GEOHYDROLOGICAL DESKTOP SCREENING FOR THE GROMIS-NAMA-AGGENEIS 400KV INTEGRATION, SPRINGBOK, NORTHERN CAPE PROVINCE

NOVEMBER 2019

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19 NOVEMBER 2019

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It is our pleasure to include one electronic copy of the report.
We trust that the report will meet your expectations.

Please feel free to contact me should you have any enquiries or suggestions.

Yours sincerely.

J.W. HAUMANN
(M.Sc. Pr.Sci.Nat.)

Copies: One (1) electronic copy to ENVIROWORKS (PTY) LTD.

SPECIALIST STATEMENT DETAIL

This statement has been prepared with the requirements of the Environmental Impact Assessment Regulations and the National Environmental Management Act (Act 107 of 1998), any subsequent amendments and any other relevant National and / or Provincial Policies in mind.

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Expertise / Field of Study: BSc Environmental Geography, Hons Geohydrology, MSc Geohydrology, consultant from 2015 to present.

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I, Mr. Kobus Haumann declare that this report has been prepared independently of any influence or prejudice as may be specified by the National Department of Environmental Affairs

PREPARED

Signed:  Date: 19 NOVEMBER 2019

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

GLOSSARY GEOHYDROLOGICAL TERMS AND ACRONYMS	
GEOHYDROLOGICAL TERMS	DEFINITIONS
Aquiclude	An aquiclude is an impermeable geological unit that does not transmit water at all. Dense unfractured igneous or metamorphic rocks are typical aquiclude.
Aquitards	An aquitard is a geological unit that is permeable enough to transmit water in significant quantities when viewed over large and long periods, but its permeability is not sufficient to justify production boreholes being placed in it. Clays, loams and shales are typical aquitards.
Borehole census	A field survey by which all relevant information regarding groundwater is gathered. This typically includes yields, borehole equipment, groundwater levels, casing height/diameter, co-ordinates, potential pollution risks, photos etc.
Confined Aquifer	A confined aquifer is bounded above and below by an aquiclude. In a confined aquifer, the pressure of the water is usually higher than that of the atmosphere, so that if a borehole taps the aquifer, the water in it stands above the top of the aquifer, or even above the ground surface. We then often speak of a free-flowing or artesian borehole.
Diffusivity (KD/S)	The hydraulic diffusitivity is the ratio of the transmissivity and the storativity of a saturated aquifer. It governs the propagation of chances a hydraulic head in the aquifer. Diffusivity has the dimension of Lenght^2/Time
Hydraulic Conductivity (K)	The hydraulic conductivity is the constant of proportionality in Darcy's Law. It is defined as the volume of water that will move through a porous medium in a unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.
Leaky Aquifer	A leaky aquifer or semi-confined aquifer, is an aquifer whose upper and lower boundaries is aquitards, or one boundary is an aquitard and the other is an aquiclude. Water is free to move through the aquitards, either upwards or downwards. If

	a leaky aquifer is in hydrological equilibrium, the water level in a borehole tapping it may coincide with the water table.
Porosity	The porosity of a rock is its property of containing pores or voids. With consolidated rocks and hard rocks, a distinction is made between primary porosity, which is present when the rock is formed and secondary porosity, which develops later as a result of solution or fracturing.
Specific Yield (S_y)	The specific yield is the volume of water that an unconfined aquifer releases from storage per unit surface area or aquifer per unit decline of the water table. The values of the specific yield range from 0.01 to 0.3 and are much higher that the storativities of confined aquifers.
Storativity (S)	The storativity of a saturated confined aquifer of thickness D is the volume of water released from storage per unit surface area of the aquifer per unit decline in the component of hydraulic head normal to that surface.
Storativity Ratio	The storativity ratio is a parameter that controls the flow from the aquifer matrix blocks into the fractures of a confined fractured aquifer of the double-porosity type.
Susceptibility	A qualitative measure of the relative ease with which a groundwater body can be potentially be contaminated by anthropogenic activities.
Sustainable Yield	The yield calculated from aquifer test pumping by a professional geohydrologist. The yield refers to the recommended abstraction rate and pumping schedule for continues use.
Transmissivity (KD or T)	Transmissivity is the product of the average hydraulic conductivity K and the saturated thickness of the aquifer D. Consequently, transmissivity is the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer.
Unconfined Aquifer	An unconfined aquifer, also known as a water table aquifer, is bounded below by an aquiclude, but is not restricted by any

	confining layer above it. Its upper boundary is the water table and is free to rise and fall.
Recharge	Groundwater recharge or deep drainage or deep percolation is a hydrologic process where water moves downward from surface water to groundwater. This process usually occurs in the vadose zone below plant roots and is often expressed as a flux to the water table surface. Recharge occurs both naturally and anthropologically, where rainwater and or reclaimed water is routed to the subsurface.
Vulnerability	The likelihood for contamination to reach a specified position in a groundwater system after introduction at some location above the uppermost aquifer.
GEOLOGICAL TERMS	
Argillaceous rock	A type of sedimentary rock that contains a substantial amount of clay or clay-like compounds
Fault (Brittle Shear)	A planar fracture or discontinuity in a volume of rock, across which there has been significant displacement along the fractures as a result of earth movement
Intrusive rock	Rock that formed due to the cooling of magma that forced its way into fractures and cavities of other rock types without reaching the surface.(usually large crystal sizes)
Metasedimentary Rock	A sedimentary rock that appears to have been altered by metamorphism.
Sedimentary rock	A type of rock that formed by sedimentation material on the earth surface or in water bodies
Shear Zone	A shear zone is a structural discontinuity surface in the Earth's crust and upper mantle which forms as a response to inhomogeneous deformation partitioning strain into planar or curviplanar high-strain zones.

1 INTRODUCTION

Sustainable GeoHydrological Solutions (PTY) LTD was appointed by **Enviroworks (Pty) Ltd** to perform a desktop geohydrological investigation as a screening process for the proposed Gromis-Nama-Aggeneys 400 kV line and establishment of a 400/132 kV yard at Nama substation within the Northern Cape Province, South Africa. This project will help Eskom ensure that the Namaqualand network is compliant and there is sufficient line capacity to evacuate potential IPPs within the Namaqualand area. An end total of three alternative corridors was proposed for investigation (alternative 1, 4 and 5) after a Strategic Environmental Assessment was undertaken by CSIR.

Proposed layout alternatives are situated across multiple quaternary catchments such as F30D, F30E, F30C, F30Fto F30G, D82D and D82C of the Lower Orange Water Management Area (LOWMA) and falls within the Pella to Alexander Bay sub-catchment area. This desktop screening process will be incorporated as part of an Environmental Impact Assessment (EIA) to determine associated impacts on the local groundwater regime.

This investigation intends to asses provided location extents, focusing on local groundwater vulnerability connected to the proposed development.

2 LIMITATIONS

The statements, opinions, and conclusions contained in this report are based solely upon the services rendered by Sustainable Geohydrological Solutions (PTY) LTD as described in this report, the scope of work as established for the report, and in accordance with our proposal. In performing these services and preparing the report, Sustainable Geohydrological Solutions (PTY) LTD relied upon the information provided by others, including public agencies, whose information is not guaranteed by Sustainable Geohydrological Solutions (PTY) LTD. No indications were found during our investigations that information contained in this report as provided to Sustainable Geohydrological Solutions (PTY) LTD, was false.

This report is based on conditions encountered and the information reviewed at the time of the site investigations. Sustainable Geohydrological Solutions (PTY) LTD disclaims responsibility for any changes that may have occurred after this time or any error in the analytical results received from the laboratory. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

3 LOCATION AND SCOPE OF WORK

The study area is situated within the Northern Cape Province, South Africa, with an overall extension from the towns Kleinsee, Springbok to Aggeneys. The study area also falls within the extent of the Khai-Ma and Nama Khoi Local Municipalities.

The initial geohydrological investigation entails:

- A desk study to collect background information regarding climate, rainfall, geology, geohydrology, and aeromagnetic structures within the proposed development area. This information will aid in conforming calculated decisions regarding the development of the proposed project with respect to possible associated impacts on the local groundwater regime.
- A site investigation will follow hereafter, assessing the information collected during the desktop analysis phase.
- Compilation of a desktop geohydrological screening report.

4 WATER MANAGEMENT AREA (WMA)

The investigated site forms part of the Lower Orange WMA (LOWMA) which is dominated by the Orange River, with few perennial tributaries and several episodic tributaries. It forms the lower reaches of the larger Orange River Basin but excludes the Vaal River Basin. The Lower Orange River is unique in that it is over 1000 km long, from the confluence of the Orange with the Vaal to a point where it becomes an estuary at Alexandra Bay and eventually meets the South Atlantic Ocean. For about half this distance if forms the main border with Namibia which necessitates a careful look at international obligations.

The topography of the LOWMA is such that it is largely flat, with large pans or endorheic areas that do not contribute significant runoff to the Orange River system. For this reason, communities and activities that exist out of logistical reach of the main stem of the river rely heavily on groundwater supplies.

In the west of the WMA are the rocky and barren Richtersveld Mountains and the north is covered by Kalahari sands. Complex geology exists south and westwards of the Orange River, with a variety of rich mineral deposits and shallow, rocky soils. The area in and around the Lower Orange WMA is typically characterized by four desert systems, three of which drain into the Orange (UNDP, 2007): the Succulent Karoo, Nama Karoo (receiving mainly summer rainfall and comprising numerous vegetation types) and the Southern Kalahari (consisting of a deep layer of windblown sand with little run-off from rainfall). The Namib desert system which does not drain into the Orange River Basin, is the driest of the four, forming a narrow strip along the Atlantic coast (GDC, 2009).

The study area extends across catchment areas F30D, F30E, F30C, F30Fto F30G, D82D, and D82C, forming part of the LOWMA. The LOWMA can be subdivided into four Sub-WMAs such as [Area1] Douglas to Boegoeberg Dam, [Area2] Boegoeberg Dam to Kanoneiland, [Area3] Kanoneiland to Pella and [Area4] Pella to Alexander Bay, with the study area forming part of the latter as presented in Figure 1. Determinants, threats, and constraints of [Area4] Pella to Alexander Bay are presented in Table 1 were relevant threats include a decrease in water quality and quantity. Land uses within the LOWA are represented in Table 2.

Table 1: Determinants, threats, and constraints of [Area4] Pella to Alexander Bay.

Strength	Determinant	Threat	Constraint
Ecology	Reserve Determination: Aquatic Biota, Riparian Veg, Instream habitat	Agriculture, sewage, regulation of system, prospecting and tourism (destruction of rip habitat), stock farming, mining, invasive species, illegal fishing	No high confidence Reserve, no consistent biomonitoring
Ecotourism	Established industries	Decreased water quality and quantity,	Lack of control
Conservation	Formalisation of conservation parks, transfrontier initiatives, TFCA, ARTP treaty	Unsustainable land use practices, decreased water quality and quantity	Financial and human resources, lack of co-operative governance

Table 2: Land uses identified in the four geographic areas

[Area 1] Douglas to Boegoeberg	[Area 2] Boegoeberg to Kanon Islands	[Area 3] Keimoes to Pella	[Area 4] Pella to Alexander Bay
Sheep and goat farming.	Sheep and goat farming, including feedlots.	Sheep and goat farming.	Stock farming and ostrich farming.
Irrigation Farming (banks of Orange, Vaal and Riet Rivers): table grapes, vineyards, mielies, wheat, potatoes, Lucerne.	Irrigation Farming (banks of Orange): Table grapes, vineyards, dried fruit.	Irrigation Farming (banks of Orange): vineyards for wine and table grapes, watermelons, spanspek. Also dried fruit production.	Irrigation Farming (banks of Orange): vineyards, Hoodia, dates, paprika, tomatoes.
Diamond mining and prospecting.	Diamond mining and prospecting.	Diamond prospecting and base metal mining.	Alluvial diamond prospecting and larger-scale alluvial diamond mining at Kleinsee, Alexander Bay and Hondeklipbaai. Also semi-precious gems and quartzite mining.
Douglas conservancy	Conservation areas (Spitskop)	Conservation areas (Augrabies Falls National Park) and eco-tourism.	Conservation areas (/Ai-/Ais-Richtersveld Transfrontier Park) and eco-tourism. Including RAMSAR site at Alexander Bay Estuary.
Interest groups – Farming, Fishing.	Interest groups – Farming, Fishing.	Interest groups – Farming, Fishing.	Interest groups – Farming, Fishing, Recreation/ Canoeing.
	Urban infrastructure: airport, fuel depot, golf course, casino, salt works.	Industries: Game farming and salt works.	Recreation

4.1 WMA Climate

The LOWMA area is largely arid and experiences a harsh climate. It has the lowest mean annual rainfall in the country, varying from 400mm in the east to 50mm per annum on the west coast. Area 1 receives between 200 and 300mm of rainfall per annum, whereas, moving westwards, Sub-Areas 2, 3 and 4 largely receive between 0 and 100m per annum. Potential evaporation can reach 3 000mm per year.

4.2 WMA Groundwater

Groundwater utilization is of major importance across wide areas in the LOWMA and often constitutes the only source of water. It is mainly used for rural domestic supplies, stock watering, and water supplies to towns off the main stem of the Orange. These resources must be properly managed and developed. As a result of the low rainfall, recharge of groundwater is limited and only small quantities can be abstracted on a sustainable basis. Aquifer characteristics (borehole yields and storage of groundwater) are also typically unfavorable because of the hard geological formation underlying most of the water management area.

In the Orange Tributaries sub-area, 60% to 70% of the available water is supplied from groundwater sources. Groundwater also constitutes an important source of water for rural water supplies in the Orange River, although only a small proportion of the total available water. Much of the groundwater abstracted near the river (Orange sub-area), is recharged from the river and could also be accounted for as surface water.

The interaction between the mining activity and groundwater is managed through the EMPR and the water use licensing process. Some impacts do exist with regard to localized dewatering of aquifers. These impacts are however localized and very little data exist in this regard. The information from the compliance monitoring systems at the mines needs to be integrated into the DWAF monitoring systems and regularly reviewed. Mines utilize the groundwater available but are still largely dependent on surface water, which is in most cases supplied from the Orange River.

Boreholes and abstraction from boreholes are seldom managed properly and therefore the failure of boreholes is experienced. Borehole siting needs to be based on proper geo-technical work to limit the drilling of unsuccessful boreholes. As a result of this, some towns have drilled many boreholes without much success.

There is a need to provide groundwater information and to create an improved understanding of groundwater at a local level. Groundwater monitoring and data on the availability of groundwater, in general, is insufficient. Water quality is a limiting factor to groundwater use and varies from good to unacceptable in terms of potable standards. Groundwater quality is one of the main factors affecting the development of available groundwater resources.

Although there are numerous problems associated with water quality, some of which are easily corrected, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) represent the majority of serious water quality problems that occur.

Figure 1: Lower Orange WMA (LOWMA) with respect to proposed powerline extension alternatives, rivers and sub Water Management Areas. Adjusted from Water Affairs and Forestry (Ref: GM08_020).

5 TOPOGRAPHY

The regional topography surrounding the proposed powerline extensions are represented in Figure 2. From this image, an overall decline in elevation is seen from the east to west. Surface water drainage will accumulate along indicated river lines to ultimately drain within the South Atlantic Ocean at the West Coast. Shallow and unconfined groundwater flow is expected to follow this overall drainage direction, draining from the eastern border of each indicated quarternary catchment towards the west (at river and catchment contact).

Prominent topographical variations are seen extending perpendicular to the proposed powerline extension. These variations extend along the power lines from Concordia for an estimated 50km toward the west. Surface and groundwater flow, occurrence and susceptibility are expected to be influenced by these variations in elevation (associated with geological structure faulting and intrusions).

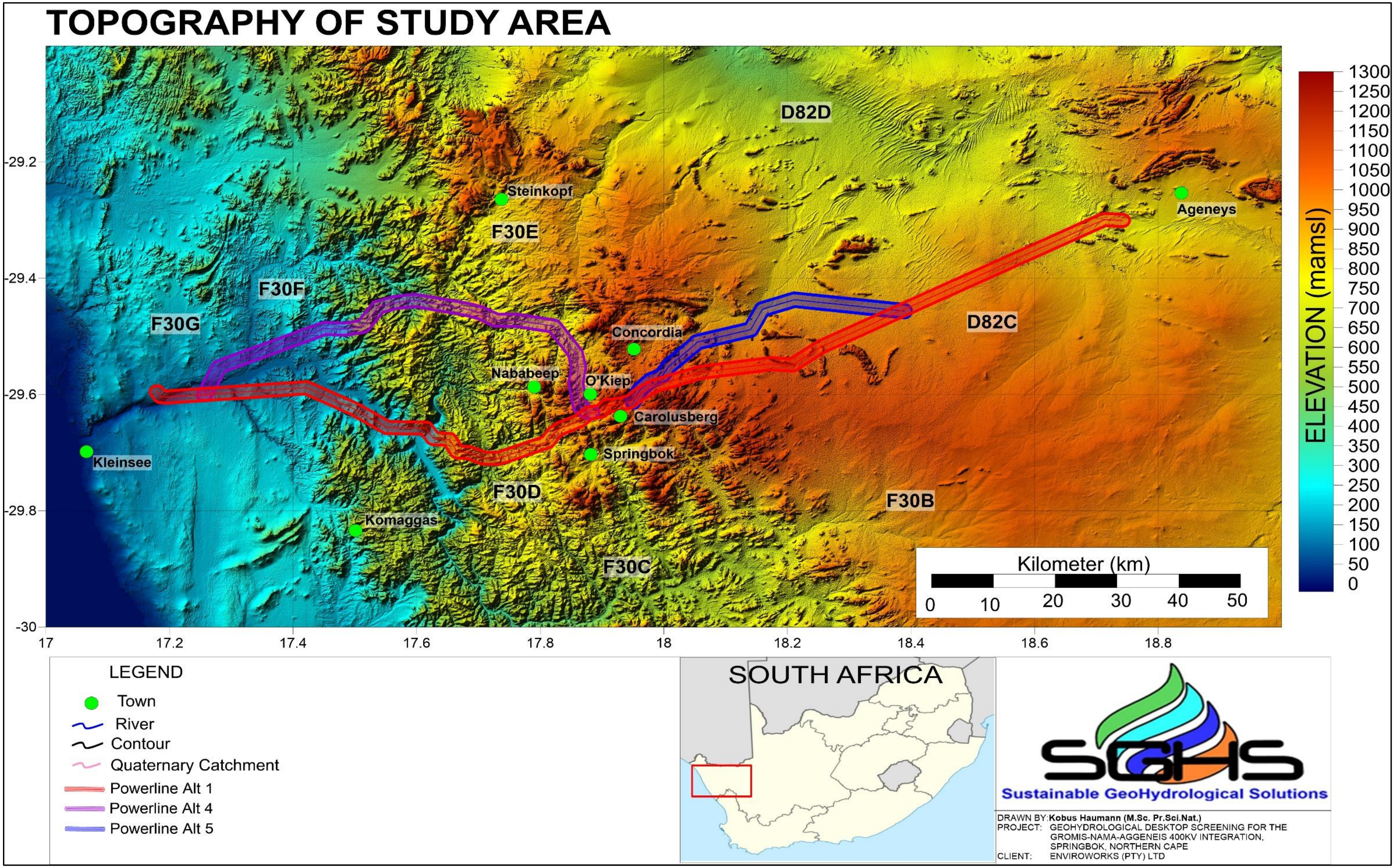

Figure 2: Topographical variation across proposed powerline extenSions with reference to Quarternary Catchment devides.

6 GEOLOGICAL SETTING

The area of investigation extends across two major geological sequences such as that of the Namaqua-Natal Metamorphic Province and the Vanrhynsdorp, Nama and Kansa Group. This section aims to provide a background for these sequences.

6.1 The Namaqua-Natal Metamorphic Province

6.1.1 Location and Extend

The Namaqua-Natal Metamorphic Province (NNMP) occurs along the southern and south western margin of the Kaapvaal Craton and is bounded in the west and south by the Gariep and Saldania Belts respectively (Figure 3). The NNMP outcrops in the Northern Cape (Namaqua Sector or Namaqua Mobile Belt) and Kwazulu-Natal (Natal Sector or Natal Metamorphic Belt) Provinces. The igneous and metamorphic rocks of the NNMP formed during the Namaqua Orogeny that occurred approximately 1200 to 1000 Ma ago.

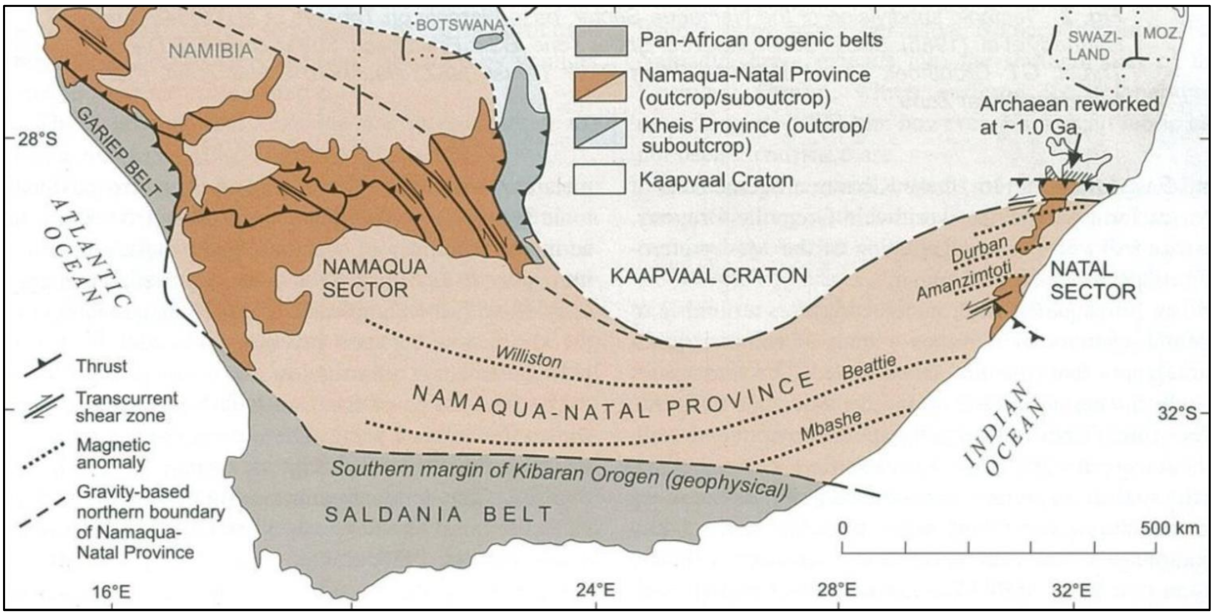

Figure 3: Geological setting of the Namaqua-Natal Metamorphic Province (Cornell et al., 2006). Study area indicated by a red square.

6.1.2 Geology

The NNMP is subdivided into different tectonostratigraphic sub-provinces and terranes, based on marked changes in lithostratigraphy across structural discontinuities (Cornell *et al.,* 2006). The area of investigation is located within the Boesmanland Terrane (Figure 4).

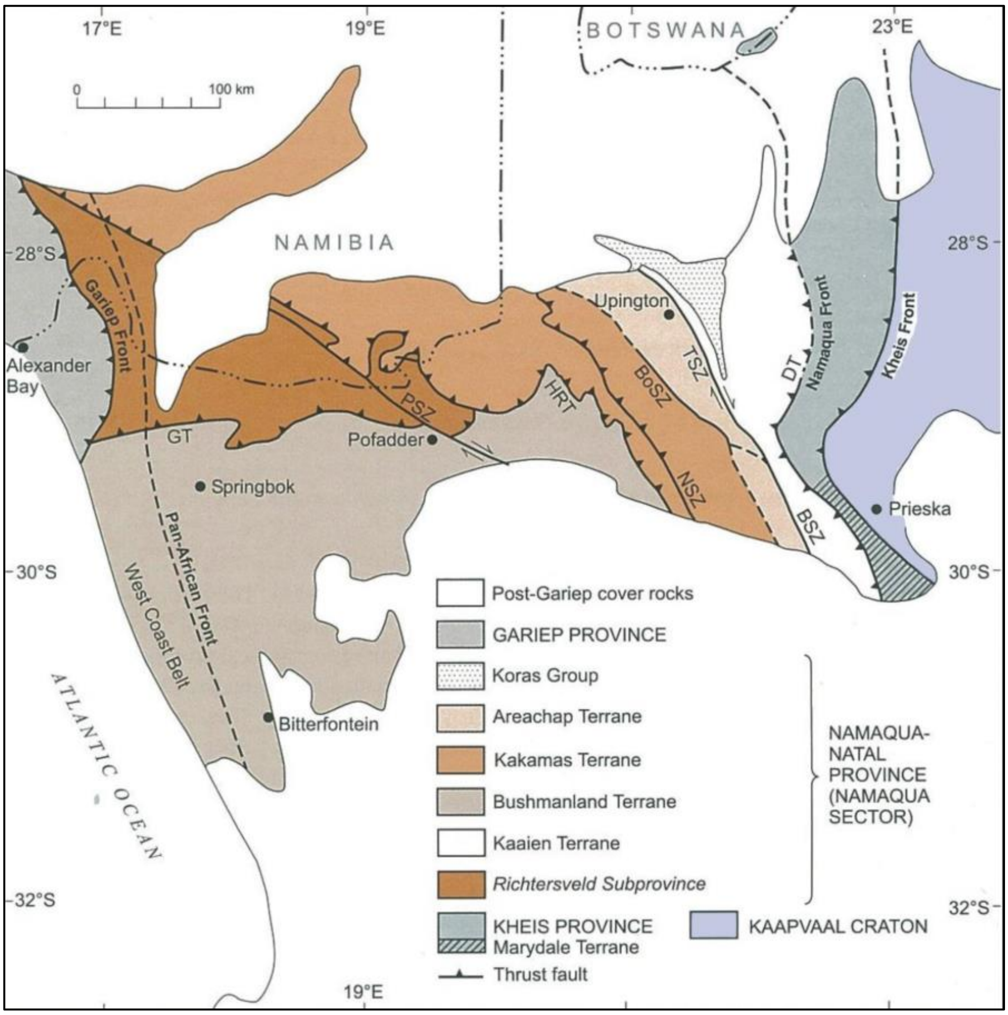

Figure 4: Tectonic subdivision of the Namaqua Sector of the NNMP (Cornell et al., 2006). BoSZ: Boven Rugzeer Shear Zone, BSZ: Brakbosch Shear Zone, DT: Dabep Thrust, GT: Groothoek Thrust, HRT: Hartbees River Thrust, NSZ: Neusberg Shear Zone, PSZ: Pofadder.

6.1.2.1 Bushmanland Terrane

The Bushmanland Terrane is bounded by the Groothoek Thrust in the north and the Hartbees River Thrust in the east (Figure 4). The terrane consists of rocks of three distinct age groups, a basement complex consisting of granitic rocks, a variety of supracrustal sequences of mixed sedimentary and volcanic origin, and intrusive rocks that are granitic to charnochitic in composition (Cornell et al., 2006). In the south the rocks of the Bushmanland Terrane are overlain by rocks of the Karoo Supergroup and Vanrhynsdorp Group.

The basement complex, also known as the Kheisian basement, occurs along the northern margin, adjacent to the Richtersveld Subprovince. These rocks include the Gladkop Suite (Steinkopf area) and the Achab Gneiss (Pofadder area). Both these gneisses contain xenoliths of amphibolite, calc-silicate rock and quartzite, interpreted as remnants of an older supracrustal sequence (Cornell et al., 2006). The Gladkop Suite was intruded by the Brandewynsbank Gneiss, which is, in turn, intruded by the Noenoemaasberg Gneiss. The supracrustal rocks of the Bushmanland Terrane occur in several discontinuous eastwest-trending belts within the terrane, with an increasing abundance towards the south.

The supracrustal belts are dominated by leucocratic and biotite-bearing quartzofeldspathic gneiss (Cornell et al., 2006). The Bushmanland Terrane is subdivided into the Bushmanland Group comprising of the Aggeneys Subgroup which forms part of the Aggeneys Terrane of Colliston, Praekelt and Schoch (1989).

The central and north-eastern part of the Bushmanland Terrane are characterised by voluminous concordant bodies of red-weathering quartzofeldspahtic gneisses, often rerred to as pink gneiss and collectively known as Hoogoor Suite (SACS, 1980).

6.1.2.2 Structural Evolution of the Namaqua Sector

According to Pettersson (2008), the structural evolution of the eastern terranes seems to be similar, with four fold phases, related to four deformation events (D1-D4). The first event (D1) is partly overprinted by the main deformational phase D2, which caused isoclinal local to regional scale north northwest trending folds. It was followed by generally northeast trending, large-scale, upright and open folds of the D3-event along with wrench-faulting near major shear zones. The last deformational event, D4, is mainly related to compression from the southwest and affected by the geometry of the wedge-shaped Kaapvaal Craton around Prieska.

The western terranes, the Richtersveld Subprovince and the Bushmanland Terrane, display three to four major deformation phases. The first folding event is seen as isolated fold closures in the Bushmanland, whereas the second event (D2) is dominated by regional recumbent east northeast trending folds. The third deformational phase occurs as east northeast striking open folds along those of D2.

7 REGIONAL MAGNETIC SETTING

In order to accurately interpret regional aeromagnetic structures in proximity to the study area, a high quality airborne magnetic TIFF map was incorporated into a high definition topo-aeromagnetic presentation represented in Figure 5. From this image, higher defined prominent regional aeromagnetic structures are observable.

From the airborne magnetic map, covering the extent of the proposed powerline layout, various aeromagnetic anomalies are seen. An overall west to east and north east anomaly trend is evident across the extent of the regional area. These trends are in all likelihood caused by the presence of magnetic associable geological intrusions. More prominently, through the center of the investigated site, an overall strong magnetic anomaly can be seen.

The location and extent of these structures are important in determining preferential groundwater flow paths through which pollution distribution may occur. These areas are also associated with an increased surface to groundwater infiltration/recharge rate.

It is expected that the west to east and north east striking magnetic anomaly extends deep within the subsurface as no clear correlation can be drawn between the magnetic anomaly extent and elevation contours provided (Figure 5). Observed prominent magnetic anomalies are in all likelihood an indication of a basement granitic rock complex.

Mentioned topographical variations, extending from an overall north to south direction is expected to represent supercrustal sequences of mixed sedimentary and volcanic origin and/or intrusive rocks which are generally of charnockitic and granitic origin.

An on-site magnetic investigation should not be discouraged but may deem unnecessary due to the deep extent of magnetic associable geological structures while shallow, non-magnetic associable sedimentary rock is believed to predominantly overly the extent of the study area at shallow depths.

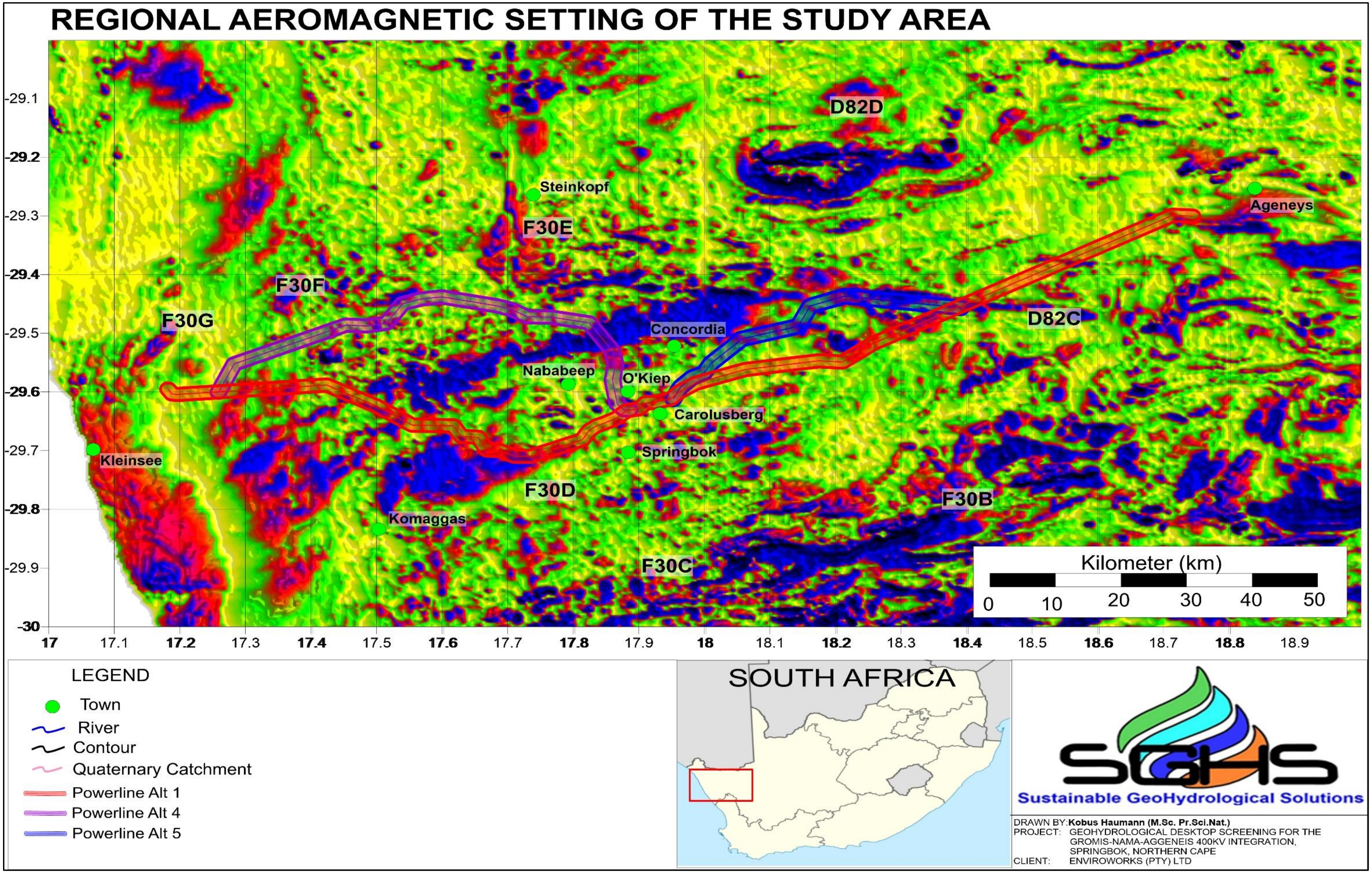

Figure 5: Regional aeromagnetic setting in relation to the study area.

8 GEOHYDROLOGY

8.1 Namaqua Sector

Groundwater within the Namaqua Sector of the NNMP occurs within three different aquifer systems (Friese *et al.,* 2006; Pietersen *et al.*, 2009):

- Fractured bedrock
- Weathered zone (regolith)
- Sandy or alluvial aquifers

The geometry of these aquifer systems are controlled and influenced by the underlying geology of igneous and metamorphic rocks and it's deformation history of metamorphic evolution, and the geomorphic development of the Namaqua Belt, including weathering (Pietersen *et al.*, 2009). Despite the great variety of these metamorphic and igneous rocks, they are homogenous in two respects (Vegter, 2006):

I. Virtually no primary porosity (except alluvial aquifers).
II. Secondary porosity due to fracturing and weathering.

According to the Pietersen *et al.* (2009) the fractured bedrock and regolith systems are generally linear systems associated with the structurally controlled valleys (Figure 6) and may be laterally extensive depending on the nature of the faults systems. Weathering processes; mechanical disintegration, chemical solution, and deposition modify the porosity/permeability of the fractures systems, implying either an increase or decrease in porosity and or permeability (Vegter, 2006). As a result of these structurally controlled valleys (Figure 6 and Figure 7), localized, shallow circulation groundwater flow systems are dominant in the near- surface environment (Friese *et al.*, 2006).

Groundwater flow within the Namaqua sector is complex as it is a function of complex topographic and hydrogeological environments with multiple flow systems (Friese *et al.*, 2006). The natural groundwater flow can be subdivided into local, intermediate and regional flow regimes:

- *Local flow* paths are characteristic short.
- *Intermediate flow* paths are longer and deeper than local flow and can underlie several local flow regimes.
- *Regional flow regimes* theoretically extend from regional recharge areas to distant discharge areas, such as rivers or may be presented by higher salinity structurally controlled artesian springs.

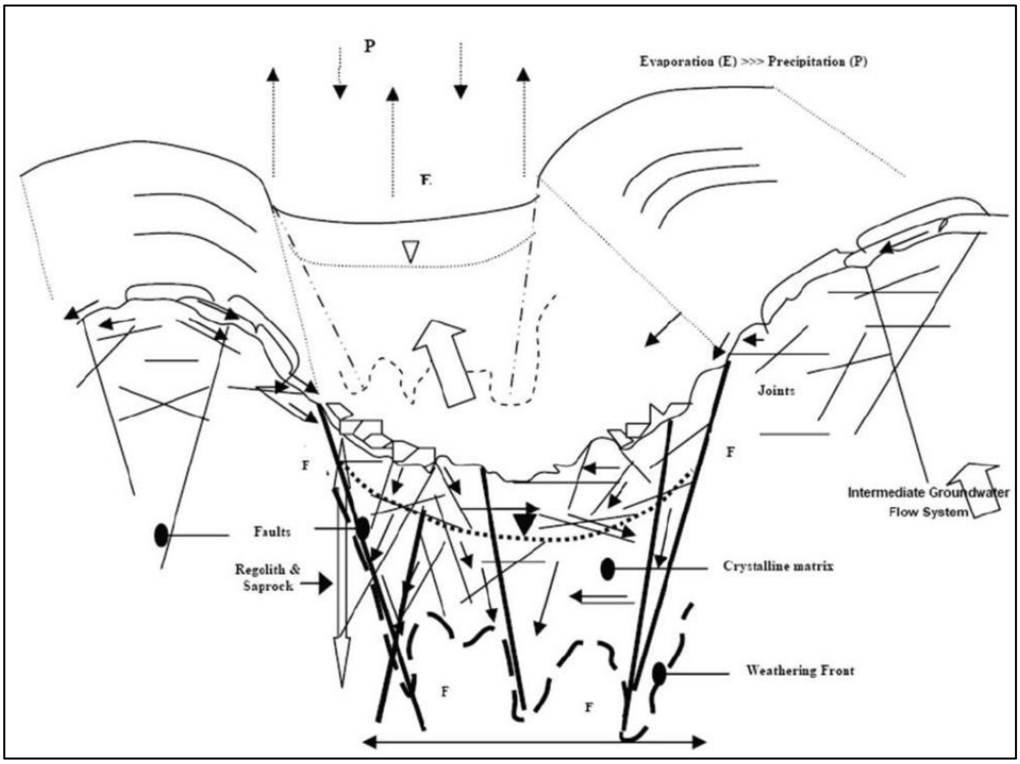

Figure 6: Proposed aquifer geometry and local to intermediate flow regimes for a typical structurally controlled valley (Friese et al., 2006).

Figure 7: Structurally controlled valley in the rocks of the Namaqua sector of the NNMP. Windpump indicates that the valley has been targeted for groundwater.

According to Vegter (2006), in contrast to areas with thick sandy cover, recharge is favored by shallow sandy soil, calcrete, and exposures of fractured rocks. The reasons are twofold;

I. A thick sand-cover retains and prevents rainwater from entering the underlying formations and thus allows its complete dissipation through evapotranspiration. On the other hand, once rainwater has passed through a shallow cover and has entered the underlying fractured rocks, evapotranspiration loss is minimized.

II. Runoff is promoted by shallow sandy soil, calcrete and rock exposure and accumulates in low lying areas and rivers. Here the concentrated volume favors recharge provided infiltration is not inhibited by the presence of clayey soil.

8.2 Groundwater Location Using Formations and Geological Features

Groundwater plays a fundamental role within the Namaqua Sector of the NNMP as surface water resources are very limited. The quartzites of the Namaqua Belt are probably the best rock type to be targeted for groundwater resources quality wise (Esterhuyse, 2011), otherwise there are no specific rock formation targeted.

The following geological features within the igneous and metamorphic rocks are targeted:

- Regional Fault Systems
- Weathered zones
- Ephemeral rivers and palaeo-channels
- Igneous dyke intrusions
- Contact zones between intrusions and its host rocks

According to Pietersen et al., (2009) the following analysis should be done in order to locate groundwater resources:

I. Stress field analysis
    - The understanding of the structures is important to locate best sites for drilling, usually places where fractures in the rock are open and can transmit groundwater.
    - Generally, the most recent tectonic events have the most significant influence on the nature of the existing fracture network and subsequently on the regional flow characteristics.

II. Geomorphic analysis
    - The more transmissive and especially larger fault zones have been weathered and eroded more intensely to form open valley profiles.

III. Regolith analysis

- The depth and extent of the weathered zone are important for groundwater yields in fractured hard rock aquifers.
- The Namaqua Belt rocks are characterized by relatively thin saturated regolith, which is generally present just above the deeper groundwater levels.
- This scenario in arid regions necessitates the drilling of deep boreholes to intercept structural features and contact zones within the unweathered bedrock.

Fault or fracture zones striking north northeast and north northwest generally represent zones where the fractures are open, especially where these structures intersect older fault systems (Pietersen et al., 2009; Potgieter, 2011), thus resulting in good yielding boreholes (not always the case). According to Potgieter (2011), it is advisable to target the eastern side of these fault zones, approximately 20 to 30 m away from the main fault (rather to far than to close).

The preferred geophysical methods used to detect these features are:

I. Resistivity
II. Magnetics

Geophysical methods play a minor role in locating the geological structures of the Namaqua sector of the NNMP, due to the fact that these structures are generally visible on the surface (Figure 8). If geophysics needs to be applied, resistivity is the best method in locating weathered basins and highly fractured fault zones, whereas, the magnetic method is used for detecting intrusive dykes, if they are not visible (Potgieter, 2011).

Figure 8: Typical fracture systems of the Namaqua Sector of the NNMP, Namaqualand, South Africa

9 CORRIDOR ALTERNATIVE PROPERTIES

9.1 Alternative 1

This extension is expected to pose the least risk for groundwater degradation compared to other alternatives. This is due to the overall extension having the smallest surface area, and the majority of the extension being localized along an already existing public road.

The extent of this alternative is expected to have lower construction and operational phase risks to groundwater degradation compared to other alternatives.

Throughout the mountainous terrain extension of this and all other corridors, the surface to groundwater infiltration is expected to be increased and therefore an increased susceptibility for groundwater contamination by conservative pollutants during construction and operational (monitoring) phase is expected. This will, however, be localized to an extension already exposed to roadside anthropogenic pollution, which may be timeously exaggerated by stormwater flushing during rainfall events (minimal). Recorded data did not indicate great groundwater abstraction in close proximity to this corridor along the mountainous terrain, which reduces vulnerability.

West of the mountainous terrain, the corridor extends past multiple mining facilities with some being in operation and some enclosure phase. It is expected that these mines may have deteriorated the channeled downstream water quality of the local groundwater regime.

This corridor does extend along an estimated 3,5km of Buffels Rivier and other non-perennial watercourses. Watercourse intersections should be avoided or intersected perpendicularly where possible to reduce associated impacts. Groundwater abstraction and dependency in close proximity to this corridor appear to be limited.

9.2 Alternative 4

The estimated groundwater impact at this corridor is expected to be low. Throughout the mountainous terrain, the surface to groundwater infiltration is expected to be increased and therefore an increased susceptibility for groundwater contamination by conservative pollutants during construction and operational (monitoring) phase is expected.

This corridor intersects multiple seasonal fountains and non-perennial streams. Direct contact with these intersections should be avoided or minimized where possible. Groundwater abstraction and dependency in close proximity to this corridor appear to be limited.

9.3 Alternative 5

The estimated groundwater impact at this corridor is expected to be low This corridor relates to all properties mentioned of alternative 1. Corridor alternative 5 varies from alternative 1 in that it breaks away from alternative 1 for an approximate 45km. The corridor extends across non-perennial watercourses that are not exposed to alternative 1, therefore making it less favorable. For example, this corridor extends along an estimated >11km of a non-perennial watercourse (Kirrie River) which is not preferred. Watercourse intersections should be avoided or intersected perpendicular to minimize associated impacts where possible.

The corridor should also avoid extending close by existing boreholes within its buffer to reduce structural and quality damage to the usable groundwater.

10 STUDY AREA ESTIMATED IMPACT

10.1 Local groundwater Susceptibility

Based on a desktop analysis of the investigated area's geohydrological conditions, corridor alternative layout routes (Alt1, 4 and 5) can not specifically be distinguished as having more or less impact on the local groundwater regime than the other. This is due to all alternatives extending across geohydrological sensitive and non-sensitive areas. The groundwater susceptibility matrix will, therefore, be determined to act as a reference and combined with estimated groundwater impact significance points to arrive at a comparable numerical based conclusion.

This section therefore analyzed the overall powerline extension as a whole with a preliminary groundwater susceptibility conclusion based on the desktop screening analysis.

For reference, groundwater quality, classification, vulnerability and susceptibility maps were compiled and added to **Appendix A.** This aims to visually represent variation in groundwater-related risks to contamination across geographical distribution, with reference to proposed powerline extensions.

The study area extends across a *poor* to *minor* aquifer system with medium to negligible groundwater yielding capacity of moderate to poor water quality.

The electrical conductivity (EC) values are expected to vary between 150 mS/m to >520 mS/m, keeping in mind that an EC concentration of >170 mS/m exceeds the allowable limits for human consumption according to 2014 SANS241 drinking water standards.

The aquifer has a *least* groundwater vulnerability rating that is only vulnerable to continuously discharged or leached pollutants in the long term.

Due to the study area's aquifer system having a ***poor/minor*** aquifer classification and ***least*** aquifer vulnerability rating, it can be assumed that the aquifer has a **LOW** susceptibility for contamination.

A groundwater susceptibility matrix is given in Table 3, representing a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification.

Table 3: Groundwater Susceptibility Matrix

		AQUIFER CLASSIFICATION		
		Poor	Minor	Major
VULNERABILITY	Least	Low 1	Low 2	Medium 3
	Moderate	Low 2	Medium 4	High 6
		Medium 3	High 6	High 9

10.2 Estimated Groundwater Impact

A list of impacts related to the proposed development which may be associated with groundwater contamination and degradation are listed below. This list is derived from impact management outcomes and actions for the development and expansion of infrastructure for the overhead transmission and distribution of electricity as part of a generic environmental management program (EMPr).

- Environmental awareness training
- Site Establishment development
- Water Supply Management
- Storm and wastewater management
- Solid and hazardous waste management
- Protection of watercourses and estuaries
- Vegetation clearing
- Sanitation
- Hazardous substances
- Workshop, equipment maintenance and storage
- Batching plants
- Blasting
- Stockpiling and stockpile areas
- Steelwork Assembly and Erection
- Cabling and Stringing
- Temporary closure of site
- Landscaping and rehabilitation

These impacts were incorporated into an impact assessment methodology, provided by Enviroworks.

For each potential impact, the duration (time scale), extent (spatial scale), irreplaceable loss of resources, reversibility of the potential impacts, the magnitude of negative or positive impacts, and the probability of occurrence of potential impacts were assessed. The assessment of the above criteria was used to determine the significance of each impact, with and without the implementation of the proposed mitigation measures. Estimated potential impact ratings, relating to the proposed development of corridor alternatives 1, 4 and 5, with proposed mitigation strategies are added to **Appendix B** for reference.

11 CONCLUSION

From the estimated impact assessment rating it can be concluded that corridor alternative 1 is the most preferred corridor extension with the least estimated impact on the local groundwater regime. Corridor alternative 5 is estimated as having the second-lowest impact and alternative 4 having the most estimated impact on the local groundwater regime.

This conclusion is based on cumulative significance points of all evaluation components in the impact assessment matrix, incorporated with a groundwater susceptibility matrix, background geohydrological conditions and groundwater dependancy.

Corridor alternative 1 is most preferred as it extends along existing corridor infrastructure, therefore localizing potential impacts to an already affected environment compared to corridor alternatives 4 and 5 wich extends away from this, posing new unique potential impacts and increasing the overall groundwater impact potential footprint.

It should be noted that corridor alternative 5 relates to all properties mentioned of alternative 1 with the only exception being a slight deviation in extension of approximate 45km. This deviation however, places alternative 5 along more than 11km of a non-perennial watercourse (Kirrie River), which is not preferred. Corridor alternative 5 therefore has a higher estimated impact rating than alternative 1, if no proposed mitigation measures are followed. **Should all provided mitigation measures be followed, the estimated impact rating significance of both corridor alternative 1 and 5 are expected to be identical (LOW).**

12 RECOMMENDATION

Although local groundwater quality and availability are deteriorated and low, the dependency on water/groundwater sources is very high. This increases the vulnerability of the local groundwater regime to conservative pollutants in the long term and structural degradation during construction.

It was found that in some areas, geological structures were targeted for both groundwater exploration and preferred corridor foundation installment at areas where corridor layout angles change. These areas should be avoided from being excavated or blasted to reduce the risk of damage to limited boreholes. The client should also refrain from using these sites, prominent geological outcrops, as storage sites for any toxic chemicals, oils, faulty machinery etc, as these sites are associated with increased surface to groundwater infiltration rates.

Areas known to collect surface water drainage should also be avoided as far as possible during construction and operational (monitoring roads) phase. Alternatively, intersecting watercourses should be intersected perpendicularly to minimize the estimated groundwater impact.

It is highly recommended that mitigation strategies listed in **Appendix B** be strictly followed.

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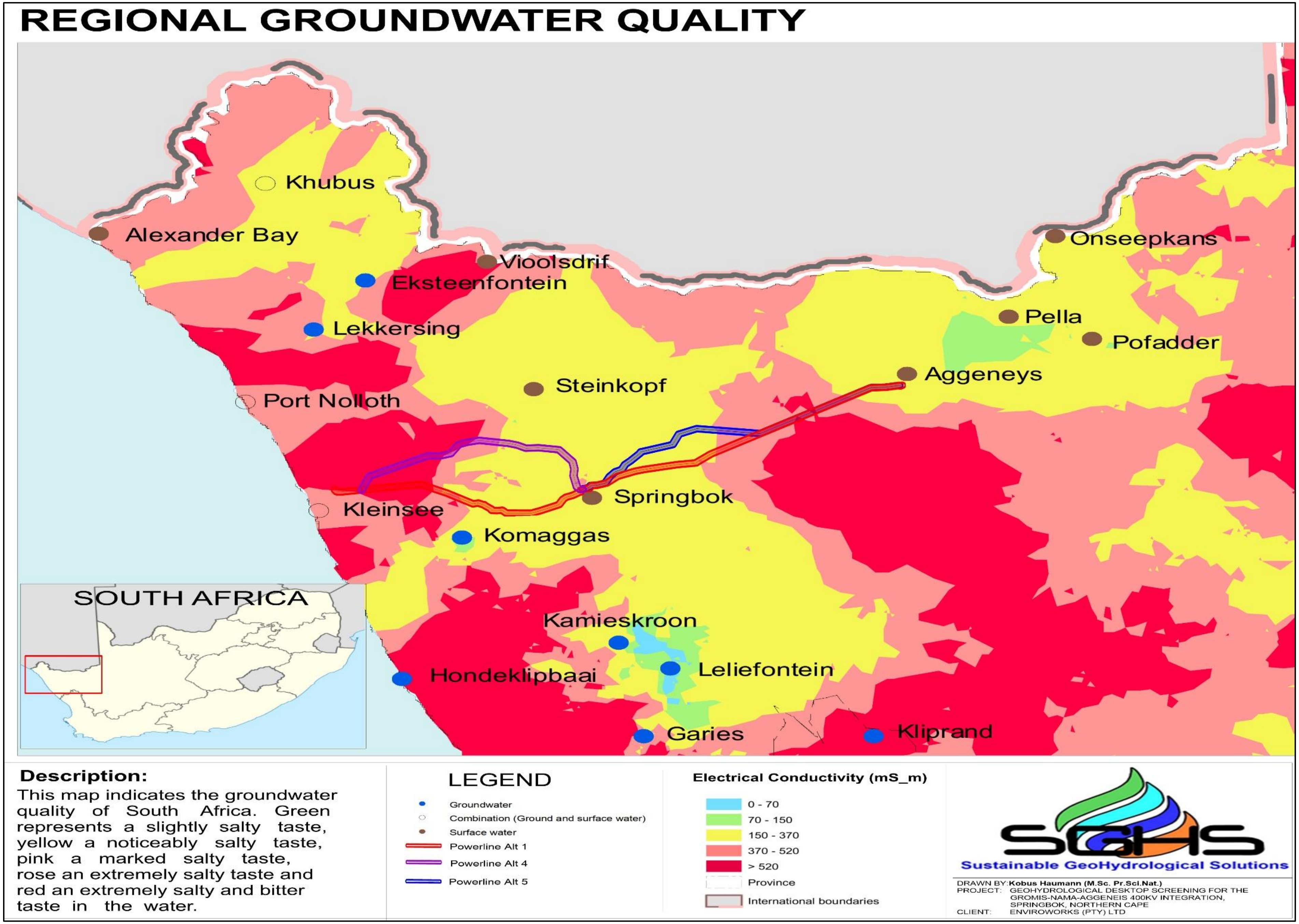
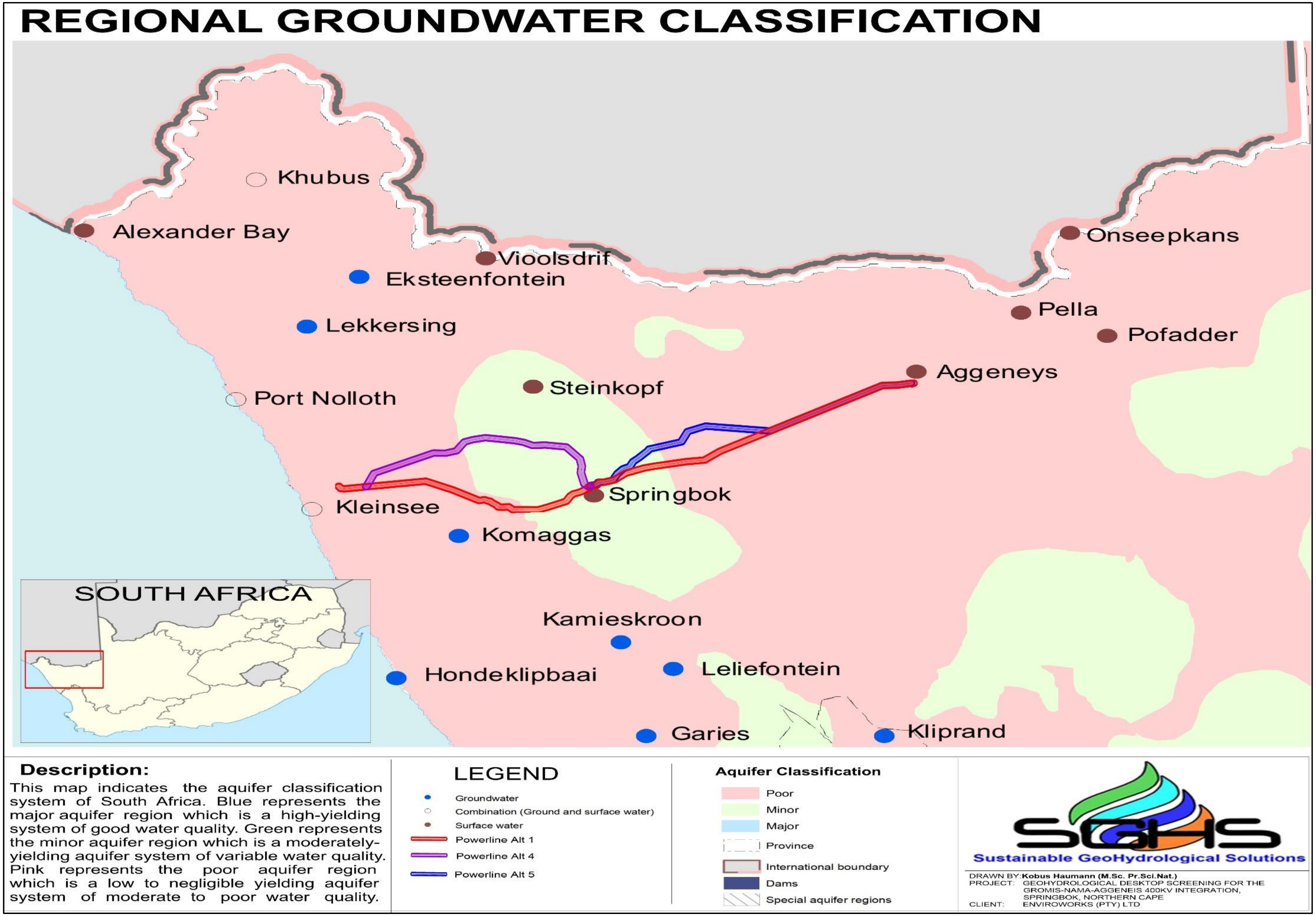
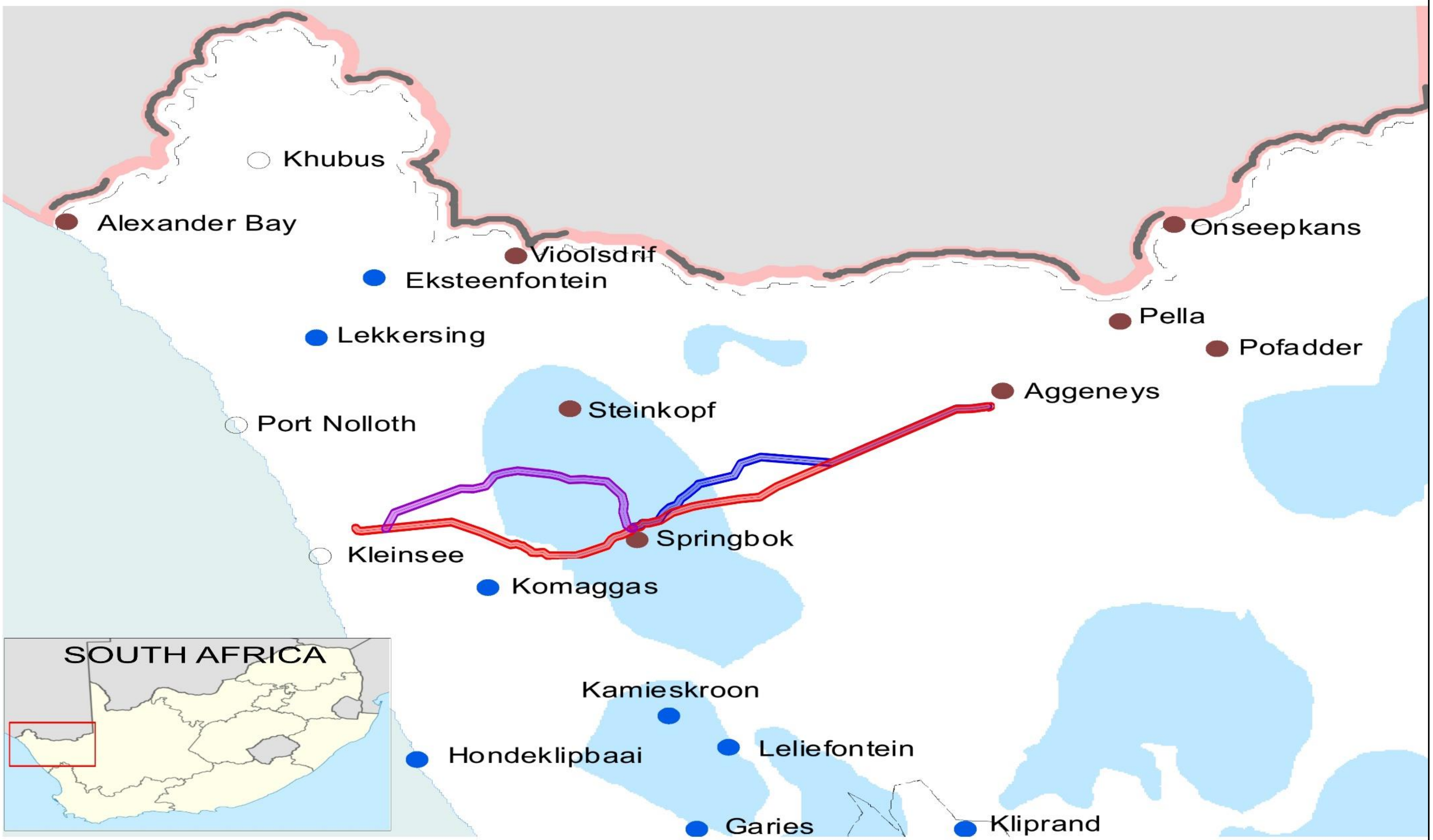
14 APPENDIX A




REGIONAL GROUNDWATER CLASSIFICATION
Khubus
Alexander Bay
Vioolsdrif
Eksteenfontein
Lekkersing
Onseepkans
Pella
Pofadder
Aggeneys
Steinkopf
Port Nolloth
Springbok
Kleinsee
Komaggas
SOUTH AFRICA
Kamieskroon
Hondeklipbaai
Leliefontein
Garies
Kliprand
Description:
This map indicates the aquifer classification system of South Africa. Blue represents the major aquifer region which is a high-yielding system of good water quality. Green represents the minor aquifer region which is a moderately-yielding aquifer system of variable water quality. Pink represents the poor aquifer region which is a low to negligible yielding aquifer system of moderate to poor water quality.
LEGEND
Groundwater
Combination (Ground and surface water)
Surface water
Powerline Alt 1
Powerline Alt 4
Powerline Alt 5
Aquifer Classification
Poor
Minor
Major
Province
International boundary
Dams
Special aquifer regions
SGHS
Sustainable GeoHydrological Solutions
DRAWN BY: Kobus Haumann (M.Sc. Pr.Sci.Nat.)
PROJECT: GEOHYDROLOGICAL DESKTOP SCREENING FOR THE GROMIS-NAMA-AGGENEIS 400KV INTEGRATION, SPRINGBOK, NORTHERN CAPE
CLIENT: ENVIROWORKS (PTY) LTD


REGIONAL GROUNDWATER VULNERABILITY
Khubus
Alexander Bay
Vioolsdrif
Eksteenfontein
Onseepkans
Pella
Pofadder
Lekkersing
Aggeneys
Steinkopf
Port Nolloth
Springbok
Kleinsee
Komaggas
SOUTH AFRICA
Kamieskroon
Hondeklipbaai
Leliefontein
Garies
Kliprand
Description:
This map indicates the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. Green represents the least vulnerable region that is only vulnerable to conservative pollutants inthe long term when continuously discharged or leached. Yellowrepresents the moderately vulnerable region which is vulnerable to some pollutants, but only when continuously discharged or leached. Red represents the most vulnerable aquifer region, which is vulnerable tomany pollutants except those strongly absorbed or readily transformed in many pollution scenarios.
LEGEND
Groundwater
Combination (Ground and surface water)
Surface water
Powerline Alt 1
Powerline Alt 4
Powerline Alt 5
Vulnerability Rating
Least
Moderate
Most
Province
International boundary
Dams
Special aquifer regions
SGHS
Sustainable GeoHydrological Solutions
DRAWN BY: Kobus Haumann (M.Sc. Pr.Sci.Nat.)
PROJECT: GEOHYDROLOGICAL DESKTOP ANALYSIS FOR THE GROMIS-NAMA-AGGENEIS 400KV INTEGRATION, SPRINGBOK, NORTHERN CAPE
CLIENT: ENVIROWORKS (PTY) LTD

REGIONAL GROUNDWATER SUSCEPTIBILITY



Description:

This map indicates the qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification.

LEGEND

- Groundwater
- Combination (Ground and surface water)
- Surface water
- Powerline Alt 1
- Powerline Alt 4
- Powerline Alt 5

Suceptibility Matrix

VULNERABILITY	AQUIFER CLASSIFICATION		
	Poor	Minor	Major
Least	Low 1	Low 2	Medium 3
Moderate	Low 2	Medium 4	High 6
	Medium 3	High 6	High 9

Sustainable GeoHydrological Solutions

DRAWN BY: Kobus Haumann (M.Sc. Pr.Sci.Nat.)
PROJECT: GEOHYDROLOGICAL DESKTOP ANALYSIS FOR THE GROMIS-NAMA-AGGENEIS 400KV INTEGRATION, SPRINGBOK, NORTHERN CAPE
CLIENT: ENVIROWORKS (PTY) LTD

15 APPENDIX B

PROJECT ALTERNATIVE	POTENTIAL ENVIRONMENTAL IMPACT / NATURE OF IMPACT	ENVIRONMENTAL SIGNIFICANCE																		MITIGATION
		BEFORE MITIGATION									AFTER MITIGATION									
		Magnitude	Duration	Extent	Irreplaceable	Reversibility	Probability	TOTAL (SP)	Significance	CUMULATIVE	Magnitude	Duration	Extent	Irreplaceable	Reversibility	Probability	TOTAL (SP)	Significance	CUMULATIVE	
Potential Impacts on geographical and physical aspects																				
CORRIDOR ALTERNATIVE 1																				
Project activity:	**Planning and design**																			
Environmental awareness training	Lack of environmental awareness training prior to commencement of the activities may lead to Environmental degradation during project development and operational phase. All staff should be aware of the conditions and controls linked to the EA and within the EMPr and made aware of their individual roles and responsibilities in achieving compliance with the EA and EMPr;	8	4	3	3	3	3	63	M	M	0	1	1	1	1	1	4	L	L	Conduct environmental awareness training prior to commencement of the activities. All staff should be aware of the conditions and controls linked to the EA and within the EMPr and made aware of their individual roles and responsibilities in achieving compliance with the EA and EMPr. Environmental awareness training must include as a minimum of the following: a) Description of significant environmental impacts, actual or potential, related to their work activities. b) Mitigation measures to be implemented when carrying out specific activities. c) Emergency preparedness and response procedures. d) Emergency procedures. e) Procedures to be followed when working near or within sensitive areas. f) Wastewater management procedures. g) Water usage and conservation. h) Solid waste management procedures. i) Sanitation procedures.
Site establishment development	Impacts on the environment during site establishment and the development footprint to be demarcated within the development area. A method statement must be provided by the contractor prior to any onsite activity that includes the layout of the construction camp in the form of a plan showing the location of key infrastructure and services .where applicable.	6	3	2	2	3	3	48	M	M	1	0	0	0	0	1	1	L	L	Specific footprints, layout and and extentions of infrastructure should aim to avoid environmentaly sensitive areas. The layout of the following infrastructure should be known where applicable. Offices, overnight vehicle parking areas, stores, the workshop, stockpile and lay down areas, hazardous materials storage areas (including fuels), the batching plant (if one is located at the construction camp), esignated access routes, equipment cleaning areas , cooking and ablution facilities, waste and wastewater management. This will help determine and ensure that the site does not impact on sensitive areas identified in the environmental assessment or site walk through. Sites must be located where possible on previously disturbed areas and/or elevated areas, away from watercourses.

Water Supply Management	Unresponsible water usage. All abstraction points or bore holes must be registered with the DWS and suitable water meters installed to ensure that the abstracted volumes are measured on a daily basis	6	3	2	3	3	4	68	**M**	**M**	2	2	1	1	1	1	7	**L**	**L**	The Contractor must ensure the following: a. The vehicle abstracting water from a river does not enter or cross it and does not operate from within the river. b. No damage occurs to the river bed or banks and that the abstraction of water does not entail stream diversion activities. c. All reasonable measures to limit pollution or sedimentation of the downstream watercourse are implemented. Ensure water conservation is being practiced by: a. Minimising water use during cleaning of equipment; b. Undertaking regular audits of water systems; and c. Including a discussion on water usage and conservation during environmental awareness training.
Storm and waste water management	Impacts to the environment caused by storm water and wastewater discharges during construction.	4	2	3	2	3	4	56	**M**	**L**	0	1	1	1	1	1	4	**L**	**L**	Runoff from cement/ concrete batching areas must be strictly controlled, and contaminated water must be collected, stored and either treated or disposed of off-site, at a location approved by the project manager; All spillage of oil onto concrete surfaces must be controlled by the use of an approved absorbent material and the used absorbent material disposed of at an appropriate waste disposal facility.Natural storm water runoff not contaminated during the development and clean water can be discharged directly to watercourses and water bodies, subject to the Project Manager's approval and support by the ECO. Water that has been contaminated with suspended solids, such as soils and silt, may be released into watercourses or water bodies only once all suspended solids have been removed from the water by settling out these solids in settlement ponds. The release of settled water back into the environment must be subject to the Project Manager's approval and support by the ECO.
Solid and hazardous waste management	If wastes are inappropriately stored, handled and unsafely disposed of at unrecognised waste facilities	6	4	3	3	4	3	60	**M**	**M**	2	1	1	1	2	1	7	**L**	**L**	All measures regarding waste management must be undertaken using an integrated waste management approach. Sufficient, covered waste collection bins (scavenger and weatherproof) must be provided. A suitably positioned and clearly demarcated waste collection site must be identified and provided. The waste collection site must be maintained in a clean and orderly manner. Waste must be segregated into separate bins and clearly marked for each waste type for recycling and safe disposal. Staff must be trained in waste segregation. Bins must be emptied regularly. General waste produced onsite must be disposed of at a registered waste disposal sites/ recycling company. Hazardous waste must be disposed of at a registered waste disposal site. Certificates of safe disposal for general, hazardous and recycled waste must be maintained.

Protection of watercourses and estuaries	Pollution and contamination of the watercourse environment and or estuary erosion	6	3	2	3	3	3	51	M	M	2	1	1	1	2	1	7	L	L	All watercourses must be protected from direct or indirect spills of pollutants such as solid waste, sewage, cement, oils, fuels, chemicals, aggregate tailings, wash and contaminated water or organic material resulting from the contractor's activities. In the event of a spill, prompt action must be taken to clear the polluted or affected areas. Where possible, no development equipment must traverse any seasonal or permanent wetland. No return flow into the estuaries must be allowed and no disturbance of the estuarine functional zone should occur. Development of permanent watercourse or estuary crossing must only be undertaken where no alternative access to tower position is available. There must not be any impact on the long term morphological dynamics of watercourses or estuaries. Existing crossing points must be favored over the creation of new crossings (including temporary access). When working in or near any watercourse or estuary, the following environmental controls and consideration must be taken: a) Water levels during the period of construction; No altering of the bed, banks, course or characteristics of a watercourse. b) During the execution of the works, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that construction equipment is well maintained. c) Where earthwork is being undertaken in close proximity to any watercourse, slopes must be stabilised using suitable materials, i.e. sandbags or geotextile fabric, to prevent sand and rock from entering the channel. d) Appropriate rehabilitation and re-vegetation measures for the watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows.
Vegetation clearing	Vegetation clearing should be restricted to the authorised development footprint of the proposed infrastructure in order to buffer soil erosion.	4	2	2	2	2	4	48	M	M	0	1	0	0	0	1	1	L	L	Indigenous vegetation which does not interfere with the development must be left undisturbed Rivers and watercourses must be kept clear of felled trees,vegetation cuttings and debris. Only a registered pest control operator may apply herbicides on a commercial basis and commercial application must be carried out under the supervision of a registered pest control operator, supervision of a registered pest control operator oris appropriately trained. No herbicides must be used in estuaries.

Sanitation	Unclean and poorly maintained toilet facilities available to staff may pose risk of disease and impact to the environment	4	2	2	2	2	4	48	M	M	0	1	0	0	1	1	2	L	L	Mobile chemical toilets are installed onsite if no other ablution facilities are available.- The use of ablution facilities and or mobile toilets must be used at all times and no indiscriminate use of the veld for the purposes of ablutions must be permitted under any circumstances. Where mobile chemical toilets are required, the following must be ensured: a) Toilets are located no closer than 100 m to any watercourse or water body. b) Toilets are secured to the ground to prevent them from toppling due to wind or any other cause. c) No spillage occurs when the toilets are cleaned or emptied and the contents are managed in accordance with the EMPr. d) Toilets are emptied before long weekends and workers holidays, and must be locked after working hours. f) Toilets are serviced regularly and the ECO must inspect toilets to ensure compliance to health standards. A copy of the waste disposal certificates must be maintained.
Hazardous substances	Unsafe storage, handling, use and disposal of hazardous substances causing environmental impact.	8	3	2	3	3	3	57	M	M	2	1	0	0	0	1	3	L	L	The use and storage of hazardous substances are to be minimised and non-hazardous and non-toxic alternatives substituted where possible. All hazardous substances must be stored in suitable containers. Containers must be clearly marked to indicate contents, quantities and safety requirements. All storage areas must be bunded. The bunded area must be of sufficient capacity to contain a spill / leak from the stored containers. Bunded areas are to be suitably lined with a SABS approved liner. An Alphabetical Hazardous Chemical Substance (HCS) control sheet must be drawn up and kept up to date on a continuous basis. Employees handling hazardous substances / materials must be aware of the potential impacts and follow appropriate safety measures. The Contractor must ensure that diesel and other liquid fuel, oil and hydraulic fluid is stored in appropriate storage tanks or in bowsers; The tanks/ bowsers must be situated on a smooth impermeable surface (concrete) with a permanent bund. The floor of the bund must be sloped, draining to an oil separator. Provision must be made for refueling at the storage area by protecting the soil with an impermeable groundcover. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained. All empty externally dirty drums must be stored on a drip tray or within a bunded area. No unauthorised access into the hazardous substances storage areas must be permitted. An appropriately sized spill kit kept onsite relevant to the scale of the activity/s involving the use of hazardous substance must be available at all times. The responsible operator must have the required training to make use of the spill kit in emergency situations.

Workshop, equipment maintenance and storage	Potential for soil, surface water and groundwater contamination if improperly managed.	4	3	2	2	2	3	39	L	M	0	1	0	0	0	1	1	L	N	Where possible and practical all maintenance of vehicles and equipment must take place in the workshop area. During servicing of vehicles or equipment, especially where emergency repairs are effected outside the workshop area, a suitable drip tray must be used to prevent spills onto the soil. Leaking equipment must be repaired immediately or be removed from site to facilitate repair. Workshop areas must be monitored for oil and fuel spills. Appropriately sized spill kit kept onsite relevant to the scale of the activity taking place must be available. The workshop area must have a bunded concrete slab that is sloped to facilitate runoff into a collection sump or suitable oil/ water separator where maintenance work on vehicles and equipment can be performed. Water drainage from the workshop must be contained and managed in accordance with Storm and waste water management.
Batching plants	Spillages and contamination of soil, surface water and groundwater	4	3	2	2	2	3	39	L	M	0	1	0	0	0	1	1	L	N	Concrete mixing must be carried out on an impermeable surface. Batching plants areas must be fitted with a containment facility for the collection of cement laden water. Dirty water from the batching plant must be contained to prevent soil and groundwater contamination. Bagged cement must be stored in an appropriate facility and at least 10 m away from any water courses, gullies and drains. A washout facility must be provided for washing of concrete associated equipment. Water used for washing must be restricted. Hardened concrete from the washout facility or concrete mixer can either be reused or disposed of at an appropriate licenced disposal facility. Empty cement bags must be secured with adequate binding material if these will be temporarily stored on site. Sand and aggregates containing cement must be kept damp to prevent the generation of dust. Any excess sand, stone and cement must be removed or reused from site on completion of construction period and disposed at a registered disposal facility.
Blasting	Impact to the environment through unsafe blasting practice.	6	4	1	3	4	4	72	M	M	2	1	1	1	1	1	6	L	L	Any blasting activity must be conducted by a suitably licensed blasting contractor. Notification of surrounding landowners, emergency services site personnel of blasting activity 24 hours prior to such activity should taking place on Site. Blasting should not occur within a 50m buffer of effective blast range based on variable geotechnical conditions to preserve borehole casing stibility.

Stockpiling and stockpile areas	Erosion and sedimentation as a result of stockpiling	6	2	1	1	2	2	24	L	M	2	1	0	0	0	1	3	L	L	All material that is excavated during the project development phase (either during piling (if required) or earthworks) must be stored appropriately on site in order to minimise impacts to watercourses, and water bodies. All stockpiled material must be maintained and kept clear of weeds and alien vegetation growth by undertaking regular weeding and control methods. Topsoil stockpiles must not exceed 2 m in height. During periods of strong winds and heavy rain, the stockpiles must be covered with appropriate material (e.g. cloth, tarpaulin etc.). Where possible, sandbags (or similar) must be placed at the bases of the stockpiled material in order to prevent erosion of the material.
Steelwork Assembly and Erection	Environmental degradation occurs as a result of steelwork assembly and erection	4	3	2	2	2	3	39	L	M	2	1	1	1	1	1	6	L	L	During assembly, care must be taken to ensure that no wasted/unused materials are left on site e.g. bolts and nuts. Emergency repairs due to breakages of equipment must be managed in accordance with Workshop, equipment maintenance and storage.
Cabling and Stringing	Cabling and Stringing	4	4	2	3	3	4	64	M	M	2	2	1	1	1	1	7	L	L	Residual solid waste (off cuts etc.) shall be recycled or disposed of in accordance with Solid waste and hazardous Management. Management of equipment used for installation shall be conducted in accordance with Workshop, equipment maintenance and storage. Management hazardous substances and any associated spills shall be conducted in accordance with Hazardous substances.
Temporary closure of site	Risk of environmental impact during periods of site closure greater than five days.	4	2	2	2	3	3	39	L	M	0	1	0	0	1	1	2	L	L	Bunds must be emptied (where applicable) and need to be undertaken in accordance with the impact management actions included in Hazardous substances and Workshop, equipment maintenance and storage. Hazardous storage areas must be well ventilated. Security personnel must be briefed and have the facilities to contact or be contacted by relevant management and emergency personnel. Cement and materials stores must have been secured. Toilets must have been emptied and secured. Refuse bins must have been emptied and secured. Drip trays must have been emptied and secured.
Landscaping and rehabilitation	Areas disturbed during the development phase are not returned to a state that approximates the original condition.	4	4	1	3	3	4	60	M	M	2	1	1	1	1	1	6	L	L	All spoil and waste must be disposed of to a registered waste site. Stockpiled topsoil must be used for rehabilitation (refer to Stockpiling and stockpiled areas). Stockpiled topsoil must be evenly spread so as to facilitate seeding and minimise loss of soil due to erosion. The rehabilitation must be timed so that rehabilitation can take place at the optimal time for vegetation establishment. Where impacted through construction related activity, all sloped areas must be stabilised to ensure proper habilitation is effected and erosion is controlled. Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments. The contract design specifications must be adhered to and implemented strictly.

Water Supply Management	Unresponsible water usage. All abstraction points or bore holes must be registered with the DWS and suitable water meters installed to ensure that the abstracted volumes are measured on a daily basis	8	3	2	3	3	4	76	M	M	2	2	1	1	1	1	7	L	L	The Contractor must ensure the following: a. The vehicle abstracting water from a river does not enter or cross it and does not operate from within the river. b. No damage occurs to the river bed or banks and that the abstraction of water does not entail stream diversion activities. c. All reasonable measures to limit pollution or sedimentation of the downstream watercourse are implemented. Ensure water conservation is being practiced by: a. Minimising water use during cleaning of equipment; b. Undertaking regular audits of water systems; and c. Including a discussion on water usage and conservation during environmental awareness training. d. The use of grey water is encouraged.
Storm and waste water management	Impacts to the environment caused by storm water and wastewater discharges during construction.	4	2	3	3	3	4	60	M	M	0	1	1	1	1	1	4	L	L	Runoff from cement/ concrete batching areas must be strictly controlled, and contaminated water must be collected, stored and either treated or disposed of off-site, at a location approved by the project manager; All spillage of oil onto concrete surfaces must be controlled by the use of an approved absorbent material and the used absorbent material disposed of at an appropriate waste disposal facility.Natural storm water runoff not contaminated during the development and clean water can be discharged directly to watercourses and water bodies, subject to the Project Manager's approval and support by the ECO. Water that has been contaminated with suspended solids, such as soils and silt, may be released into watercourses or water bodies only once all suspended solids have been removed from the water by settling out these solids in settlement ponds. The release of settled water back into the environment must be subject to the Project Manager's approval and support by the ECO.
Solid and hazardous waste management	If wastes are inappropriately stored, handled and unsafely disposed of at unrecognised waste facilities	8	4	3	3	4	3	66	M	M	2	1	1	1	2	1	7	L	L	All measures regarding waste management must be undertaken using an integrated waste management approach. Sufficient, covered waste collection bins (scavenger and weatherproof) must be provided. A suitably positioned and clearly demarcated waste collection site must be identified and provided. The waste collection site must be maintained in a clean and orderly manner. Waste must be segregated into separate bins and clearly marked for each waste type for recycling and safe disposal. Staff must be trained in waste segregation. Bins must be emptied regularly. General waste produced onsite must be disposed of at a registered waste disposal sites/ recycling company. Hazardous waste must be disposed of at a registered waste disposal site. Certificates of safe disposal for general, hazardous and recycled waste must be maintained.

PROJECT ALTERNATIVE	POTENTIAL ENVIRONMENTAL IMPACT / NATURE OF IMPACT	ENVIRONMENTAL SIGNIFICANCE																		MITIGATION
		BEFORE MITIGATION									AFTER MITIGATION									
		Magnitude	Duration	Extent	Irreplaceable	Reversibility	Probability	TOTAL (SP)	Significance	CUMULATIVE	Magnitude	Duration	Extent	Irreplaceable	Reversibility	Probability	TOTAL (SP)	Significance	CUMULATIVE	
Potential Impacts on geographical and physical aspects																				
CORRIDOR ALTERNATIVE 4																				
Project activity:	**Planning and design**																			
Environmental awareness training	Lack of environmental awareness training prior to commencement of the activities may lead to Environmental degradation during project development and operational phase. All staff should be aware of the conditions and controls linked to the EA and within the EMPr and made aware of their individual roles and responsibilities in achieving compliance with the EA and EMPr;	8	4	3	3	3	3	63	M	M	0	1	1	1	1	1	4	L	L	Conduct environmental awareness training prior to commencement of the activities. All staff should be aware of the conditions and controls linked to the EA and within the EMPr and made aware of their individual roles and responsibilities in achieving compliance with the EA and EMPr. Environmental awareness training must include as a minimum of the following: a) Description of significant environmental impacts, actual or potential, related to their work activities. b) Mitigation measures to be implemented when carrying out specific activities. c) Emergency preparedness and response procedures. d) Emergency procedures. e) Procedures to be followed when working near or within sensitive areas. f) Wastewater management procedures. g) Water usage and conservation. h) Solid waste management procedures. i) Sanitation procedures.
Site establishment development	Impacts on the environment during site establishment and the development footprint to be demarcated within the development area. A method statement must be provided by the contractor prior to any onsite activity that includes the layout of the construction camp in the form of a plan showing the location of key infrastructure and services .where applicable.	6	3	2	2	3	3	48	M	M	1	0	0	0	0	1	1	L	L	Specific footprints, layout and and extentions of infrastructure should aim to avoid environmentaly sensitive areas. The layout of the following infrastructure should be known where applicable. Offices, overnight vehicle parking areas, stores, the workshop, stockpile and lay down areas, hazardous materials storage areas (including fuels), the batching plant (if one is located at the construction camp), esignated access routes, equipment cleaning areas , cooking and ablution facilities, waste and wastewater management. This will help determine and ensure that the site does not impact on sensitive areas identified in the environmental assessment or site walk through. Sites must be located where possible on previously disturbed areas and/or elevated areas, away from watercourses.

Water Supply Management	Unresponsible water usage. All abstraction points or bore holes must be registered with the DWS and suitable water meters installed to ensure that the abstracted volumes are measured on a daily basis	8	3	2	3	3	4	76	M	M	2	2	1	1	1	1	7	L	L	The Contractor must ensure the following: a. The vehicle abstracting water from a river does not enter or cross it and does not operate from within the river. b. No damage occurs to the river bed or banks and that the abstraction of water does not entail stream diversion activities. c. All reasonable measures to limit pollution or sedimentation of the downstream watercourse are implemented. Ensure water conservation is being practiced by: a. Minimising water use during cleaning of equipment; b. Undertaking regular audits of water systems; and c. Including a discussion on water usage and conservation during environmental awareness training. d. The use of grey water is encouraged.
Storm and waste water management	Impacts to the environment caused by storm water and wastewater discharges during construction.	4	2	3	3	3	4	60	M	M	0	1	1	1	1	1	4	L	L	Runoff from cement/ concrete batching areas must be strictly controlled, and contaminated water must be collected, stored and either treated or disposed of off-site, at a location approved by the project manager; All spillage of oil onto concrete surfaces must be controlled by the use of an approved absorbent material and the used absorbent material disposed of at an appropriate waste disposal facility.Natural storm water runoff not contaminated during the development and clean water can be discharged directly to watercourses and water bodies, subject to the Project Manager's approval and support by the ECO. Water that has been contaminated with suspended solids, such as soils and silt, may be released into watercourses or water bodies only once all suspended solids have been removed from the water by settling out these solids in settlement ponds. The release of settled water back into the environment must be subject to the Project Manager's approval and support by the ECO.
Solid and hazardous waste management	If wastes are inappropriately stored, handled and unsafely disposed of at unrecognised waste facilities	8	4	3	3	4	3	66	M	M	2	1	1	1	2	1	7	L	L	All measures regarding waste management must be undertaken using an integrated waste management approach. Sufficient, covered waste collection bins (scavenger and weatherproof) must be provided. A suitably positioned and clearly demarcated waste collection site must be identified and provided. The waste collection site must be maintained in a clean and orderly manner. Waste must be segregated into separate bins and clearly marked for each waste type for recycling and safe disposal. Staff must be trained in waste segregation. Bins must be emptied regularly. General waste produced onsite must be disposed of at a registered waste disposal sites/ recycling company. Hazardous waste must be disposed of at a registered waste disposal site. Certificates of safe disposal for general, hazardous and recycled waste must be maintained.

Protection of watercourses and estuaries	Pollution and contamination of the watercourse environment and or estuary erosion.	6	3	2	3	3	3	51	M	M	2	1	1	1	2	1	7	L	L	All watercourses must be protected from direct or indirect spills of pollutants such as solid waste, sewage, cement, oils, fuels, chemicals, aggregate tailings, wash and contaminated water or organic material resulting from the contractor's activities. In the event of a spill, prompt action must be taken to clear the polluted or affected areas. Where possible, no development equipment must traverse any seasonal or permanent wetland. No return flow into the estuaries must be allowed and no disturbance of the estuarine functional zone should occur. Development of permanent watercourse or estuary crossing must only be undertaken where no alternative access to tower position is available. There must not be any impact on the long term morphological dynamics of watercourses or estuaries. Existing crossing points must be favored over the creation of new crossings (including temporary access). When working in or near any watercourse or estuary, the following environmental controls and consideration must be taken: a) Water levels during the period of construction; No altering of the bed, banks, course or characteristics of a watercourse. b) During the execution of the works, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that construction equipment is well maintained. c) Where earthwork is being undertaken in close proximity to any watercourse, slopes must be stabilised using suitable materials, i.e. sandbags or geotextile fabric, to prevent sand and rock from entering the channel. d) Appropriate rehabilitation and re-vegetation measures for the watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows.
Vegetation clearing	Vegetation clearing should be restricted to the authorised development footprint of the proposed infrastructure in order to buffer soil erosion.	4	2	2	2	2	4	48	M	M	0	1	0	0	0	1	1	L	L	Indigenous vegetation which does not interfere with the development must be left undisturbed Rivers and watercourses must be kept clear of felled trees,vegetation cuttings and debris. Only a registered pest control operator may apply herbicides on a commercial basis and commercial application must be carried out under the supervision of a registered pest control operator, supervision of a registered pest control operator oris appropriately trained. No herbicides must be used in estuaries.

Sanitation	Unclean and poorly maintained toilet facilities available to staff may pose risk of disease and impact to the environment	8	2	2	2	2	4	64	M	M	0	1	0	0	1	1	2	L	L	Mobile chemical toilets are installed onsite if no other ablution facilities are available.- The use of ablution facilities and or mobile toilets must be used at all times and no indiscriminate use of the veld for the purposes of ablutions must be permitted under any circumstances. Where mobile chemical toilets are required, the following must be ensured: a) Toilets are located no closer than 100 m to any watercourse or water body. b) Toilets are secured to the ground to prevent them from toppling due to wind or any other cause. c) No spillage occurs when the toilets are cleaned or emptied and the contents are managed in accordance with the EMPr. d) Toilets are emptied before long weekends and workers holidays, and must be locked after working hours. f) Toilets are serviced regularly and the ECO must inspect toilets to ensure compliance to health standards. A copy of the waste disposal certificates must be maintained.
Hazardous substances	Unsafe storage, handling, use and disposal of hazardous substances causing environmental impact.	8	3	2	3	3	4	76	M	M	2	1	0	0	0	1	3	L	L	The use and storage of hazardous substances are to be minimised and non-hazardous and non-toxic alternatives substituted where possible. All hazardous substances must be stored in suitable containers. Containers must be clearly marked to indicate contents, quantities and safety requirements. All storage areas must be bunded. The bunded area must be of sufficient capacity to contain a spill / leak from the stored containers. Bunded areas are to be suitably lined with a SABS approved liner. An Alphabetical Hazardous Chemical Substance (HCS) control sheet must be drawn up and kept up to date on a continuous basis. Employees handling hazardous substances / materials must be aware of the potential impacts and follow appropriate safety measures. The Contractor must ensure that diesel and other liquid fuel, oil and hydraulic fluid is stored in appropriate storage tanks or in bowsers; The tanks/ bowsers must be situated on a smooth impermeable surface (concrete) with a permanent bund. The floor of the bund must be sloped, draining to an oil separator. Provision must be made for refueling at the storage area by protecting the soil with an impermeable groundcover. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained. All empty externally dirty drums must be stored on a drip tray or within a bunded area. No unauthorised access into the hazardous substances storage areas must be permitted. An appropriately sized spill kit kept onsite relevant to the scale of the activity/s involving the use of hazardous substance must be available at all times. The responsible operator must have the required training to make use of the spill kit in emergency situations.

Workshop, equipment maintenance and storage	Potential for soil, surface water and groundwater contamination if improperly managed.	6	3	2	2	2	4	60	M	M	0	1	0	0	0	1	1	L	L	Where possible and practical all maintenance of vehicles and equipment must take place in the workshop area. During servicing of vehicles or equipment, especially where emergency repairs are effected outside the workshop area, a suitable drip tray must be used to prevent spills onto the soil. Leaking equipment must be repaired immediately or be removed from site to facilitate repair. Workshop areas must be monitored for oil and fuel spills. Appropriately sized spill kit kept onsite relevant to the scale of the activity taking place must be available. The workshop area must have a bunded concrete slab that is sloped to facilitate runoff into a collection sump or suitable oil/ water separator where maintenance work on vehicles and equipment can be performed. Water drainage from the workshop must be contained and managed in accordance with Storm and waste water management.
Batching plants	Spillages and contamination of soil, surface water and groundwater	6	3	2	2	2	3	45	M	M	0	1	0	0	0	1	1	L	L	Concrete mixing must be carried out on an impermeable surface. Batching plants areas must be fitted with a containment facility for the collection of cement laden water. Dirty water from the batching plant must be contained to prevent soil and groundwater contamination. Bagged cement must be stored in an appropriate facility and at least 10 m away from any water courses, gullies and drains. A washout facility must be provided for washing of concrete associated equipment. Water used for washing must be restricted. Hardened concrete from the washout facility or concrete mixer can either be reused or disposed of at an appropriate licenced disposal facility. Empty cement bags must be secured with adequate binding material if these will be temporarily stored on site. Sand and aggregates containing cement must be kept damp to prevent the generation of dust. Any excess sand, stone and cement must be removed or reused from site on completion of construction period and disposed at a registered disposal facility.
Blasting	Impact to the environment through unsafe blasting practice.	6	4	1	3	4	4	72	M	L	2	1	1	1	1	1	6	L	L	Any blasting activity must be conducted by a suitably licensed blasting contractor. Notification of surrounding landowners, emergency services site personnel of blasting activity 24 hours prior to such activity should taking place on Site. Blasting should not occur within a 50m buffer of effective blast range based on variable geotechnical conditions to preserve borehole casing stibility.

Stockpiling and stockpile areas	Erosion and sedimentation as a result of stockpiling	6	2	1	1	2	3	36	L	L	2	1	0	0	0	1	3	L	L	All material that is excavated during the project development phase (either during piling (if required) or earthworks) must be stored appropriately on site in order to minimise impacts to watercourses, and water bodies. All stockpiled material must be maintained and kept clear of weeds and alien vegetation growth by undertaking regular weeding and control methods. Topsoil stockpiles must not exceed 2 m in height. During periods of strong winds and heavy rain, the stockpiles must be covered with appropriate material (e.g. cloth, tarpaulin etc.). Where possible, sandbags (or similar) must be placed at the bases of the stockpiled material in order to prevent erosion of the material.
Steelwork Assembly and Erection	Environmental degradation occurs as a result of steelwork assembly and erection	6	3	2	2	2	3	45	M	M	2	1	1	1	1	1	6	L	L	During assembly, care must be taken to ensure that no wasted/unused materials are left on site e.g. bolts and nuts. Emergency repairs due to breakages of equipment must be managed in accordance with Workshop, equipment maintenance and storage.
Cabling and Stringing	Cabling and Stringing	6	4	2	3	3	4	72	M	M	2	2	1	1	1	1	7	L	L	Residual solid waste (off cuts etc.) shall be recycled or disposed of in accordance with Solid waste and hazardous Management. Management of equipment used for installation shall be conducted in accordance with Workshop, equipment maintenance and storage. Management hazardous substances and any associated spills shall be conducted in accordance with Hazardous substances.
Temporary closure of site	Risk of environmental impact during periods of site closure greater than five days.	4	2	2	2	3	3	39	L	M	0	1	0	0	1	1	2	L	L	Bunds must be emptied (where applicable) and need to be undertaken in accordance with the impact management actions included in Hazardous substances and Workshop, equipment maintenance and storage. Hazardous storage areas must be well ventilated. Security personnel must be briefed and have the facilities to contact or be contacted by relevant management and emergency personnel. Cement and materials stores must have been secured. Toilets must have been emptied and secured. Refuse bins must have been emptied and secured. Drip trays must have been emptied and secured.
Landscaping and rehabilitation	Areas disturbed during the development phase are not returned to a state that approximates the original condition.	6	4	1	3	3	4	68	M	M	2	2	1	1	1	1	7	L	L	All spoil and waste must be disposed of to a registered waste site. Stockpiled topsoil must be used for rehabilitation (refer to Stockpiling and stockpiled areas). Stockpiled topsoil must be evenly spread so as to facilitate seeding and minimise loss of soil due to erosion. The rehabilitation must be timed so that rehabilitation can take place at the optimal time for vegetation establishment. Where impacted through construction related activity, all sloped areas must be stabilised to ensure proper habilitation is effected and erosion is controlled. Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments. The contract design specifications must be adhered to and implemented strictly.

PROJECT ALTERNATIVE	POTENTIAL ENVIRONMENTAL IMPACT / NATURE OF IMPACT	ENVIRONMENTAL SIGNIFICANCE																		MITIGATION
		BEFORE MITIGATION									AFTER MITIGATION									
		Magnitude	Duration	Extent	Irreplaceable	Reversibility	Probability	TOTAL (SP)	Significance	CUMULATIVE	Magnitude	Duration	Extent	Irreplaceable	Reversibility	Probability	TOTAL (SP)	Significance	CUMULATIVE	
Potential Impacts on geographical and physical aspects																				
CORRIDOR ALTERNATIVE 5																				
Project activity:	**Planning and design**																			
Environmental awareness training	Lack of environmental awareness training prior to commencement of the activities may lead to Environmental degradation during project development and operational phase. All staff should be aware of the conditions and controls linked to the EA and within the EMPr and made aware of their individual roles and responsibilities in achieving compliance with the EA and EMPr;	8	4	3	3	3	3	63	M	M	0	1	1	1	1	1	4	L	L	Conduct environmental awareness training prior to commencement of the activities. All staff should be aware of the conditions and controls linked to the EA and within the EMPr and made aware of their individual roles and responsibilities in achieving compliance with the EA and EMPr. Environmental awareness training must include as a minimum of the following: a) Description of significant environmental impacts, actual or potential, related to their work activities. b) Mitigation measures to be implemented when carrying out specific activities. c) Emergency preparedness and response procedures. d) Emergency procedures. e) Procedures to be followed when working near or within sensitive areas. f) Wastewater management procedures. g) Water usage and conservation. h) Solid waste management procedures. i) Sanitation procedures.
Site establishment development	Impacts on the environment during site establishment and the development footprint to be demarcated within the development area. A method statement must be provided by the contractor prior to any onsite activity that includes the layout of the construction camp in the form of a plan showing the location of key infrastructure and services .where applicable.	6	3	2	2	3	3	48	M	M	1	0	0	0	0	1	1	L	L	Specific footprints, layout and and extentions of infrastructure should aim to avoid environmentaly sensitive areas. The layout of the following infrastructure should be known where applicable. Offices, overnight vehicle parking areas, stores, the workshop, stockpile and lay down areas, hazardous materials storage areas (including fuels), the batching plant (if one is located at the construction camp), esignated access routes, equipment cleaning areas , cooking and ablution facilities, waste and wastewater management. This will help determine and ensure that the site does not impact on sensitive areas identified in the environmental assessment or site walk through. Sites must be located where possible on previously disturbed areas and/or elevated areas, away from watercourses.

Water Supply Management	Unresponsible water usage. All abstraction points or bore holes must be registered with the DWS and suitable water meters installed to ensure that the abstracted volumes are measured on a daily basis	6	3	2	3	3	4	68	M	M	2	2	1	1	1	1	7	L	L	The Contractor must ensure the following: a. The vehicle abstracting water from a river does not enter or cross it and does not operate from within the river. b. No damage occurs to the river bed or banks and that the abstraction of water does not entail stream diversion activities. c. All reasonable measures to limit pollution or sedimentation of the downstream watercourse are implemented. Ensure water conservation is being practiced by: a. Minimising water use during cleaning of equipment; b. Undertaking regular audits of water systems; and c. Including a discussion on water usage and conservation during environmental awareness training. d. The use of grey water is encouraged.
Storm and waste water management	Impacts to the environment caused by storm water and wastewater discharges during construction.	4	2	3	2	3	4	56	M	L	0	1	1	1	1	1	4	L	L	Runoff from cement/ concrete batching areas must be strictly controlled, and contaminated water must be collected, stored and either treated or disposed of off-site, at a location approved by the project manager; All spillage of oil onto concrete surfaces must be controlled by the use of an approved absorbent material and the used absorbent material disposed of at an appropriate waste disposal facility.Natural storm water runoff not contaminated during the development and clean water can be discharged directly to watercourses and water bodies, subject to the Project Manager's approval and support by the ECO. Water that has been contaminated with suspended solids, such as soils and silt, may be released into watercourses or water bodies only once all suspended solids have been removed from the water by settling out these solids in settlement ponds. The release of settled water back into the environment must be subject to the Project Manager's approval and support by the ECO.
Solid and hazardous waste management	If wastes are inappropriately stored, handled and unsafely disposed of at unrecognised waste facilities	8	4	3	3	4	3	66	M	M	2	1	1	1	2	1	7	L	L	All measures regarding waste management must be undertaken using an integrated waste management approach. Sufficient, covered waste collection bins (scavenger and weatherproof) must be provided. A suitably positioned and clearly demarcated waste collection site must be identified and provided. The waste collection site must be maintained in a clean and orderly manner. Waste must be segregated into separate bins and clearly marked for each waste type for recycling and safe disposal. Staff must be trained in waste segregation. Bins must be emptied regularly. General waste produced onsite must be disposed of at a registered waste disposal sites/ recycling company. Hazardous waste must be disposed of at a registered waste disposal site. Certificates of safe disposal for general, hazardous and recycled waste must be maintained.

Protection of watercourses and estuaries	Pollution and contamination of the watercourse environment and or estuary erosion	8	3	2	3	3	3	57	M	M	2	1	1	1	2	1	7	L	L	All watercourses must be protected from direct or indirect spills of pollutants such as solid waste, sewage, cement, oils, fuels, chemicals, aggregate tailings, wash and contaminated water or organic material resulting from the contractor's activities. In the event of a spill, prompt action must be taken to clear the polluted or affected areas. Where possible, no development equipment must traverse any seasonal or permanent wetland. No return flow into the estuaries must be allowed and no disturbance of the estuarine functional zone should occur. Development of permanent watercourse or estuary crossing must only be undertaken where no alternative access to tower position is available. There must not be any impact on the long term morphological dynamics of watercourses or estuaries. Existing crossing points must be favored over the creation of new crossings (including temporary access). When working in or near any watercourse or estuary, the following environmental controls and consideration must be taken: a) Water levels during the period of construction; No altering of the bed, banks, course or characteristics of a watercourse. b) During the execution of the works, appropriate measures to prevent pollution and contamination of the riparian environment must be implemented e.g. including ensuring that construction equipment is well maintained. c) Where earthwork is being undertaken in close proximity to any watercourse, slopes must be stabilised using suitable materials, i.e. sandbags or geotextile fabric, to prevent sand and rock from entering the channel. d) Appropriate rehabilitation and re-vegetation measures for the watercourse banks must be implemented timeously. In this regard, the banks should be appropriately and incrementally stabilised as soon as development allows.
Vegetation clearing	Vegetation clearing should be restricted to the authorised development footprint of the proposed infrastructure in order to buffer soil erosion.	4	2	2	2	2	4	48	M	M	0	1	0	0	0	1	1	L	L	Indigenous vegetation which does not interfere with the development must be left undisturbed Rivers and watercourses must be kept clear of felled trees,vegetation cuttings and debris. Only a registered pest control operator may apply herbicides on a commercial basis and commercial application must be carried out under the supervision of a registered pest control operator, supervision of a registered pest control operator oris appropriately trained. No herbicides must be used in estuaries.

Sanitation	Unclean and poorly maintained toilet facilities available to staff may pose risk of disease and impact to the environment	6	2	2	2	2	4	56	M	M	0	1	0	0	1	1	2	L	L	Mobile chemical toilets are installed onsite if no other ablution facilities are available.- The use of ablution facilities and or mobile toilets must be used at all times and no indiscriminate use of the veld for the purposes of ablutions must be permitted under any circumstances. Where mobile chemical toilets are required, the following must be ensured: a) Toilets are located no closer than 100 m to any watercourse or water body. b) Toilets are secured to the ground to prevent them from toppling due to wind or any other cause. c) No spillage occurs when the toilets are cleaned or emptied and the contents are managed in accordance with the EMPr. d) Toilets are emptied before long weekends and workers holidays, and must be locked after working hours. f) Toilets are serviced regularly and the ECO must inspect toilets to ensure compliance to health standards. A copy of the waste disposal certificates must be maintained.
Hazardous substances	Unsafe storage, handling, use and disposal of hazardous substances causing environmental impact.	8	3	2	3	3	3	57	M	M	2	1	0	0	0	1	3	L	L	The use and storage of hazardous substances are to be minimised and non-hazardous and non-toxic alternatives substituted where possible. All hazardous substances must be stored in suitable containers. Containers must be clearly marked to indicate contents, quantities and safety requirements. All storage areas must be bunded. The bunded area must be of sufficient capacity to contain a spill / leak from the stored containers. Bunded areas are to be suitably lined with a SABS approved liner. An Alphabetical Hazardous Chemical Substance (HCS) control sheet must be drawn up and kept up to date on a continuous basis. Employees handling hazardous substances / materials must be aware of the potential impacts and follow appropriate safety measures. The Contractor must ensure that diesel and other liquid fuel, oil and hydraulic fluid is stored in appropriate storage tanks or in bowsers; The tanks/ bowsers must be situated on a smooth impermeable surface (concrete) with a permanent bund. The floor of the bund must be sloped, draining to an oil separator. Provision must be made for refueling at the storage area by protecting the soil with an impermeable groundcover. Where dispensing equipment is used, a drip tray must be used to ensure small spills are contained. All empty externally dirty drums must be stored on a drip tray or within a bunded area. No unauthorised access into the hazardous substances storage areas must be permitted. An appropriately sized spill kit kept onsite relevant to the scale of the activity/s involving the use of hazardous substance must be available at all times. The responsible operator must have the required training to make use of the spill kit in emergency situations.

Workshop, equipment maintenance and storage	Potential for soil, surface water and groundwater contamination if improperly managed.	6	3	2	2	2	3	45	M	M	0	1	0	0	0	1	1	L	N	Where possible and practical all maintenance of vehicles and equipment must take place in the workshop area. During servicing of vehicles or equipment, especially where emergency repairs are effected outside the workshop area, a suitable drip tray must be used to prevent spills onto the soil. Leaking equipment must be repaired immediately or be removed from site to facilitate repair. Workshop areas must be monitored for oil and fuel spills. Appropriately sized spill kit kept onsite relevant to the scale of the activity taking place must be available. The workshop area must have a bunded concrete slab that is sloped to facilitate runoff into a collection sump or suitable oil/ water separator where maintenance work on vehicles and equipment can be performed. Water drainage from the workshop must be contained and managed in accordance with Storm and waste water management.
Batching plants	Spillages and contamination of soil, surface water and groundwater	6	3	2	2	2	3	45	M	M	0	1	0	0	0	1	1	L	N	Concrete mixing must be carried out on an impermeable surface. Batching plants areas must be fitted with a containment facility for the collection of cement laden water. Dirty water from the batching plant must be contained to prevent soil and groundwater contamination. Bagged cement must be stored in an appropriate facility and at least 10 m away from any water courses, gullies and drains. A washout facility must be provided for washing of concrete associated equipment. Water used for washing must be restricted. Hardened concrete from the washout facility or concrete mixer can either be reused or disposed of at an appropriate licenced disposal facility. Empty cement bags must be secured with adequate binding material if these will be temporarily stored on site. Sand and aggregates containing cement must be kept damp to prevent the generation of dust. Any excess sand, stone and cement must be removed or reused from site on completion of construction period and disposed at a registered disposal facility.
Blasting	Impact to the environment through unsafe blasting practice.	6	4	1	3	4	4	72	M	M	2	1	1	1	1	1	6	L	L	Any blasting activity must be conducted by a suitably licensed blasting contractor. Notification of surrounding landowners, emergency services site personnel of blasting activity 24 hours prior to such activity should taking place on Site. Blasting should not occur within a 50m buffer of effective blast range based on variable geotechnical conditions to preserve borehole casing stibility.

Stockpiling and stockpile areas	Erosion and sedimentation as a result of stockpiling	6	2	1	1	2	2	24	L	M	2	1	0	0	0	1	3	L	L	All material that is excavated during the project development phase (either during piling (if required) or earthworks) must be stored appropriately on site in order to minimise impacts to watercourses, and water bodies. All stockpiled material must be maintained and kept clear of weeds and alien vegetation growth by undertaking regular weeding and control methods. Topsoil stockpiles must not exceed 2 m in height. During periods of strong winds and heavy rain, the stockpiles must be covered with appropriate material (e.g. cloth, tarpaulin etc.). Where possible, sandbags (or similar) must be placed at the bases of the stockpiled material in order to prevent erosion of the material.
Steelwork Assembly and Erection	Environmental degradation occurs as a result of steelwork assembly and erection	4	3	2	2	2	3	39	L	M	2	1	1	1	1	1	6	L	L	During assembly, care must be taken to ensure that no wasted/unused materials are left on site e.g. bolts and nuts. Emergency repairs due to breakages of equipment must be managed in accordance with Workshop, equipment maintenance and storage.
Cabling and Stringing	Cabling and Stringing	6	4	2	3	3	4	72	M	M	2	2	1	1	1	1	7	L	L	Residual solid waste (off cuts etc.) shall be recycled or disposed of in accordance with Solid waste and hazardous Management. Management of equipment used for installation shall be conducted in accordance with Workshop, equipment maintenance and storage. Management hazardous substances and any associated spills shall be conducted in accordance with Hazardous substances.
Temporary closure of site	Risk of environmental impact during periods of site closure greater than five days.	4	2	2	2	3	3	39	L	M	0	1	0	0	1	1	2	L	L	Bunds must be emptied (where applicable) and need to be undertaken in accordance with the impact management actions included in Hazardous substances and Workshop, equipment maintenance and storage. Hazardous storage areas must be well ventilated. Security personnel must be briefed and have the facilities to contact or be contacted by relevant management and emergency personnel. Cement and materials stores must have been secured. Toilets must have been emptied and secured. Refuse bins must have been emptied and secured. Drip trays must have been emptied and secured.
Landscaping and rehabilitation	Areas disturbed during the development phase are not returned to a state that approximates the original condition.	4	4	1	3	3	4	60	M	M	2	1	1	1	1	1	6	L	L	All spoil and waste must be disposed of to a registered waste site. Stockpiled topsoil must be used for rehabilitation (refer to Stockpiling and stockpiled areas). Stockpiled topsoil must be evenly spread so as to facilitate seeding and minimise loss of soil due to erosion. The rehabilitation must be timed so that rehabilitation can take place at the optimal time for vegetation establishment. Where impacted through construction related activity, all sloped areas must be stabilised to ensure proper habilitation is effected and erosion is controlled. Sloped areas stabilised using design structures or vegetation as specified in the design to prevent erosion of embankments. The contract design specifications must be adhered to and implemented strictly.