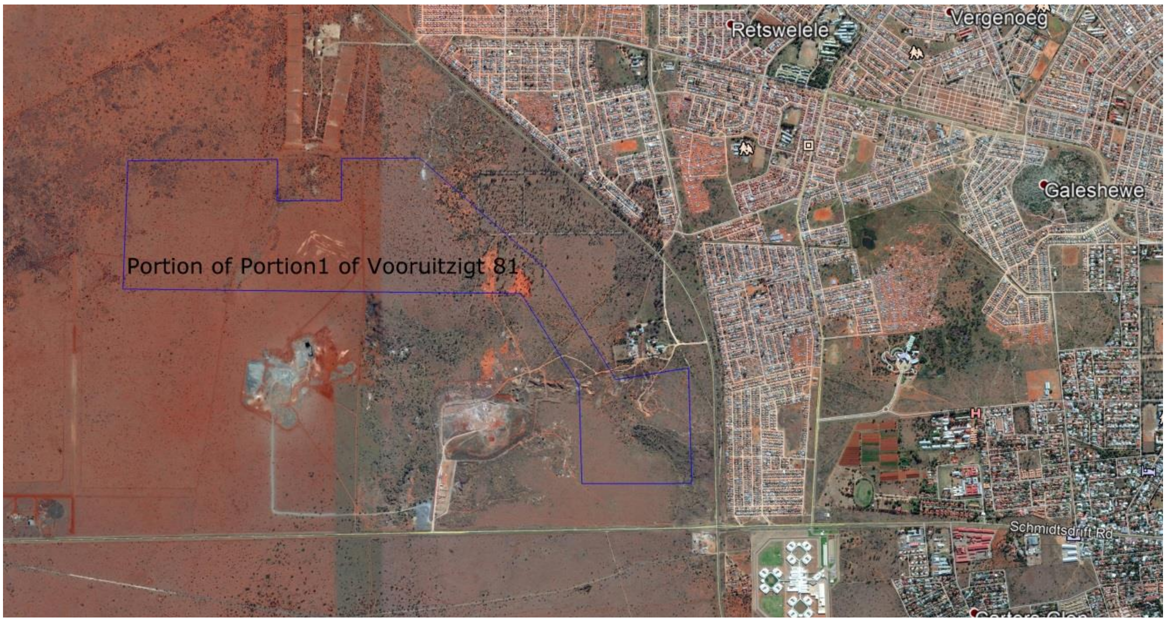
Groundwater Assessment of Portion of Portion 1 of the Farm Vooruitzigt 81,Northern Cape Province.

Report Prepared for

Mystic-Pearl

Report Number SRK 522081



Report Prepared by

srk consulting

August 2017

Groundwater Assessment of Portion of Portion 1 of the Farm Vooruitzigt 81, Baseline Groundwater Assessment, Northern Cape Province.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd (SRK) by Mystic-Pearl and data obtained from the National Groundwater Archive (NGA). The opinions in this Report are provided in response to a specific request from Mystic-Pearl to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

Glossary of Terms

Andesite	An extrusive igneous, volcanic rock, with aphanitic to porphyritic texture.
Aquiclude	An impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater.
Aquifer	A water-bearing geological formation capable of supplying economic quantities of groundwater to wells, boreholes and springs.
Conglomerate	It is a coarse-grained clastic sedimentary rock that is composed of a substantial fraction of rounded to subangular gravel-size clasts, larger than 2 mm in diameter.
Contamination	The introduction of any substance into the environment by the action of man.
Fractured-rock Aquifer	Aquifers where groundwater occurs within fractures and fissures in hard-rock formations.
Groundwater	Refers to the water filling the pores and voids in geological formations below the water table.
Groundwater Flow	The movement of water through openings and pore spaces in rocks below the water table i.e. in the saturated zone. Groundwater naturally drains from higher lying areas to low lying areas such as rivers, lakes and the oceans. The rate of flow depends on the slope of the water table and the transmissivity of the geological formations.
Groundwater Recharge	Refers to the portion of rainfall that actually infiltrates the soil, percolates under gravity through the unsaturated zone (also called the Vadose Zone) down to the saturated zone below the water table (also called the Phreatic Zone).
Groundwater Resource	All groundwater available for beneficial use, including by man, aquatic ecosystems and the greater environment.
Groundwater Resource Units	(GRU's) Represent provisional zones defined for the purposes of assessing and managing the groundwater resources of a region, in terms of large-scale abstraction from relatively shallow (depth < 300m) production boreholes. They represent areas where the broad geohydrological characteristics (i.e. water occurrence and quality, hydraulic properties, flow regime, aquifer boundary conditions etc.) are anticipated to be similar.
Pollution	The introduction into the environment of any substance by the action of man that is, or results in, significant harmful effects to man or the environment.
Quartzite	A nonfoliated metamorphic rock composed almost entirely of quartz. It usually forms from the metamorphism of sandstone.
Saturated Zone	The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.
Unconfined Aquifer	An aquifer with no confining layer between the water table and the ground surface where the water table is free to fluctuate.
Unsaturated Zone	That part of the geological stratum above the water table where interstices and voids contain a combination of air and water; synonymous with *zone of aeration* or *vadose zone*.
Water Table	The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally.

List of Abbreviations

DMR	Department of Mineral Resources
DWS	Department of Water and Sanitation
EC	Electrical Conductivity (Salinity of water)
GA	General Authorisation
L/s	Litres per second
m	metres
mamsl	metres above mean sea level
mbgl	metres below ground level
mS/m	milli-Siemens per metre
m^3/a	cubic metres per annum
mm	millimetres
m^3/m	cubic metres per month
SRK	SRK Consulting (South Africa) (Pty) Ltd
mg/ℓ	milligrams per litre
Ma	Million years
MAP	Mean annual precipitation or rainfall
NGA	National Groundwater Archive

1 Introduction

1.1 Appointment

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by Mr. Frank Crossley of Mystic-Pearl to carry out a basic groundwater assessment of a portion of Portion 1 of the Farm Vooruitzigt 81 (hereafter both known as “the site”). The site is is located immediately west of Kimberley at the intersection of the N8 and R31 routes in the Northern Cape Province (**Figure 1-1**). Mystic-Pearl intends to construct a diamond processing plant at this site. Kimberlite rock removed from the Ottos Kopje mine, located approximately 3 km northeast of the site, is proposed to be washed and processed here. Due to space constraints, it is not feasible to have a processing plant at the mine site.

In terms of the National Environmental Management Act 107 of 1998 (NEMA) and the Environmental Impact Assessment (EIA) Regulations, 2014, the processing of ore is a listed activity and may not commence without an Environmental Authorisation (EA) from the competent authority, and a Basic Assessment (BA) is required to support the application for the EA. A groundwater assessment of the site and surrounds is needed as part of this BA.

1.2 Scope of Report

No formal terms of reference were provided, however, in order to complete a preliminary assessment of the proposed mine’s impact on the groundwater resource in the area, SRK proposed that a baseline and impact study be undertaken which required that the following scope of work be executed:

1. Collate available groundwater information such as those data at the Department of Water Affairs’ (DWA) national groundwater archives (NGA), the DWA 1:500 000 hydrogeological map series, the DWA phase 2 national groundwater resource assessment data, satellite images and published geological maps and reports;
2. Conduct a hydrocensus of the site and the surrounding area (2 km radius);
3. Undertake satellite image lineament mapping for the area to ascertain if there are any significant faults or dykes near or beneath the site which may form a conduit for movement of contaminants into the aquifer;
4. Capture the data collected in a GIS database;
5. Assess impacts on groundwater and recommend mitigation measures to reduce the potential impacts; and
6. Compile a report in which the groundwater baseline conditions and impacts aredescribed and the results and recommendations summarized.

Impacts associated with the mine are not considered in this report.

1.3 Project Description

The client is in the process of applying for a right to process kimberlite ore at this site. Water will be used at the proposed processing plant to wash the ore and for dust suppression. This water will be obtained from the Sol Plaatje Municipality. A Boerevestnik plant will be utilised to recover diamonds from the kimberlite. This mining method utilizes X-rays to recover diamonds and uses much less water than the conventional panning method. No chemicals or additives will be added to the water. Water demand for the operational phase was calculated by the client and reported as 115.2 m^3/d. The waste water will be ducted to a slimes dam where sediment will settle. Recovered water will be re-cycled to the plant. The site layout plan, as supplied by the client, is indicated in **Figure 1-2**.

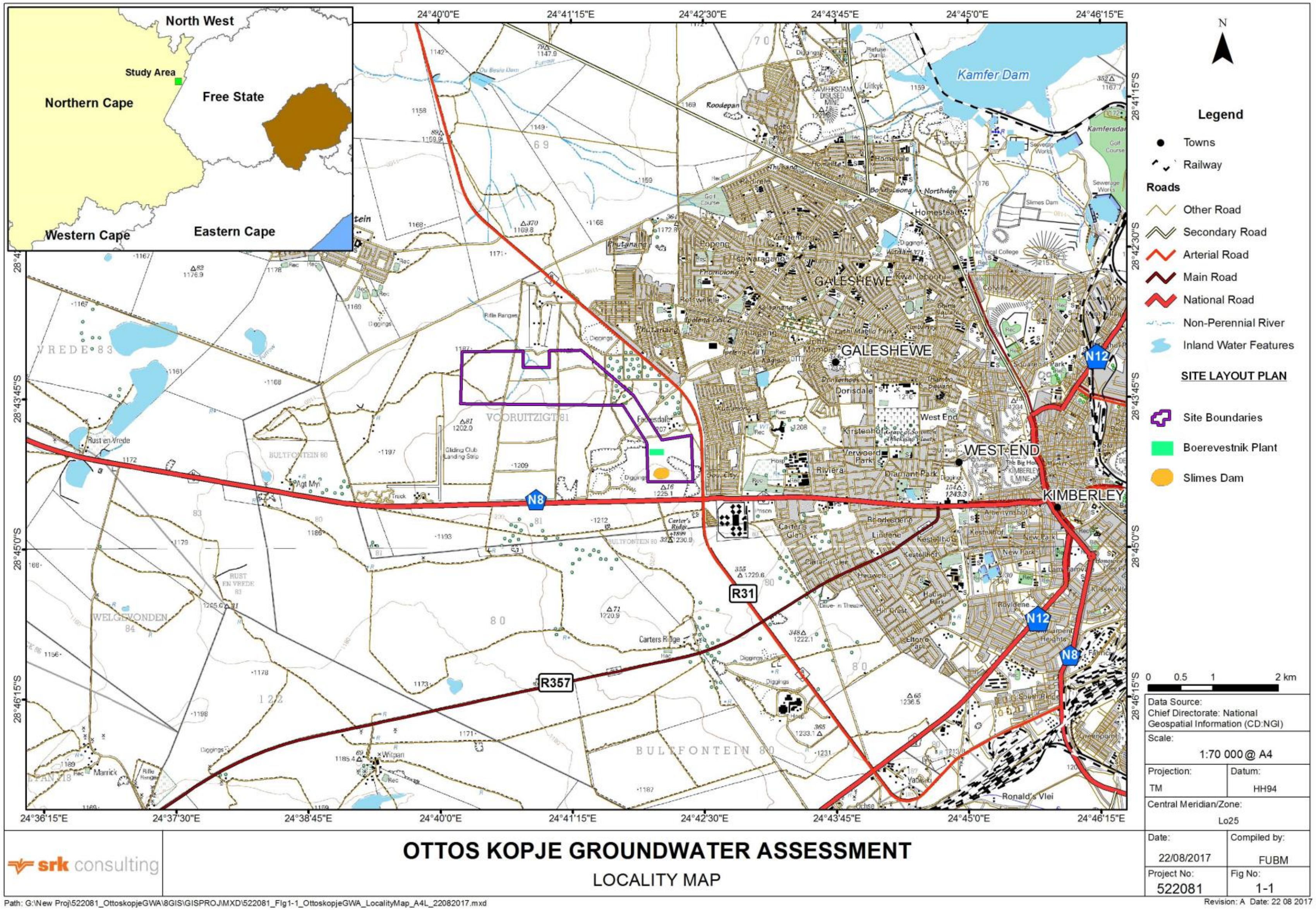

Figure 1-1: Locality Map

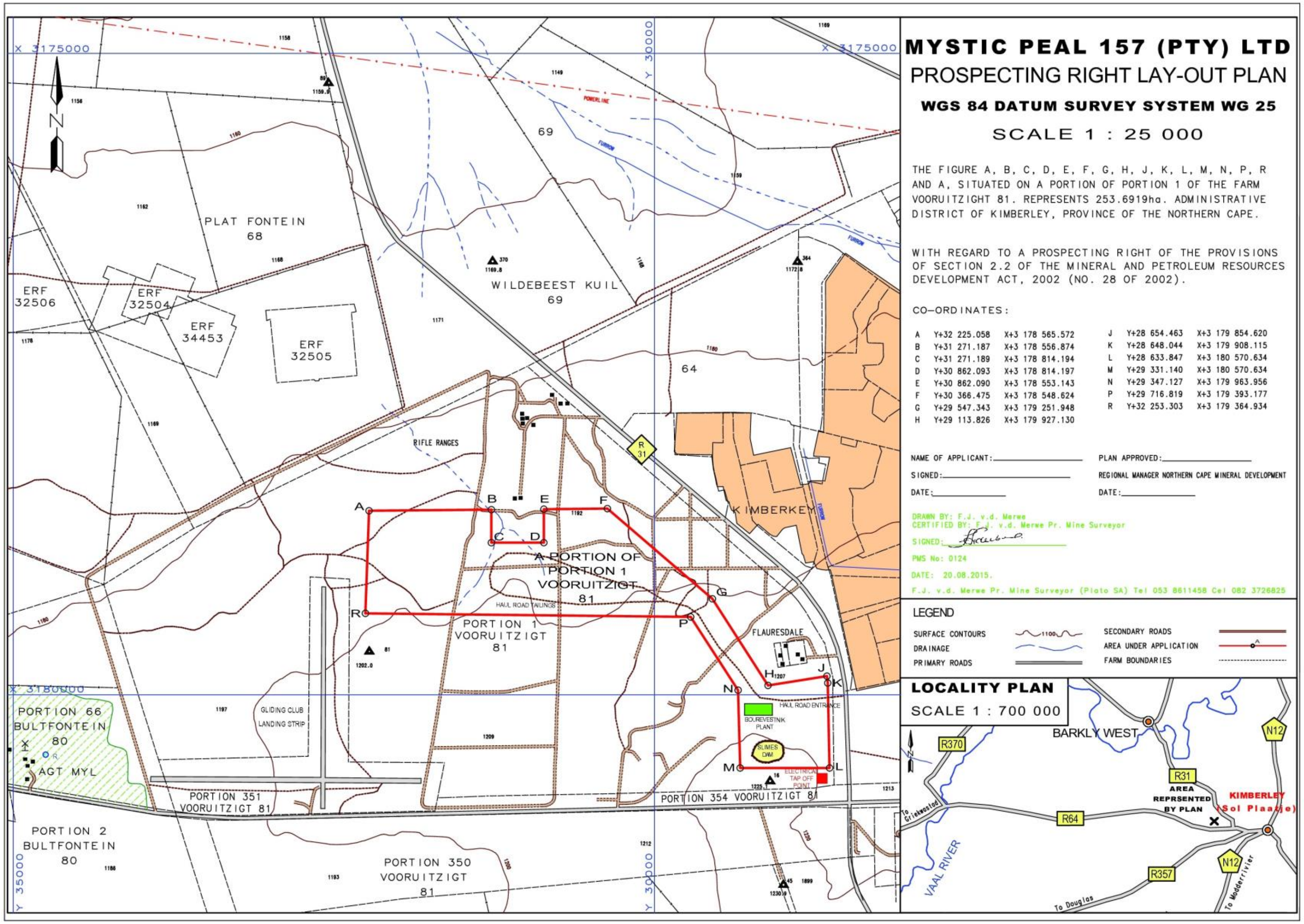

Figure 1-2: Ottos Kopje Processing Plant Site Layout Plan

The site is located immediately west of Kimberley, and is in the Sol Plaatje Local Municipality, Frances Baard District Municipality, of the Northern Cape Province. Both the N8 and R31 asphalt routes border the site. Access to the site will be via a junction to the R31 route. Farms and small communities in the area are totally dependent on groundwater, whilst larger communities like Kimberley, Platfontein and Barkley West use surface water from the Vaal River.

1.4 Purpose of Report

The purpose of this report is to provide an independent hydrogeological assessment of the baseline groundwater conditions and resources at the site, and to carry out a preliminary assessment of the potential groundwater impacts that may arise as a result of the proposed processing plant. In addition, it is a requirement to advise the client about necessary precautions to be taken to protect the groundwater resources of the area.

1.5 Methodology

A hydrocensus was conducted on 7 August 2017 at the site and immediate surrounds. Simultaneously, hydrogeological information (borehole depth, yield, groundwater intersections, groundwater use and estimated abstraction, etc.) was collected for the area. Additional information obtained from the DWS National Groundwater Archive (NGA) was added to this database.

2 Physiography and Climate

The site varies in altitude from a minimum of 1 192 meters above mean sea level (mamsl) in the northwest, to a maximum of 1 225 mamsl in the south. The site's surface topography slopes gently to the north, and is relative flat. A surface watershed occurs immediately south of the site and surface water south of this watershed flows westwards towards the Vaal River. Surface water from the site drains to the north and joins an ephemeral tributary of the Vaal River.

Surface water on the site is only present briefly during and after thunderstorms. A number of dry pans can be observed on the photographs north and west of the site, and many of these are indicated on the 1:50 000 topographic maps. Only one drainage line is mapped for the site. It occurs on the northern site boundary and drains to the north.

The climate of the area is typical semi-desert, with very hot summers and cold winters. Temperature data for Kimberley (as supplied by the South African Weather Service) for the period 1960-2000 is summarized in **Table 2-1** over page. The data indicates that January is the hottest month, with an average maximum daily temperature of 32.7°C, and July the coldest, with an average maximum daily temperature of 19.5°C. In June and July, the average minimum daily temperature drops to <3°C.

Table 2-1: Temperature Data for Kimberley (South African Weather Service)

KIMBERLEY CLIMATIC AVERAGES 1960-2000													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
MAX TEMP	32.6	31.2	28.9	25	21.5	18.4	18.8	21.4	25.7	28	30.1	32.1	26.2
MIN TEMP	17.7	17.3	15.2	10.7	6.2	2.8	2.5	4.7	8.8	11.9	14.5	16.5	10.7
AVE TEMP	25.2	24.3	22	17.9	13.9	10.6	10.6	13.1	17.3	19.9	22.3	24.3	18.5
KIMBERLEY CLIMATIC ABSOLUTES 1960-2000													
HIGHEST TEMP	40.4	39.9	37.8	34.9	31.3	26.6	26.8	31.2	36.6	37.6	39.2	40.9	40.9
LOWEST TEMP	6.5	5.6	2	-2.8	-5.7	-7.9	-8.1	-7.8	-5.5	-0.5	2.5	3.8	-8.1

The above table also indicates that the absolute maximum temperature recorded during this period was 40.9°C and the lowest -8.1°C.

The site falls within the summer rainfall area with a mean annual precipitation (MAP) of 448 mm (World Bank, 22 Aug 2017). The average monthly precipitation, as provided by the World Bank's online interactive rainfall map, is summarized in
Table 2-2 below.

Table 2-2: Precipitation Statistics for Kimberley (Source: World Bank)

	Average monthly precipitation for Kimberley (1900-2009)												
Month	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***	***Year***
Mean (mm):	*65.8*	*70.1*	*70.8*	*41.4*	*20.7*	*4.9*	*5.0*	*7.3*	*18.9*	*37.1*	*50.3*	*56.4*	***448.5***

The data indicates that >79% of the MAP occurs during the months November to April. This phenomenon is characteristic of a late-summer rainfall area. February and March are the wettest months with an average monthly precipitation of >70 mm whilst June is the driest with <5 mm.

The MAP for this area, derived from the GRA2 database (DWAF, 2005), is indicated in **Figure 2-1**. The figure indicates that the highest precipitation in the area occurs 10 km east of the site where it reaches >500 mm/a. The rainfall generally decreases from east to west and the lowest precipitation occurs 7 km northwest of the site where it decreases to <420 mm/a. **Figure 2-1** indicates that the MAP for the site varies between 455 mm/a in the northwest and 470 mm/a in the southeast. Throughout the area the MAP indicated by **Figure 2-1** is slightly higher than that suggested by the World Bank's rainfall atlas (which is similar to data from the South African Rain Atlas' website which has been discontinued). The GRA2 database was derived by modelling existing rainfall station data and incorporating topography as rainfall varies with topography. Therefore the MAP derived for a certain area will often differ slightly from the MAP for a single rainfall station within that area.

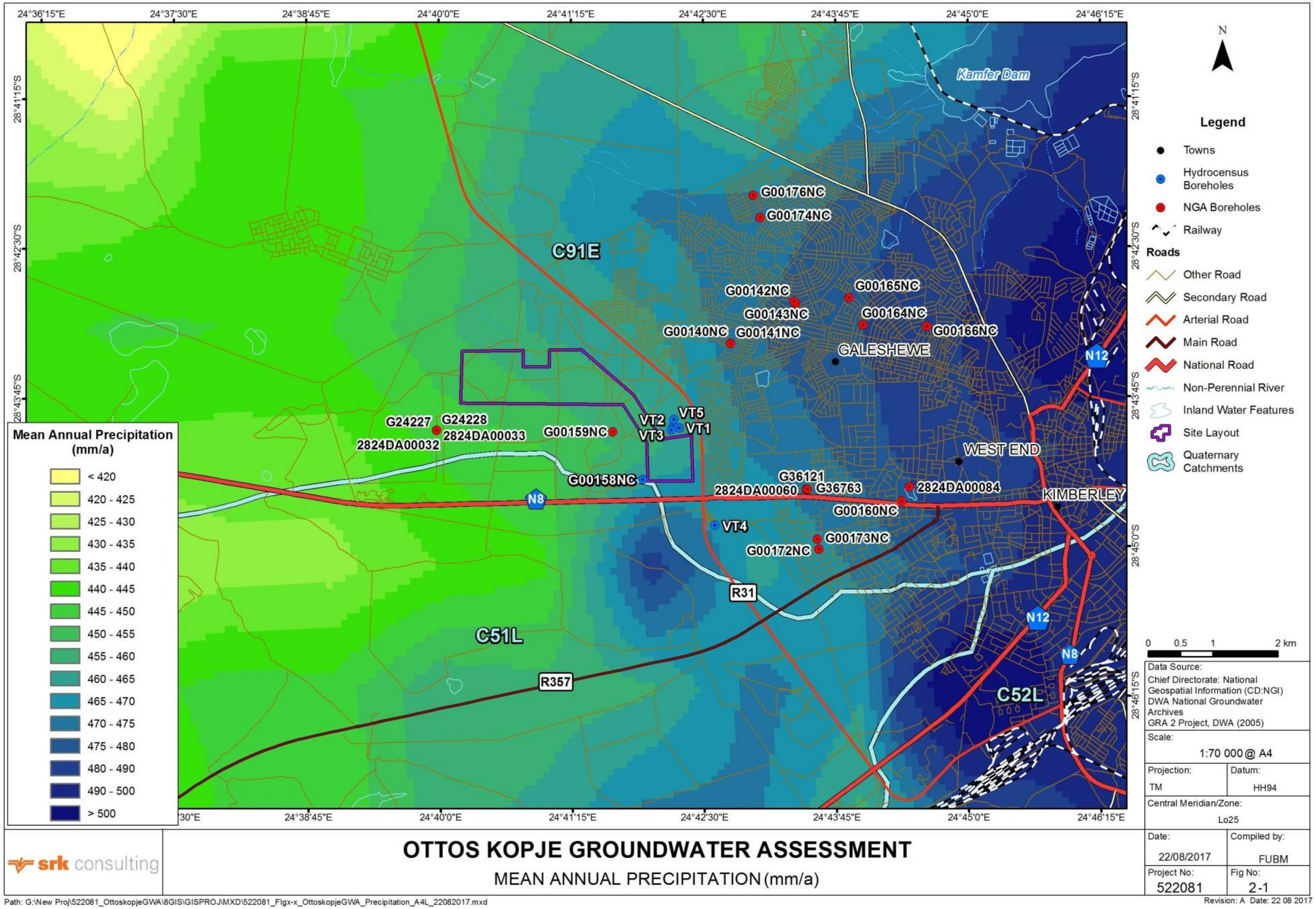

Figure 2-1: Mean Annual Precipitation (mm/a)

3 Geology

Figure 3-1 indicates the general surface geology of the site as derived from the published 1:250 000 scale geological map sheet 2824 Kimberley (CGS, 1993). The figure indicates that the site is partially underlain by a Karoo dolerite sill, whilst windblown sand covers the central area. This windblown sand is mined in the central part of the site where it is >3 m thick. Borehole information indicates that the dolerite intrusions in the immediate vicinity of the site are generally thin and are underlain by sediments (mostly shale) of the Prince Albert Formation of the Ecca Group, Karoo Sequence. This Group has a total thickness of approximately 1 300 m (SACS, 1980).

The oldest rocks in the area are andesite, quartzite and conglomerate of the Allanridge Formation. Outcrops of this Formation occur approximately 2 km northwest and 3 km north of the site.

The Allanridge Formation is overlain by the Ecca Group in this area. This Group consists of sandstones, siltstones and shales, which originated as clastic sediment deposited in a large and shallow inland sea. The post glacial marine mudstones of the Prince Albert Formation form the base of the Ecca Group and mainly consist of grey shale with subordinate sandstone beds. The latter were deposited by as a result of turbidity currents. Hydrocensused borehole VT4 at the horse club, <1 km southeast of the site, intersected such a sandstone bed beneath the dolerite sill. The dip of the Ecca Group in this area is difficult to measure due to weak outcrops, but is generally horizontal.

The Prince Albert Formation is overlain by black carbon-rich shale and thin carbonate beds of the Whitehill Formation. It is characterized by white weathering, pyrite and gypsum at surface and dolomite concretions. A small outcrop of this formation is mapped <2 km southeast of the site and east of the R31/R357 intersection.

Numerous marine fossils are imbedded in the Ecca Group. These include petrified wood, shells, shark teeth and more.

Numerous kimberlite intrusions are mapped north and east of the site. These structures include pipes and two fissures. The two fissures are parallel with a ENE-WSW strike and extend over distances of 1 200 and 1 600 m, respectively.

The two fissures are the only lineaments mapped on the geological map. However, several lineaments were mapped from Google Earth images and overlain on the geology map (see **Figure 3-1**). Most of these lineaments are difficult to locate in the field due to weak outcrops (covered by recent deposits or weathered formation). Normally these structures have been intruded by dolerite dykes, but this could not be confirmed in the field due to weak outcrops. It is also expected that the structures extend well beyond the mapped occurrences, but are obscured by the sand cover and calcrete. In the area southwest of the site these mapped lineaments indicate a preferred NW-SE strike.

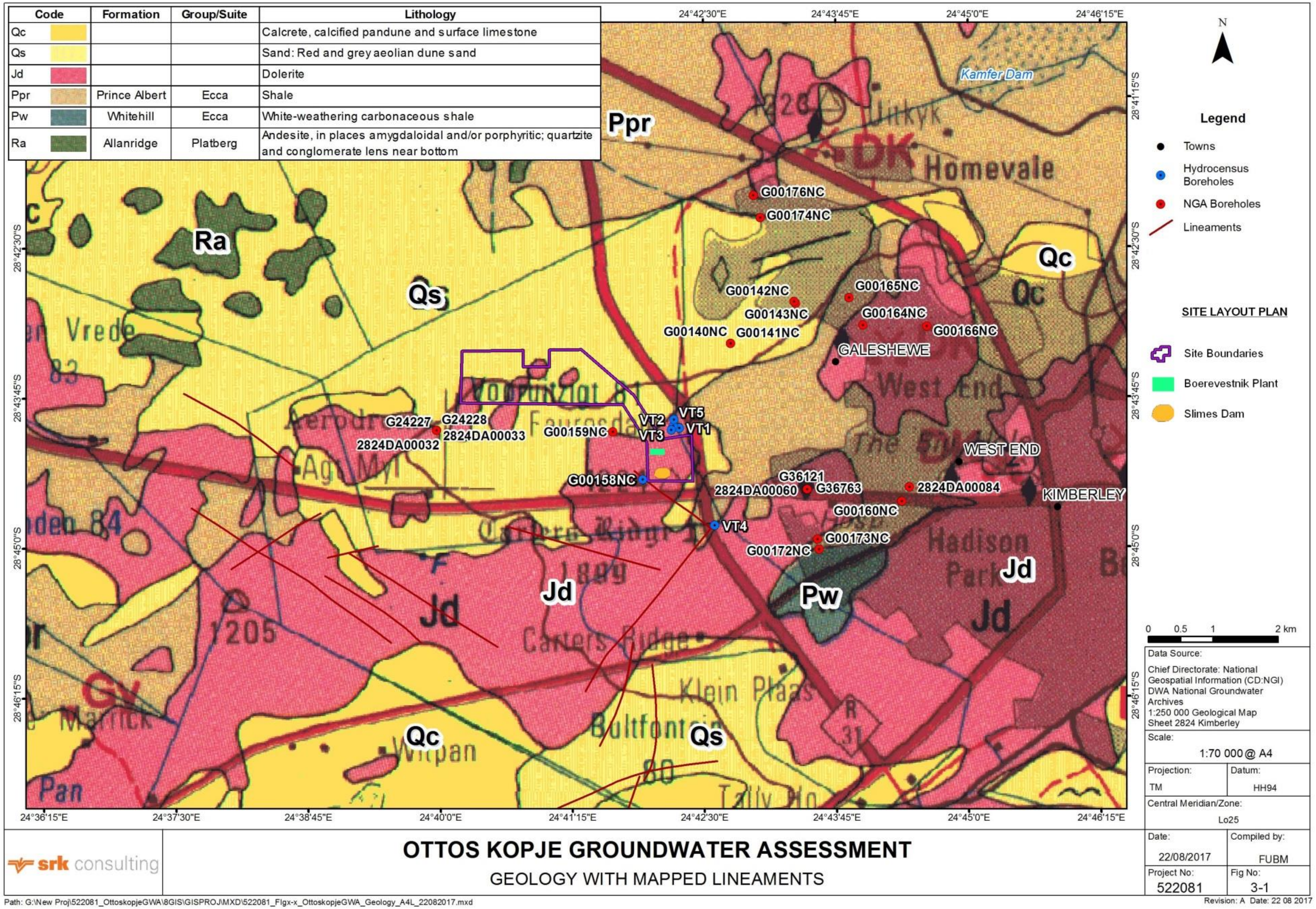

Figure 3-1: Geology with Mapped Lineaments (after the CGS, 1993)

4 Geohydrology

4.1 Aquifer Characteristics

Groundwater at the site occurs mainly in a secondary (or fractured-rock) aquifer system. Secondary aquifers are formed by jointing and fracturing of the otherwise solid bedrock. Joints and fractures are formed by faulting, cooling of magma outflows, intrusion of dolerite dykes and sills, intrusion of kimberlite pipes and fissures, folding and other geological forces. Generally, the harder rocks (sandstone and dolerite) fracture more easily under stress to form superior aquifers compared to the softer sediments like shale and mudstone, which rather deform than fracture under stress.

Successful boreholes may also abstract groundwater from the weathered zone in areas where the groundwater levels are shallow, i.e. <10 metres below ground level (mbgl). These weathered aquifers behave like unconsolidated aquifers and successful boreholes can be placed at random in these areas. However, these aquifers have a restricted distribution and are very vulnerable to droughts. Therefore it does not form an important aquifer in this study area.

According to the 1:500 000 Hydrogeological map sheet of Kuruman (DWAF, 2003), the site falls within Quaternary Catchment C91E. It straddles both a fractured-rock aquifer with expected yields ranging between 0.5 – 2 L/s and an intergranular and fractured-rock aquifer with expected yields ranging between 0.0 and 0.1 L/s. The fractured-rock aquifer occurs in the central and northern part of the site and the intergranular and fractured-rock aquifer in the far southern part of the site, as illustrated in **Figure 4-1**. The proposed localities for the processing plant and slimes dam are in the southern part of the site and underlain by the latter aquifer.

Figure 4-1 also indicates that the groundwater quality, expressed as electrical conductivity (EC), throughout the study area ranges between 70 and 300 mS/m and therefore is only marginally suitable-to-unsuitable for human consumption, according to the SANS 241:2015 Drinking Water Guidelines. However, groundwater quality may deviate from this “average range” and the sandstone beds and dolerite and kimberlite intrusions may yield groundwater with lower ECs. For example, groundwater from a sandstone layer below the top dolerite sill at the Kimberley Big Hole has a measured EC of approximately 60 mS/m.

The aquifer vulnerability of the site is indicated in **Figure 4-2**. Vulnerability is determined by evaluating seven parameters, namely:

- Depth to groundwater;
- Recharge;
- Aquifer media;
- Soil media;
- Topography;
- Impact on vadose zone; and
- Hydraulic conductivity.

Aquifer vulnerability is defined as the likelihood for contamination to reach a specified position in the groundwater system after being introduced at some point above the uppermost aquifer. Figure 5 2 indicates that the groundwater source of the site has a low medium to high vulnerability to contamination from surface sources. The only area of low medium groundwater vulnerability exists in the extreme southeastern side of the property. Aquifer vulnerability in the area directly north thereof is classified as medium. The central and northern parts of the site are underlain by an aquifer with high groundwater vulnerability. The high groundwater vulnerability in this area is mainly caused by shallow groundwater levels. **Figure 4-2** also indicates that the proposed sites for the slimes dam and processing plant are in the area where aquifer vulnerability is the lowest. In this are the aquifer occurs beneath a dolerite sill. This sill is approximaly 25-30 m in vertical thickness and forms an aquiclude above the underlaying Ecca aquifer.

The mean annual recharge for the area increases from north to south (**Figure 4-3**) ranging from 7 to 9 mm/a. Although this seems contradictory to the rainfall distribution, factors such as slope, soil type, depth to groundwater level and others also influence recharge. Recharge at the site varies between 7.8 mm/a in the north and 8.6 mm/a in the south.

4.2 Hydrocensus

The hydrocensus was conducted on 7 August 2017. Mr Frank Crossley accompanied Mrs Lize van Zyl of SRK and indicated the boundaries of the site and some borehole localities. The hydrocensus results are summarised in **Table 4-1**. **Figure 4-4** indicates the localities of the hydrocensus and NGA boreholes. Six boreholes, in the immediate area of the the site, were surveyed. No boreholes could be identified on site. The hydrocensus data indicate that borehole yields are low and groundwater quality poor (unsuitable for human consumption – SANS 241:2015). Groundwater is exclusively used for stock watering only. Total abstraction from the two production boreholes and one dugwell surveyed is approximately 16 000 m^3/a.

Groundwater levels in the area surrounding the site are relative shallow ranging between 6.7 and 15.7 mbgl. The latter groundwater level was measured in borehole G00158NC directly west of the southern boundary of the site. This deeper groundwater level is linked to a high lying area and the groundwater elevation of this borehole is similar to that of borehole VT4 (1 212 mamsl). Groundwater levels immediately north of the area are shallower due to lower lying terrain. However, the groundwater elevation in this area is lower than in the area south and southeast of the site, which suggests that groundwater flow at the site is roughly from southeast to northwest. This flow direction is similar to the surface water drainage direction, which is to be expected as natural groundwater flow directions in the Karoo regions usually mimics surface water flow directions.

EC values measured during the hydrocensus vary between 190 and 280 mS/m. These relatively high EC values are normal for groundwater of the Karoo region. These values are also similar to the published (DWAF, 2003) average values for Quaternary GRU C91E in which the site is located.

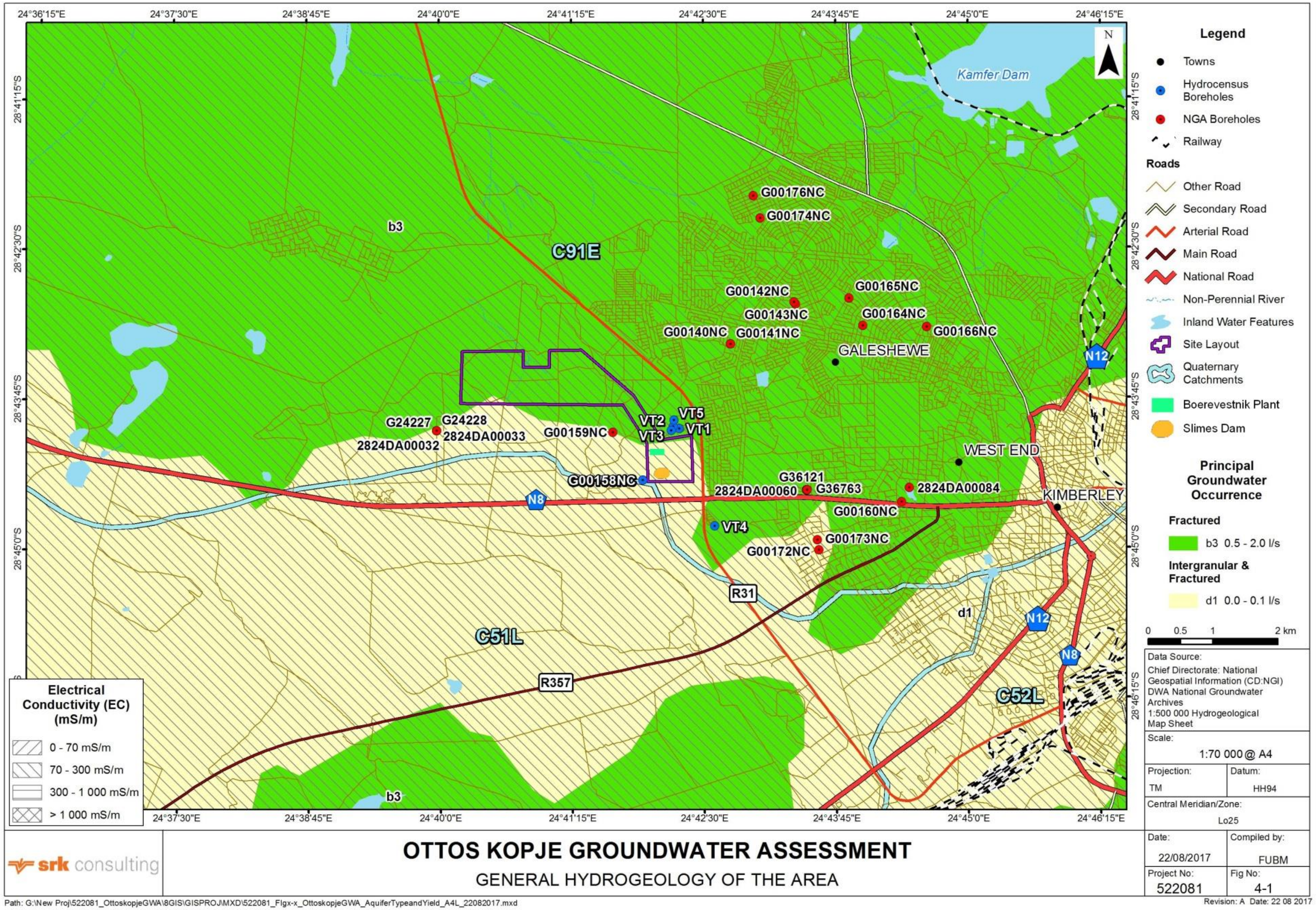

Figure 4-1: General Hydrogeology of the Area (after the DWS, 2003)

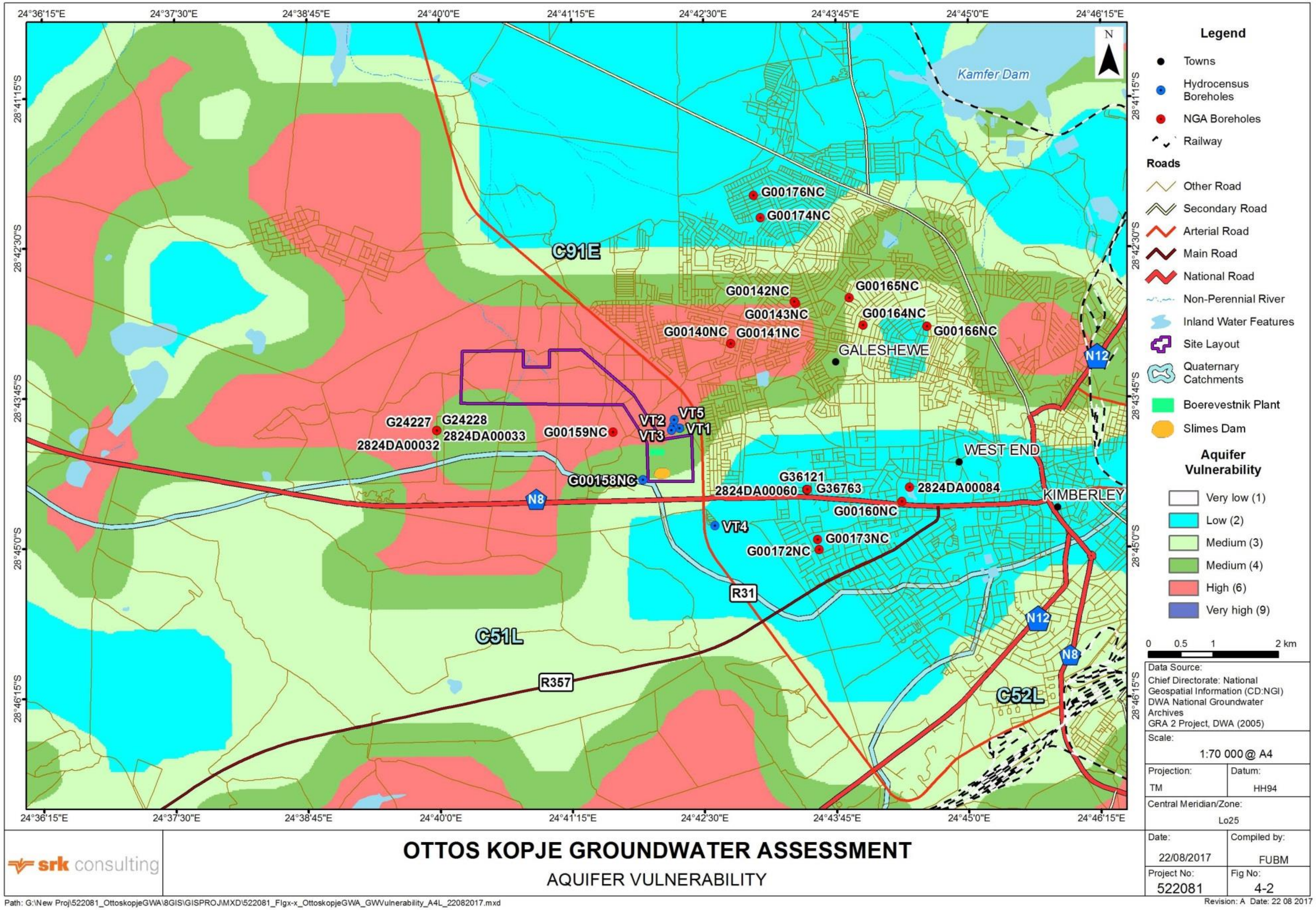

Figure 4-2: Aquifer Vulnerability

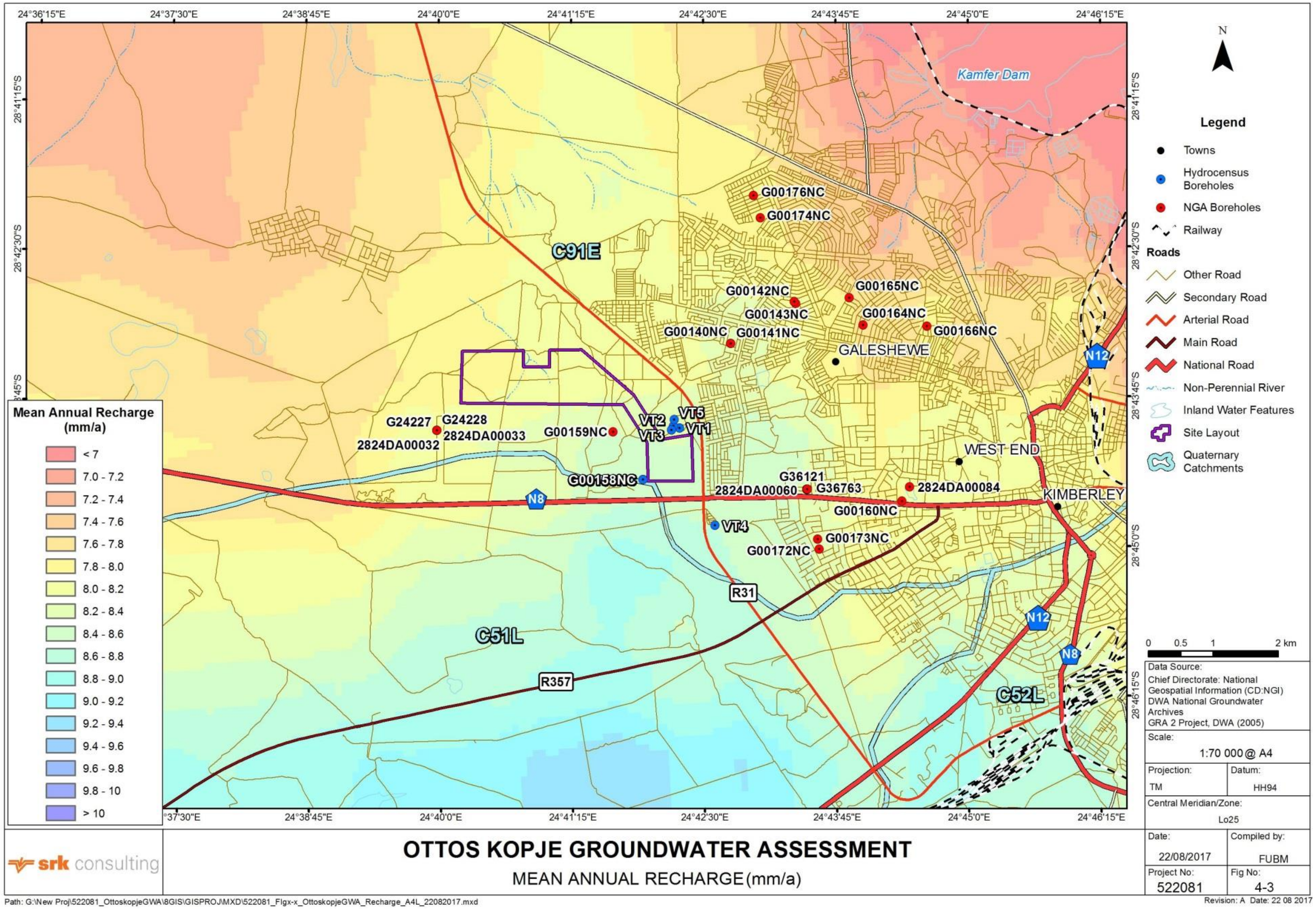

Figure 4-3: Mean Annual Recharge (mm/a)

Table 4-1: Summary of Hydrocensus Results Collected in the Vooruitzigt Portion 1 Area

Hydrocensus data collected 7 August 2017														
BH Name	Longitude	Latitude	Eleva-tion (mamsl)	Depth (mbgl)	Water Strike (mbgl)	Yield (L/s)	Water Level (mbgl)	pH	EC (mS/m)	Equipment	Pump Intake (mbgl)	Use	Abstrac-tion (m^3/d)	Comments
VT1	-28.73347	24.70445	1211				6.67	7.46	235	Submersible		Stock	7 000	No information available from owner
VT2	-28.73323	24.70348	1211	90						None			0	Bh drilled 2009, Shale, dry
VT3	-28.73323	24.70348	1211	10				7.4	280	Submersible	9.8	Stock	6 500	Dug Well, Pump yield 0.8 L/s, Sealed - WL was 6.5 mbgl in 2012. Weathered shale
VT4	-28.74705	24.71002	1223	32	29-30	0.50	10.75	7.38	190	Solar Pump	27	Stock	2 700	Pumping water level, Pump Yield 0.47 L/s, Water Strike in sandstone below dolerite sill
VT5	-28.73229	24.70360	1210			0.10				None				Owner not available, Was equipped with windpump, Yield too low
G00158NC	-28.74065	24.69869	1228	80	25.4		15.74			None				Monitoring bh for solid waste disposal site

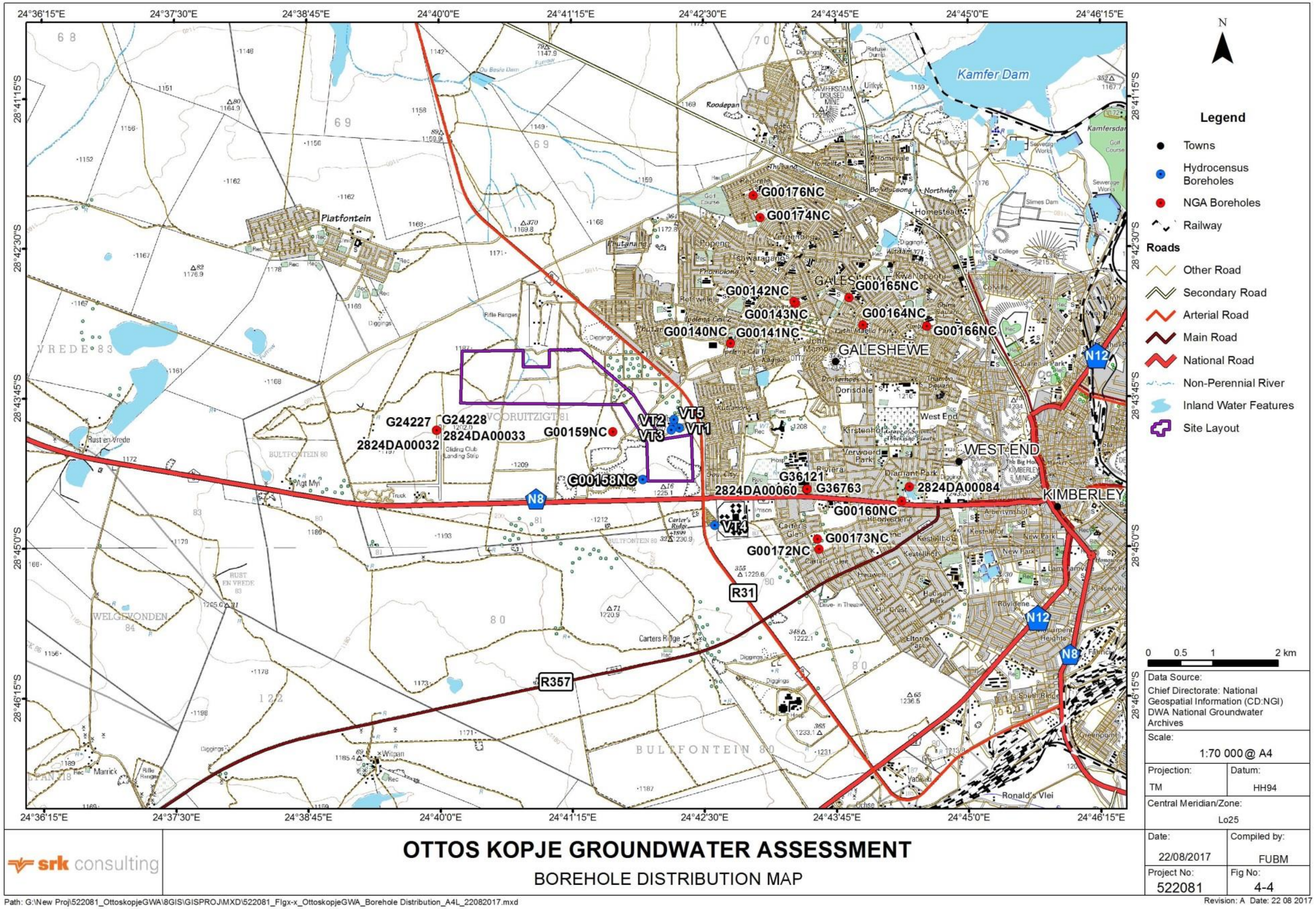

Figure 4-4: Borehole Distribution Map

Table 4-2 below defines the different aquifer classes. Based on this table the aquifer underlying the site can be classified as a Poor Aquifer Region.

Table 4-2: Aquifer Class

Aquifer Class	Description
Sole source aquifer	An aquifer which is used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources should this aquifer be impacted upon on or depleted
Major Aquifer region	High-yielding aquifer of acceptable quality water
Minor Aquifer region	Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor quality, or aquifer which will never be utilized for water supply and which will not contaminate other aquifers
Poor Aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer which will never be utilized for water supply and which will not contaminate other aquifers
Special Aquifer region	An aquifer designated as such by the Minister of Water Affairs, after due process

5 Potential Impacts and Mitigation Measures

The aim of this section is to provide a preliminary assessment of any potential groundwater impacts that are likely to arise as a result of the proposed processing plant.

Table 5-1, **Table 5-2** and **Table 5-3** indicate possible groundwater impacts during the construction, operation and decommissioning phase of the processing plant respectively, with and without implementation of mitigation measures. Potential impacts include the following:

- Wastewater from the washbays that can contaminate groundwater if not handled correctly;
- Contamination of groundwater from on-site sanitation facilities;
- Contamination of groundwater from workshops, fuel storage facilities and refuelling of mine vehicles;
- Contamination of groundwater from wastewater recycling and slimes dams; and
- Contamination of groundwater from stockpiles, waste rock piles and slimes dam.

Mitigation measures need to be implemented to minimise identified impacts during all phases of the proposed project life-cycle (construction, operation and decommissioning). These measures are also indicated in this table.

Note: (Potential Significance) = (*Magnitude* + *Duration* + *Scale*) x *Probability*

The potential significance (PS) has a maximum rating of 100 points. Environmental impacts are rated as having either a High (H), a Moderate (M) or a Low (L) significance according to the following scale:

PS ≥ 60 = High Environmental Significance
60 < PS ≥ 30 = Moderate Environmental Significance
PS < 30 = Low Environmental Significance

The impact rating methodoly is indicated in Appendix 2.

Table 5-1: Potential Groundwater Impacts During Construction With and Without Mitigation Measures

	Impact description	Status of Impacts		Spatial Scale of Impacts		Temporal Scale of Impacts		Probability of Impacts		Magnitude of Impacts		Potential Significance of impacts	
		Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating
Without Mitigation Measures	Groundwater contamination by oil and fuel spills from construction vehicles	Negative	-	Site	1	Short	2	Medium	3	Low	4	Low	21
	Groundwater contamination by on-site sanitation facilities	Negative	-	Site	1	Medium	3	Medium	3	Low	4	Low	24
	Essential mitigation measures: • Place oil traps under stationary machinery, only re-fuel machines at fuelling station, construct structures to trap fuel spills at fuelling station, immediately clean oil and fuel spills and dispose contaminated material (soil, etc.) at licensed sites only. • On-site sanitation must be constructed far away from permeable formations and significant aquifer systems. • Ensure vehicles and equipment are in good working order and drivers and operators are properly trained. • Ensure that good housekeeping rules are applied.												
With Mitigation Measures	Groundwater contamination by oil and fuel spills from construction vehicles	Negative	-	Site	1	Short	2	Medium	2	Low	4	Low	14
	Groundwater contamination by on-site sanitation facilities	Negative	-	Site	1	Medium	2	Medium	2	Low	4	Low	14

Table 5-2: Possible Groundwater Impacts During Operation With and Without Mitigation Measures

Phase	Impact description	Status of Impacts		Spatial Scale of Impacts		Temporal Scale of Impacts		Probability of Impacts		Magnitude of Impacts		Potential Significance of impacts	
		Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating
Without Mitigation	Increased salinity in aquifers, due to infiltration of recycled waste water from slimes dams with higher salt concentrations due to evaporation	Negative	-	Local	1	Long	4	Low	2	Low	2	Low	14
Without Mitigation	Groundwater contamination by oil, fuel, recycling dams and stock piles, as well as on-site sanitation.	Negative	-	Site	1	Long	4	Medium	3	Low	4	Low	27
Without Mitigation	**Essential mitigation measures:** • Implement and follow water saving procedures and methodologies. • Minimise waste water by the appropriate engineering design and re-use for other purposes where possible. • A monitoring system must be implemented to monitor groundwater and surface water quality, flow and water levels. • Ensure vehicles and equipment are in good working order and drivers and operators are properly trained. • Place oil traps under stationary machinery, only re-fuel machines at fuelling station, construct structures to trap fuel spills at fuelling station, immediately clean oil and fuel spills and dispose contaminated material (soil, etc.) at licensed sites only.												
With Mitigation	Increased salinity in aquifers, due to evaporation of waste water	Negative	-	Site	1	Short	2	Impro-bable	1	None	0	Low	3
With Mitigation	Groundwater contamination by oil, fuel, recycling dams and stock piles, as well as on-site sanitation.	Negative	-	Site	1	Long	4	Low	2	Low	4	Low	18

Table 5-3: Potential Groundwater Impacts During Decommissining With and Without Mitigation Measures

Phase	Impact description	Status of Impacts		Spatial Scale of Impacts		Temporal Scale of Impacts		Probability of Impacts		Magnitude of Impacts		Potential Significance of impacts	
		Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating	Quanti-tative Rating	Rating		Rating	Quanti-tative Rating	Rating	Quanti-tative Rating
Without Mitigation Measures	Groundwater contamination by oil, fuel and waste ore	Negative	-	Site	1	Short	2	Low	1	Low	3	Low	6
Without Mitigation Measures	**Essential mitigation measures:** • A procedure for the storage, handling and transport of different hazardous materials and waste ore must be drawn up and strictly enforced. • Ensure vehicles and equipment are in good working order and drivers and operators are properly trained. • Place oil traps under stationary machinery, only re-fuel machines at selected re-fuelling points, construct structures to trap fuel spills at re-fuelling points, immediately clean oil and fuel spills and dispose contaminated material (soil, etc.) at licensed sites only.												
With Mitigation Measures	Groundwater contamination by oil, fuel and waste ore	Negative	-	Site	1	Short	2	Low	3	Low	3	Low	18

The site boundaries are superimposed on the geology and lineament map (**Figure 3-1**) whilst the Boerevestnik plant and slimes dam are indicated on the aquifer type and aquifer vulnerability maps (**Figure 4-1** & **Figure 4-2**). It is evident that no mapped structures intersect the site area. Therefore the proposed localities for the Boerevestnik plant and slimes dam are favourable and in an area with a reduced risk to contaminate groundwater.

It is concluded that the negative impact of proposed plant and slimes dam on groundwater is medium low and with mitigation measures implemented, the risk of groundwater contamination, is low.

6 Groundwater Monitoring Programme

To monitor the potential impact of the proposed processing plant on the groundwater resources, the following monitoring is recommended:

- With permission of the owners, boreholes VT4 and VT1 can be used as upstream and downstream water quality monitoring boreholes, respectively. Should the owners deny permission for this purpose, Mystic-Pearl has to construct an upstream monitoring borehole between the slimes dam and the southern boundary fence and a downstream monitoring borehole approximately 50 m north of the Boerevestnik plant;
- Groundwater levels must be recorded at the above-mentioned quality monitoring boreholes and G00158NC on a monthly basis. A water level dipmeter with 1 cm calibration and 30 m cable will have to be obtained for this;
- Water samples must be collected at the quality monitorings boreholes mentioned above (either production boreholes VT1 and VT4 or two newly constructed boreholes) on a six-monthly basis and submitted to SANAS accredited laboratories for analysis of the macro-chemistry and inductively coupled plasma mass spectrometry (ICP-MS) metal scan;
- The monitoring data must be evaluated on an annual basis by a geohydrologist and a monitoring report compiled and presented to Mystic Pearl; and
- Monitoring must continue post closure of the facility, for at least two years on a six-monthly basis, to establish trends, if any. The data must be evaluated on an annual basis by a geohydrologist and after two years assessed to determine if monitoring needs to continue.

7 Conclusions

Based on the information discussed in this report, the following can be concluded regarding the groundwater conditions in the area of Portion of Portion 1 of the Farm Vooruitzigt 81 :

- The site is partially underlain by a dolerite sill and the central part is covered with windblown sand;
- The dolerite sill is generally thin and underlain by Ecca mudstone, shale and sandstone. However, it forms an aquiclude above the Ecca aquifer below;
- Average MAP for the site is approximately 460 mm/a and recharge varies from 7.8 mm/a in the north-west to 8.6 mm/a in the south-east;
- The groundwater map indicates that the northern part of the site is underlain by a fractured-rock aquifer and the average maximum immediate yield of successful boreholes drilled in this region ranges between 0.5 – 2.0 L/s. The southern part of the site (where the processing plant and

slimes dam are proposed) is underlain by a low yielding (0 – 0.1 L/s) intergranular and fractured-rock aquifer;

- Lineament mapping indicates some lineaments in the area surrounding the site, but none of these intersect the site;
- Six boreholes were surveyed in the area surrounding the site during the hydrocensus. The data indicates that groundwater from these is exclusively used for stock watering;
- A Quaternary watershed occurs immediately south of the site, and surface water flows from the site to the northwest;
- Groundwater levels in the area surrounding the site vary between 6.7 and 15.7 mbgl;
- Groundwater quality in the study area, based on field measured ECs, is generally poor with measured ECs ranging from 190 to 280 mS/m;
- The proposed slimes dam and Boerevestnik plant are located in an area where groundwater vulnerability to surface pollution is medium, whilst the area to the north thereof is highly vulnerable to contamination from surface sources;
- From a groundwater perspective, the proposed processing site is favourable with low impact potentail, as long as possible groundwater contamination sources are kept away from lineaments;
- The potential impact of the proposed processing plant on local groundwater sources can be reduced by implementing mitigation measures during all phases of the project;
- A monitoring programme is essential to identify red flag situations, if any, timeously.

8 Recommendations

Based on the conclusions in this report, the following is recommended for the proposed processing plant:

1. Implement the recommended monitoring programme as indicated in **Table 5-2**; and
2. Implement the recommended mitigation measures as indicated in **Table 5-1** to **Table 5-3**.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

9 References

Council for Geoscience (CGS) (1993). 1 : 250,000 Geological map 2824 Kimberley.

Department of Water Affairs and Forestry (DWAF), (2003). 1 : 500,000 Hydrogeological Map Series Sheet 2722 Kuruman.

Department of Water Affairs and Forestry (DWAF), (2005). Groundwater Resource Assessment Phase 2. Reports 2C and 3E. Pretoria.

South African Committee for Stratigraphy (SACS), (1980). Stratigraphy of South Africa. Part 1. Litostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Bophuthatswana, Transkei and Venda: Handb. Geol. Surv. S. Afr., 8.

South African National Standard (SANS) 241-1: 2015, 241-2: 2015 Drinking Water.

South African Weather Service (2017/08/22): *http://www.weathersa.co.za*

World Bank (2017/08/22): http://sdwebx.worldbank.org/climateportal/

World Weather Online (2017/08/22): http://www.worldweatheronline.com/Kimberley-weather-averages/Northern-Cape/ZA.aspx

Appendix 1: NGA Data for the Farm Vooruitzigt 81 Area

Bh No	Latitude	Longitude	Acc (m)	Water Level (mbgl)	Yield (L/s)	Depth (mbgl)	Water Strike (mbgl)	Lithology
G00172NC	-28.75039	24.72646	10	17.57	1.5	60	23, 46	0-2m: Calcrete 2-60m: Shale
G00173NC	-28.74898	24.72619	10	6.99		50	20	0-50m: Shale
G00160NC	-28.74370	24.73952	10	2		80	10	0-80m: Shale
2824DA00060	-28.74209	24.72452		7	3.2	60	12, 18	0-47m: Shale, -60m: Dolerite
G36121	-28.74208	24.72452		25	2.6	93	30	0-30m: Shale, -93m: Dolerite
2824DA00056	-28.74207	24.72452		15	1.7	106	20	0-50m:Dolerite, -99m: Shale, -106m:Dolerite
2824DA00054	-28.74206	24.72452				22.86		0-3.66m: Boulders, -22.86m: Dolerite
2824DA00009	-28.74205	24.72452		5.95		12	11	0-12m: Dolerite
2824DA00007	-28.74204	24.72452		6.5	5.0	49	25.5	0-31m: Dolerite, -49m: Shale
2824DA00006	-28.74203	24.72452		10		36	18	
2824DA00008	-28.74203	24.72453		10	2.0	38	16	0-30m: Shale, -38m: Dolerite
2824DA00010	-28.74203	24.72454		5.68		12	11	0-12m: Dolerite
2824DA00055	-28.74203	24.72455		12.19	2.3	69.2	21.34	0-6m: Boulders, -65.5m: Shale, -69.2: Dolerite
2824DA00057	-28.74203	24.72456				126		0-75m: Dolerite, -80m: Shale, -126m: Dolerite
2824DA00059	-28.74203	24.72457		35	2.6	100	40	0-25m: Shale, -35m: Dolerite, -45m: Shale, -55m: Dolerite, -95m: Shale, -100m: Dolerite
G36763	-28.74203	24.72458				62		0-62m: Shale
2824DA00084	-28.74176	24.74071	10					No Info
G00158NC	-28.74065	24.69869	10	25.4		80	54	0-2m: Dolerite, -80m: Shale
G00159NC	-28.73398	24.69396	10	9.07		102	17	0-51m: Shale, -102m: Lava
2824DA00032	-28.73371	24.66619				123.5		0-16m: Shale, -57m: Kimberlite, -123.5m: Dolerite
G24227	-28.73370	24.66619				60		0-7m: Dolerite, -27m: Shale, -60m: Lava
G24228	-28.73370	24.66620				74		0-74m: Dolerite
2824DA00033	-28.73370	24.66621				70		0-6m: Calcrete, -27.4m: Shale; -70m: Dolerite
G00140NC	-28.72176	24.71258	100			102		0-1m: Calcrete, -33m: Shale, -102m: Lava
G00141NC	-28.72173	24.71258	100			110		0-1m: Calcrete, -22m: Clay, -51m: Shale, -110m: Lava
G00166NC	-28.71942	24.74352	10	10.34		36	17	0-18m: Dolerite, -36m: Shale
G00164NC	-28.71923	24.73346	10	9.89		30	17	0-17m: Dolerite, -30m: Shale
G00143NC	-28.71620	24.72285	100	6.74		80	18	0-6m: Calcrete, -51m: Shale; -80m: Lava
G00142NC	-28.71593	24.72258	100			102		0-1m: Calcrete, -4m: Shale, -7m: Clay, -54m: Shale, -61m: Dolerite, -73m: Shale, -102m: Lava
G00165NC	-28.71542	24.73124	10	2.43		50	10	0-50m: Shale
G00174NC	-28.70426	24.71730	10			80		0-4m: Overburden, -19m: Clay, -80m: Shale
G00176NC	-28.70120	24.71619	10	2.31		80	11	0-2m: Overburden, -80m: Shale

Appendix 2: Impact Assessment Methodology

Determination of Impact Significance

The information presented above in terms of identifying and describing the aspects and impacts is summarised in tabular form and significance is assigned with supporting rational.

The environmental significance rating is an attempt to evaluate the importance of a particular impact, the consequence and likelihood of which has already been assessed by the relevant specialist as and when required.

In order to assess the significance of each impact, the following ranking scales will be employed:

Table 9-1: Impact Significance Ranking Scales

PROBABILITY:	DURATION:
5 - Definite/don't know 4 - Highly probable 3 - Medium probability 2 - Low probability 1 - Improbable 0 - None	5 - Permanent 4 - Long-term (impact ceases after the operational life of the activity) 3 - Medium-term (5-15 years) 2 - Short-term (0-5 years) 1 - Immediate
SCALE:	**MAGNITUDE:**
5 - International 4 - National 3 - Regional 2 - Local 1 - Site only	10 - Very high/don't know 8 - High 6 - Moderate 4 - Low 2 - Minor 0 - None

Once the above factors had been ranked for each impact, the overall significance of each impact was assessed using the following formula:

(Potential Significance) = (*Magnitude* + *Duration* + *Scale*) x *Probability*

The potential significance (PS) has a maximum rating of 100 points. Environmental impacts are rated as having either a High (H), a Moderate (M) or a Low (L) significance according to the following scale:

PS ≥ 60 = High Environmental Significance

60 < PS ≥ 30 = Moderate Environmental Significance

PS < 30 = Low Environmental Significance

Significance will thus be classified according to the following:

- **Low:** Low Environmental Significance – Mitigation easily achieved or little is required;
- **Moderate:** Moderate Environmental Significance – Mitigation is both feasible and fairly easily possible; and
- **High:** High Environmental Significance – Adverse Impact. Mitigation, if possible, is often difficult, expensive and time consuming.

The Potential Environmental Impact Significance can then be calculated for each impact at the various stages of the project before and after mitigational measures are implemented. The various stages of the project can be classified as follows:

- Construction Phase before mitigation,

- Construction Phase after mitigation,
- Operational Phase before mitigation,
- Operational Phase after mitigation,
- Closure Phase before mitigation,
- Closure Phase after mitigation.

The Potential Environmental Impact Significance is calculated by using the following matrix:

POTENTIAL ENVIRONMENTAL	CRITERIA					SCORE	SIGNIFICANCE		
IMPACT	Nature	P	D	S	M	TOTAL	L	M	H
CONSTRUCTION	-	3	2	1	4	21	L		
CONSTRUCTION MITIGATION	+	2	2	1	3	12	L		
OPERATION	-	3	4	1	3	24	L		
OPERATION MITIGATION	-	1	4	1	3	8	L		
CLOSURE	+	3	2	1	3	18	L		
CLOSURE MITIGATION	+	1	2	1	3	6	L		

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