test Pumping Of Boreholes To Evaluate The Potential Of Water Supply From Groundwater To The Villages Of: Munghonghoma, Hlaniki/Gon'on'o, Mbawula And Gawula. Mopane District Rural Village Water Supply Project	Kgatelopele Consulting Engineers	Fumu Msiska 0834479831